<table>
<thead>
<tr>
<th>Sr No</th>
<th>Paper Id</th>
<th>Name Of Paper</th>
<th>Page No</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>Mech 01</td>
<td>Role of Management in Education System</td>
<td>5</td>
</tr>
<tr>
<td>02</td>
<td>Mech 02</td>
<td>Selection of Supplier by Using Multi Criteria Decision Making Methods</td>
<td>10</td>
</tr>
<tr>
<td>03</td>
<td>Mech 04</td>
<td>A review paper on study of vibrations in cantilever beam by using different material with the help of analyser</td>
<td>13</td>
</tr>
<tr>
<td>04</td>
<td>Mech 10</td>
<td>Processing and Characterization of Duplex Stainless Steels: A Review</td>
<td>16</td>
</tr>
<tr>
<td>05</td>
<td>Mech 11</td>
<td>Recent Trend And Development In Natural Composite</td>
<td>21</td>
</tr>
<tr>
<td>06</td>
<td>Mech 12</td>
<td>Recent Trends and development in Hybrid Composites</td>
<td>28</td>
</tr>
<tr>
<td>07</td>
<td>Mech 13</td>
<td>Performance Analysis of battery operated rickshaw with different battery bank</td>
<td>34</td>
</tr>
<tr>
<td>08</td>
<td>Mech 16</td>
<td>Retrofitting of profile projector for non-contact type of measurement</td>
<td>40</td>
</tr>
<tr>
<td>09</td>
<td>Mech 17</td>
<td>Design and development of Multipurpose Spraying and Weeding Machine for Agriculture</td>
<td>43</td>
</tr>
<tr>
<td>10</td>
<td>Mech 20</td>
<td>Design and Manufacturing of Conveyer System for Quality Analysis of Gear by Using Image Processing</td>
<td>48</td>
</tr>
<tr>
<td>11</td>
<td>Mech 21</td>
<td>Fused Deposition Modelling Process Parameter Optimization Using Desirability Approach.</td>
<td>54</td>
</tr>
<tr>
<td>12</td>
<td>Mech 22</td>
<td>Flywheel Energy Application in Commercial and Agricultural Field: A typical review</td>
<td>57</td>
</tr>
<tr>
<td>13</td>
<td>Mech 24</td>
<td>Process Optimization for TRB Cup Inspection Machine</td>
<td>65</td>
</tr>
<tr>
<td>14</td>
<td>Mech 23</td>
<td>Design and fabrication of multipurpose wood working machine</td>
<td>68</td>
</tr>
<tr>
<td>15</td>
<td>Mech 35</td>
<td>Compost Machine: A Key towards Sustainability</td>
<td>74</td>
</tr>
<tr>
<td>16</td>
<td>Mech 37</td>
<td>Thordon (Elastomeric) Bearings for marine propeller shaft system and Water quality packaged</td>
<td>82</td>
</tr>
<tr>
<td>17</td>
<td>Mech 42</td>
<td>Design, Fabrication &amp; Experimental Investigation of Heat Pipe</td>
<td>87</td>
</tr>
<tr>
<td>18</td>
<td>Mech 43</td>
<td>Electronic Brakeforce Distribution System</td>
<td>92</td>
</tr>
<tr>
<td>19</td>
<td>Mech 44</td>
<td>Review of Autonomous Vehicles: Concept, Barriers and Opportunities</td>
<td>98</td>
</tr>
<tr>
<td>20</td>
<td>Mech 45</td>
<td>Develop and Implement Preventive Maintenance System for</td>
<td>104</td>
</tr>
<tr>
<td>No.</td>
<td>Code</td>
<td>Title</td>
<td>Page</td>
</tr>
<tr>
<td>-----</td>
<td>-------</td>
<td>----------------------------------------------------------------------</td>
<td>------</td>
</tr>
<tr>
<td>21</td>
<td>Mech 46</td>
<td>Design and Fabrication of Wheel Conveyor for Boxer Headlamp Assembly</td>
<td>112</td>
</tr>
<tr>
<td>22</td>
<td>Mech 47</td>
<td>360 Degree Conveyor With Up Down Mechanism</td>
<td>117</td>
</tr>
<tr>
<td>23</td>
<td>Mech 53</td>
<td>IIoT (Industrial Internet of Things) implementation using 10 WCM (World Class Manufacturing) Tools</td>
<td>122</td>
</tr>
<tr>
<td>24</td>
<td>Mech 55</td>
<td>Experimental Study of New Chamber Design for OWC</td>
<td>127</td>
</tr>
<tr>
<td>25</td>
<td>Mech 51</td>
<td>Advances in nanotechnology in solar cell -A Review</td>
<td>133</td>
</tr>
<tr>
<td>26</td>
<td>Mech 32</td>
<td>Design and Development of Car Seat Constrain System (May 2020)</td>
<td>137</td>
</tr>
<tr>
<td>27</td>
<td>Mech 50</td>
<td>Recent trends in manufacturing technology“3-dimensional printing technology</td>
<td>143</td>
</tr>
<tr>
<td>28</td>
<td>Mech 59</td>
<td>Complete Approach for Industrial Safety Measures and Precautions</td>
<td>144</td>
</tr>
<tr>
<td>30</td>
<td>Mech-73</td>
<td>A Review on Phase Change Materials and Their Applications</td>
<td>152</td>
</tr>
<tr>
<td>31</td>
<td>Mech-76</td>
<td>Design and Development of coconut tree climbing and harvesting machine.</td>
<td>158</td>
</tr>
<tr>
<td>32</td>
<td>Mech-78</td>
<td>Investigative Study on Change in Behaviour of Composite Materials under Thermal Loading</td>
<td>166</td>
</tr>
<tr>
<td>33</td>
<td>Mech-83</td>
<td>A Review on Methanol as a Fuel for I.C. Engine</td>
<td>172</td>
</tr>
<tr>
<td>34</td>
<td>Mech-86</td>
<td>Design and Manufacturing of Conveying System for Onion Harvester</td>
<td>175</td>
</tr>
<tr>
<td>35</td>
<td>Mech-87</td>
<td>Design and Manufacturing of Motorized Paint Roller</td>
<td>179</td>
</tr>
<tr>
<td>36</td>
<td>Mech-89</td>
<td>Development of Test Rig for Behaviour Study of Metal to Composite Bolted Joint under Combined Bending and Vibration Loading</td>
<td>186</td>
</tr>
<tr>
<td>37</td>
<td>Mech-90</td>
<td>Development of Attachment for Experimental Behaviour Analysis of CFRP Specimen Subjected to Combined Bending</td>
<td>194</td>
</tr>
<tr>
<td>38</td>
<td>Mech 92</td>
<td>A Review on Enhancement Of Flame Retardancy of Natural Based Fibres and Their Testing</td>
<td>203</td>
</tr>
<tr>
<td>39</td>
<td>Mech 93</td>
<td>Semi-Automatic Multifunctional Farm Machine</td>
<td>209</td>
</tr>
<tr>
<td>40</td>
<td>Mech 95</td>
<td>Magnetic levitation wind turbine</td>
<td>215</td>
</tr>
<tr>
<td>41</td>
<td>Mech 96</td>
<td>Optimization Of Sheetmetal Brackets Using 3d Printing Technology</td>
<td>219</td>
</tr>
<tr>
<td>42</td>
<td>Mech 97</td>
<td>Analysis of Covid-19 in five zones of India</td>
<td>227</td>
</tr>
<tr>
<td>43</td>
<td>Mech 101</td>
<td>Introduction to Recent Development in Heat Pipe &amp; their Applications</td>
<td>232</td>
</tr>
<tr>
<td>44</td>
<td>Mech 102</td>
<td>Quad Bike Differential</td>
<td>239</td>
</tr>
<tr>
<td>45</td>
<td>Mech 103</td>
<td>Hybrid Compressed Air Drive System</td>
<td>244</td>
</tr>
<tr>
<td>46</td>
<td>Mech 104</td>
<td>Residual Stress Effect Due To Autofrettage in Hydraulic Cylinders for Thick cylinder</td>
<td>250</td>
</tr>
<tr>
<td>47</td>
<td>Mech 110</td>
<td>Performance Investigation Of PV Thermal Collector By Using Water Cooling</td>
<td>254</td>
</tr>
<tr>
<td>48</td>
<td>Mech 114</td>
<td>A Comprehensive Analysis of Designing and Manufacturing Dies for a Plastic Moulding Production</td>
<td>263</td>
</tr>
<tr>
<td>49</td>
<td>Mech 115</td>
<td>An Overview of Computer Aided Process Planning and its Applications in Digital Manufacturing</td>
<td>282</td>
</tr>
<tr>
<td>50</td>
<td>Mech 120</td>
<td>Development and Fabrication of Airbrake System Using Engine Exhaust Gas</td>
<td>290</td>
</tr>
<tr>
<td>51</td>
<td>Mech 123</td>
<td>Rotocasting :A review</td>
<td>293</td>
</tr>
<tr>
<td>52</td>
<td>Mech 124</td>
<td>Atomiser Device</td>
<td>298</td>
</tr>
<tr>
<td>53</td>
<td>Mech 125</td>
<td>Investigation on Influence of Hybrid Nano fluid on Surface Roughness in Drilling Ti6Al4V by MQL</td>
<td>303</td>
</tr>
<tr>
<td>54</td>
<td>Mech 126</td>
<td>Design And Optimization Of Hydraulic Cylinder Mounting Bracket</td>
<td>307</td>
</tr>
<tr>
<td>55</td>
<td>Mech 127</td>
<td>A review paper on Automatic Emergency Braking</td>
<td>317</td>
</tr>
<tr>
<td>56</td>
<td>Mech 128</td>
<td>Review of Matrix Applications in Solving Coupled Differential Equations</td>
<td>324</td>
</tr>
</tbody>
</table>
Role of Management in Education System

M.V.BORSE¹  PERMIDUR SINGH²  S. R. UPASANI³  V.K. DHAGTE⁴

¹Lecturer in Mechanical engineering Department GGSP, Nashik Email id :- mayur.borse@ggsf.edu.in
²CEO ggsf Nashik Email id :- permidur.singh@ggsf.edu.in
³Principal,ggsp,Nashik Email id :- shrihari.upasani@ggsf.edu.in
⁴HOD, Mechanical Engineering Department, GGSP, Nashik Email id :- vikas.dhagate@ggsf.edu.in

ABSTRACT

Management of education system is the process of planning, organizing, directing and controlling the activities of an institution by utilizing human and material resources so as to effectively and efficiently accomplish functions of teaching and extension work and research.

INDEX TERMS
Planning, Organizing, Directing and Controlling

1. INTRODUCTION :

Educational management helps is the achievement institution’s objectives i.e. it ensures school and college effectiveness. It improves planning, organizing and implementing and institution’s activities and process. It helps in creating, maintain and enhancing a good public image of the institution. It helps in appropriate utilization of its human resources i.e. teaching staff, non –teaching staff and students. It enhances efficiency of the institution i.e. it helps in attaining the goals with minimum cost and time. It facilitates optimum utilization of infrastructural facilities (playground, building, equipment, library etc.)

It prevents duplication of work. It enhances job satisfaction among staff members and satisfaction with the institution among students. It enables the institution to create and maintain a congenial school and college climate. It helps staff and students to manage, their interpersonal conflicts, stress and time effectively. It improves interpersonal communication among members of the school /college. It enables the principal (head of institute), registrar, and head of departments to understand their role and carry out function more effectively.

2 IMPORTANCE OF EDUCATIONAL MANAGEMENT :

- Finance Management
- Infrastructure Management
- Teaching learning process Management
- Management of teacher work
- Students work Management
- Co-curricular activity Management
- Examination Management
- Facilities Management
- Laboratory Management
- Special lab (Skill development centre) Management
- It deals with material and institutional effectiveness.

3 NEED OF EDUCATIONAL MANAGEMENT :

- Social change-the system of education is expected to provide society with human resources with specialized knowledge, attitudes, work ethics and values social moral political values, expertise, and skills so as to sustain and enhance this development. This places demands on education to make its curriculum more relevant to the life and needs of the changing society in and effective and efficient manner. It is also expected to enable students to bring about desirable social changes, the same time preserving the desirable and positive aspects of the existing culture.
• To create congenial environment at institutional level – for the attainment of the aims and objectives of the educational system in particular and those of the country in general and knowledge of relevant management theories, principles, concepts, techniques, skills and strategies and their application to educational systems is necessary for its effective and efficient function and outputs.

• Need to make our system of education more proactive rather than reactive by using applying principles and techniques of management science.

• Leaders and managers in our educational institutions are selected and promoted from the teaching faculty. Majority of them have very little knowledge and experience of running a school or a college which sometimes creates a situations where the institution loses a very good teacher and come up with poor managers.

4 VALUATION :

• Evaluating includes the process of monitoring the teaching-learning process and providing feedback. The principal of the Institution is accountable to the parents, teachers, local community, government departments, Society as well as the management or the managing committee of the institution. Evaluation of curricular process and outcomes is a very important function at all levels of education in view of the accountability of the institution to satisfy the expectations and demands of the various stakeholders.

• Evaluation is the educational setting incorporates a variety of operations and feedback as well as internal and external indicators concerning individual students, class, stream, departments or the whole institution. Evaluation is aimed at finding out whether institution has been effective in achieving the aims of the institution or not.

• The feedback mechanisms used in the evaluation process are simple and routine in nature such as regular attendance and health checks, assessing and correcting homework, results of units tests and Term End examinations, monthly records and so on. This kind of formative and summative evaluation decreases administrative hassles and encourages a “learning approach” to circumstances and situations.

5 ERP FEATURES AND FUNCTIONS IN EDUCATION

• Timetable Management system enables creation of both manual and automatic timetables. It guarantees timely updates on faculty substitution and assists in superior management of rooms, resources and faculty.

• Financial Accounting module takes care of accounts receivable and payable, general ledger, taxation, income/expense and reconciliation statements as well as other documents needed for accounting purposes. This module also offers a robust and multifarious portfolio of reports.

• Admission Management system helps to control pre-admission selection and screening of students, short listing of applications, online registration, identification cards registration and sending/receiving electronic alerts.

• Grades and Exam Operation system gives the ability to conduct offline and online examinations, consider student performance, differentiate book management, generate report cards, hold mass competitive/entrance exams as well as provide the students with the results.

• Hostel Management module streamlines arrangement and reservation of rooms in teacher accommodations and student hostels. It helps track student outings and visitor records thus ensuring discipline. It also assists to control room facilities, room shifting and interchanging processes, and provides other important logistic support.

• Asset and Inventory Management program provides stock and inventory management for multiple positions. It allows to increase significantly operational effectiveness and categorize the assets. This program also helps to conduct the wise search of assets location.
- Budget and cost control module helps in accurate and quick budgeting. It provides efficient costing and performance evaluation, and assists distinguish between unavoidable and controllable costs.
- Recruitment operation system helps the students get the view of the whole situation and make use of pre-placement opportunities. This program provides exhaustive resume search and allows the students receive or send interview letters or e-mails without encumbrance.
- Biometrics payroll Management module provides the user with a defined classification for integral reporting. This program can make up a flexible payroll processing stage, cost centres and control the biometric system as well.
- Fees Management system helps the user create a special fee structure according to which fees can be paid weekly, monthly or annually, as the student wishes. This module has a function of automatic generation of defaulter lists, fine structures and scholarship rewards schedules.

6 BENEFITS ERP CAN BRING TO EDUCATION

Educational institutes around the globe are quite busy while trying to re-organize their management system and those who have already started using ERP systems have experienced a rise in effectiveness, productivity and proficiency of the administration. With the use of ERP system you and your institute are capable of:

- Improving the organization of teachers, students, lectures, etc.
- Systemizing various educational processes
- Simplifying student management
- Reinforcing relationships with parents and stakeholders
- Reducing expenses, saving energy and time
- Organizing the data in the order you need and want.

7 TEACHING LEARNING PROCESS MANAGEMENT :

Before selecting any teaching learning process for assigned subject, course’s rational and Objective must be known and causes of previous batch’s students poor performance has to be consider(if any). Following aspects should be consider while working on root cause analysis:

- Available Resources
- Student’s behaviour
- Subject Teacher Role
- Question Paper Pattern
- How to study
- Syllabus content

8 MANAGEMENT OF TEACHER WORK :

Teacher’s daily work load, status of assigned task, work done in leisure hour can be monitored in daily activity. Following daily report will give exact idea about the faculty’s Time Management for workload.
9 PROJECT PLANNING SHEET FOR FINAL YEAR STUDENTS:

The best use of management from student’s point of view is Project planning sheet for Major Project (Final Year Project). From this sheet students can regularly monitor the progress of their project work and they can take corrective action if needed.

10 STANDARD OPERATING PROCEDURE (SOP):

SOP is very popular in industry to make every process standardized. This helps in achieving high accuracy even though operator changes as per working time. This procedure is also very useful in technical education institution as every year new students got admitted, this SOP gives them brief idea about the working procedure and precautions which needs to be taken.
11 ADVANTAGES:

- It helps in decision-making and solving problems
- It helps in communication and managing information
- Building effective teams

- It helps in managing academic and co-curricular activities, time table, discipline
- It will be helpful motivating staff and students.
- Managing conflicts and stress
- Helpful in maintaining healthy and conducive organization climate.
- Helpful in counselling and guidance.
- Helpful in maintaining school records and financing and budgeting.
- Helpful in evaluating student achievement

12 CONCLUSION:

This paper elaborates the Role of Management which includes key contribution from each of modules like ERP, DailyReport, Project Sheet that are clearly specific that gives commitment to organization with strong, visible accountability and which in turn can accomplish what might otherwise be seen to be the impossible”.

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Selection of Supplier by Using Multi Criteria Decision Making Methods

N. J. Rathod1S. S. Gangurde2
1Assistant Professor Department of Mechanical Engineering Brahma Valley college of Engineering and Research, Nashik, Maharashtra, India
2Assistant Professor Department of Mechanical Engineering Brahma Valley college of Engineering and Research, Nashik, Maharashtra, India

ABSTRACT

In India, Selection of supplier is very serious problem in supply chain management (SCM). In the past few years, selection of suppliers in the supply chain management has become very significant to mould a trade-off between the quantitative and qualitative criteria. These selection criteria are considered for making final decisions on supplier selection inadvertently and systematically. Conversely, these decisions frequently involve in numerous criteria or objectives to compromise among all potential conflicting parameters. This paper contracts with the uncertain issue of the supplier selection using SAW and WPM model for multi criteria decision making (MCDM). To gain from is that, it discriminates between the cost (less the better) and benefit (more the better) criteria and selects the solutions which are closest and farthest from the positive and negative best possible solution. Very Sensitivity analysis is carried out to examine the effect of criteria weights on the supplier selection. A comparative model is explained for a supplier’s selection problem with best possible supplier selection solution

INDEX TERMS
WPM, SAW, MCDM, Quantitative, Qualitative, Supplier Selection, Weights for the Criteria

1. INTRODUCTION

Generally, in any industry selection of supplier is very critical job does it have multiple selection criteria on that basis supplier have various weights are obtained from expert groups. Thus MCDM is play vital role get well organized structure and solve decision and planning problems containing multiple criteria. To identify the main objective of supplier selection, detail. Information is to support decision maker to get the optimal solution for their particular problems, whereas there are huge option available for selector. While performing the operation combination various outcome get cited by their weights and using various method.

2. METHODOLOGY

The initial step for the methodology (Fig. 1) is to prepare the decision matrix. To prepare the decision matrix we have to identify the alternatives, criteria and calculate the weights of the criteria. Then we compare Supplier selection on different criteria (performance measures). The ranking of the criteria is done on the basis of the performance index calculated by the MADM methods.

FIGURE 1. METHODOLOGY

A. Simple Additive Weighing (SAW) Method

This method was developed by Fishburn in 1967 [6] and is also called Weighted Sum Method. The decision matrix is normalized before calculating the overall scores.

\[ P_i = \sum_{j=1}^{m} w_j (y_{ij})_{\text{normal}} \]

Where \((Z_{ij})_{\text{normal}}\) is the normalized value of \(Z_{ij}\) i.e. normalized values of performance measures. The overall scores are calculated by Eq. The alternative having the highest composite score \(P_i\) is the best option from the given
set of alternatives. The normalized matrix is shown in Table 3.

**B. Weighted Product Method (WPM)**

This method is similar to SPM and was developed by Miller and Starr in 1969 [7]. WPM uses multiplication instead of addition. The normalized matrix is same as that of calculated in SPM. The overall scores (ESI) is calculated by Eq.

\[ P_i = \prod_{j=1}^{m} \left( v_{ij} \right)_{normal}^{w_j} \]

### 3. CASE STUDY

To apply this methodology, we have solved simulated numerical problem. Based on methodology, three steps are applied for assessment and selection of suppliers. In this part we deal with application of these steps. After forming decision making team, step 1 starts developing an updated pool of supplier selection criteria for the industry, using those accepted criteria given in the literature, as well as those criteria recommended by the experts. In this numerical example, the criteria are selected as shown in Table 1. Although, the criteria considered in supplier evaluation are condition-industry specific. Selection of criteria is totally industry specific and based on each case and the criteria are changed and replaced. Opinions of decision makers on criteria were aggregated and weights of all criteria have been calculated by organizing the expert meeting. Its results have Assuming 4 suppliers are included in the evaluation process, information of each of suppliers has been mentioned in Table 2. After normalizing information and considering weight of criteria in them, negative and positive separation measures, based on normalized Euclidean distance for each supplier is calculated and then final weight of each supplier is calculated.

**Table No. 1 Supplier’s information**

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Weight</th>
<th>S 1</th>
<th>S 2</th>
<th>S 3</th>
<th>S 4</th>
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<tr>
<td>Material Quality</td>
<td>0.20</td>
<td>95</td>
<td>94</td>
<td>96</td>
<td>90</td>
</tr>
<tr>
<td>On time delivery</td>
<td>0.08</td>
<td>90</td>
<td>96</td>
<td>94</td>
<td>91</td>
</tr>
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</table>

**Table No. 2 Normalized matrix for SAW and WPM**

<table>
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<th>Criteria</th>
<th>S 1</th>
<th>S 2</th>
<th>S 3</th>
<th>S 4</th>
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<tr>
<td>Material Quality</td>
<td>0.9896</td>
<td>0.9792</td>
<td>1.000</td>
<td>0.9375</td>
</tr>
<tr>
<td>On time delivery</td>
<td>1.011</td>
<td>0.9479</td>
<td>0.9681</td>
<td>1.000</td>
</tr>
<tr>
<td>Ordering cost</td>
<td>1.000</td>
<td>0.9000</td>
<td>0.9310</td>
<td>0.9643</td>
</tr>
<tr>
<td>Delivery lead time</td>
<td>0.8333</td>
<td>0.6667</td>
<td>0.7143</td>
<td>1.000</td>
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<tr>
<td>Technical Capability</td>
<td>0.8846</td>
<td>1.000</td>
<td>0.7308</td>
<td>0.7692</td>
</tr>
<tr>
<td>Transportation cost</td>
<td>0.7231</td>
<td>1.000</td>
<td>0.8545</td>
<td>0.6714</td>
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<tr>
<td>Rejection of defective product</td>
<td>0.5000</td>
<td>0.3333</td>
<td>1.0000</td>
<td>0.5000</td>
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**4. RESULT AND DISCUSSION**

The results of MADM methods applied for the selection of Supplier.
### Criteria

<table>
<thead>
<tr>
<th>Supplier</th>
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<th>WPM</th>
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<tbody>
<tr>
<td>Supplier 1</td>
<td>0.5619</td>
<td>0.9068</td>
</tr>
<tr>
<td>Supplier 2</td>
<td>0.5413</td>
<td>0.8691</td>
</tr>
<tr>
<td>Supplier 3</td>
<td>0.5808</td>
<td>0.9345</td>
</tr>
<tr>
<td>Supplier 4</td>
<td>0.5524</td>
<td>0.8966</td>
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Table No. 4 Ranking of Supplier

<table>
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<th>Ranking</th>
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<tbody>
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<td>Supplier 1</td>
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</tr>
<tr>
<td>Supplier 2</td>
<td>4</td>
</tr>
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<td>Supplier 3</td>
<td>1</td>
</tr>
<tr>
<td>Supplier 4</td>
<td>3</td>
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</table>

This result is then compared to other methods. SPM and WPM also ranks Supplier 3 as the best supplier. Hence, from the rankings shown in Table 4, supplier 3 is the best option from the available supplier.

### 5. CONCLUSION

In this paper, we identified the important criteria for selection of supplier. The results by all the methods showed that Supplier 3 is the best supplier from the available another supplier. A close look at the attributes of the alternatives will show that Supplier 3 is having the highest deposition rate which is a very important criterion. Hence, we can say that the Supplier 3 is the best supplier from the given set of alternatives.

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A Review Paper on Study Of vibrations in cantilever beam by using different material with the help of FFT analyser

Abhijit Kadam*, Suyog raut², Mahesh Kore³

1Assistant Professor, Department of Mechanical Engg., PG Moze COE Wagholi, Pune, India
2BE Student, Department of Mechanical Engg., PG Moze COE Wagholi, Pune, India
3BE Student, Department of Mechanical Engg., PG Moze COE Wagholi, Pune, India
*abhijitkadam555@gmail.com

ABSTRACT
In present work, natural frequencies and mode shapes are computed for structural steel, aluminium and brass cantilever beam elements for various vibrations by theoretical analysis as well as experimental analysis and numerical analysis is carried out by Finite Element Method by using ANSYS program

INDEX TERMS
Cantilever beam, FFT analyser, Real time photon software, Natural frequency, ANSYS program

1.Introduction

Beam is a inclined or horizontal structural member casing a distance among one or additional supports, and carrying vertical loads across (transverse to) its longitudinal axis.

Three basic types of beams are: [1]&[2]

i. Simple span, supported at both ends
ii. Continuous, supported at more than two points
iii. Cantilever, supported at one end with the other end overhanging and free.

There exist two kinds of beams namely Euler-Bernoulli’s beam and Timoshenko beam. By the theory of Euler-Bernoulli’s beam it is assumed that

i. Cross-sectional plane perpendicular to the axis of the beam remain plane after deformation.
ii. The deformed cross-sectional plane is still perpendicular to the axis after deformation.
iii. The theory of beam neglects the transverse shearing deformation and the transverse shear is determined by the equation of equilibrium.

In Euler – Bernoulli beam theory, shear deformations and rotation effects are neglected, and plane sections remain plane and normal to the longitudinal axis. In the

Timoshenko beam theory, plane sections still remain plane but are no longer normal to the longitudinal axis [3].

Vibration is the motion of a particle or a body or system of connected bodies displaced from a position of equilibrium. Most vibrations are undesirable in machines and structures because they produce increased stresses, energy losses, cause added wear, increase bearing loads, induce fatigue, create passenger discomfort in vehicles, and absorb energy from the system. Rotating machine parts need careful balancing in order to prevent damage from vibrations [4]

2. Literature Review

- Nirmall & Dr. Vimala [1] explained that The Vibration damping characteristics of beams made up of three different materials i.e. aluminium, brass, mild steel with respect to different parameters like thickness, length, width of the cantilever beam and tapered cantilever beam are studied by theoretical and analytical method by using ANSYS software. The natural frequency increases with decreases in thickness for each material. The Natural frequency of cantilever beam and tapered cantilever beam will be studied by experimental method. Natural frequencies of beams obtained from theoretical and experimental methods will be compared with analytical results.

- Baviskar et. al. [2] explained that, the method of multiple cracks detection in moving parts or beams by monitoring the natural frequency and forecasting of crack location and depth using Artificial Neural Networks (ANN). Detection of crack properties like depth and location is vital in the fault diagnosis of rotating machine
components. For the theoretical analysis, Finite Element Method (FEM) is used whereas the natural frequency of beam is calculated whereas the experimentation is done by using Fast Fourier Transform (FFT) analyser. In experimentation, simply supported beam with one crack and cantilever beam with two cracks are considered. The experimental results are validated with the results of FEM (ANSYS) software. This formulation can be extended for various boundary conditions as well as varying cross sectional areas. The database obtained by FEM is used for prediction of crack location and depth using Artificial Neural Network (ANN). To investigate the validity of the proposed method, some predictions by ANN are compared with the results given by FEM. It is found that the method is capable of predicting the crack location and depth for single as well as two cracks. This work may be useful for improving online conditioning and monitoring of machine components and integrity assessment of the structures.

- Kamble & Chavan [3] explained that, evaluating first three natural frequencies using by vibration measurements, curves of crack stiffness are plotted and the intersection of the three curves indicates the crack location and size. Cantilever beam with single crack (different location and different size) using ANSYS package to obtain natural frequency, which are compared with FFT results. Both the FEM and FFT results show that the accurate accuracy and high sensitivity for small cracks. As the crack depth increases the estimated error of the crack location increases. This method provides effective, simple and fast non-destructive techniques by using the continuous wave technique tool. This method be extended for damage detection of complex structures.

- Pawar & Sawant [4] compare with previous old systems of vibration analysis of cantilever beam this method identifies the nonlinearities & effects on load deflection characteristics of cantilever. In this method Numerical verification of vibration analysis of cracked cantilever beam with nonlinear parameters and evaluation of natural frequency and mode shapes with MATLAB/ANSYS software for both Free and Forced vibration are done & the Experimental validation of results obtained by theoretical and numerical method with the help of FFT Analyzer for both Free and Forced vibration of cracked cantilever beam with nonlinear parameters gives better result than previous old systems.

- Singh et. al. [5] investigated the vibration damping characteristics of mild steel, brass and aluminium of different lengths. Data is collected based on excitation frequency using free vibration technique and compare it theoretical results. Accelerometer is connected at its free end and cantilever beams have been subjected to impact hammer test. The objective of the study is to find out the natural frequency, damping ratio and vibration characteristics by using OMNITREND. Then these values compared with theoretical values obtained from ANSYS. It concluded that when the thickness decreases but length same then the natural frequency decreases and when the length decreases but thickness same then the natural frequency goes to increase.

- Kuppast et. al. [6] study the effect of vibration characteristics of aluminium alloys of different compositions. The modelling and analysis are carried out using ANSYS software. A modal analysis is carried out to understand the vibration behaviour i.e., natural frequency and mode shapes, of the material considered. The harmonic analysis has been made to determine frequency characteristics. The analysis program reads the data from the input file processes the data and creates the output file containing the nodal displacements and nodal stress values of different stresses.

- Mahmoud [7] This article presents a general solution for the free transverse vibration of non-uniform, axially functionally graded cantilevers loaded at the tips with point masses. Attention is focused on undamped cantilevers that fall within the range of validity of Euler-Bernoulli beam theory. Results are presented for a number of cases of different beam geometries and material gradients.

- Wahrhaftig[8] in his paper present an investigation of the initial resonant vibration frequency of largely deformed cantilever beam this study is important because the vibration of beam with this level of deformation occurs from a position that differs significantly from the
undistorted configuration as the deformation increases changing the stiffness and influence the resonant frequency of the system

- Hamid [9] in his paper focus on modelling of structural response of RC cantilever beam retrofitted with a thin layer of ultra-high-performance fibre reinforced cement-based composite (UHPFRC) composite system is carried out by numerical model incorporating the real nonlinear material law in order to predict accurately mechanical behaviour

- Mustapha [10] in this paper the cantilever beam is discretized into number of zone in cantilever beam where each zone has a specific classification of normalised frequencies of the structure in case when the damage is symmetric to vibration node we use the unchanged natural frequency as second information to obtain a more accurate location the effectiveness pf proposed method is shown by numerical simulation with ANSYS software and experimental investigation of cantilever beam with different damage

3. Conclusions
The purpose of this experiment is to calculate the vibration characteristics of Brass, Stainless Steel and Aluminium as a cantilever beam with experimentally and analytical. The increase in material damping could be correlated to the stiffness of materials. The damping ratio increases with decrease in thickness for each material. The natural frequency decreases with decreases in thickness for each material. But it is vice versa in case of length. The damping of specimen made up of aluminium was found to be lowest than either steel or brass.

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Processing and Characterization of Duplex Stainless Steels: A Review

Rayappa Shrinivas Mahale¹, Dr Shamanth V², and Dr Sharath P C³

¹Research Scholar, School of Mechanical Engineering, REVA University, Bengaluru, Karnataka, India, 560064
²Associate Professor, School of Mechanical Engineering, REVA University, Bengaluru, Karnataka, India, 560064
³Assistant Professor, Faculty of Engineering and Technology, JAIN Deemed to be University, Bengaluru, Karnataka, India, 562112

ABSTRACT

In duplex stainless steels ferrite and austenitic phases are present in balanced quantities and are easy to fabricate and having excellent corrosion resistance with higher strength. Duplex stainless steels find major applications in oil and gas industries, chemical process plants, pulp and paper industry and desalination plants. The widely used duplex stainless steel grades are 2205, 2304 and 2507. The present study includes the preparation of DSS nano powders by planetary ball milling procedure and then the consolidated metal powder will be compacted and sintered by Selective Laser Sintering (SLS) technique. Microstructural characterization will be done for sintered material using X-Ray Diffraction, Scanning Electron Microscopy equipped with Energy Dispersive Spectroscope and a Field Emission Gun. Fracture toughness, fatigue crack initiation and growth behaviour as well as the controlling failure mechanism of the processed nano structured duplex stainless steel will be determined.


Major characteristic of duplex stainless steel is high Chromium content (Approx. 20–25. 4%) but low content of Nickel (1.4–7%) compare to austenitic grades. For balancing the microstructure Molybdenum (0.3–4%) and Nitrogen additions are essential [1,2]. Nitrogen is added to increase the strength. Manganese can be added in replacement to Nickel and it also increases the solubility of nitrogen in the material.

The metallurgical behaviour of DSS can be studied in detail with the help of Fe-Cr-Ni ternary phase diagram plotted for 68% iron content. From the above diagram it is clear that Fe-Cr-Ni alloys solidifies as ferrite (α) and some of the alloys transform into austenite (γ) when the temperature reaches 1000 °C. The ferrite - austenite phase balance in the microstructure can be studied with the help of multi variable linear regressions [3].

1. $C_{req} = % Cr + 1.73% Si + 0.88% Mo$
2. $Nieq = % Ni + 24.55% C + 21.75% N + 0.4% Cu$
3. $% Ferrite = -20.93 + 4.01 C_{req} – 5.6 N_{eq} + 0.016T$

Where T = Annealing temperature ranging from 1050 to 1150°C.

Nitrogen addition can rapidly increase the rate of transformation of ferrite to austenite by increasing the temperature.

![FIGURE 1. Fe-Cr-Ni ternary phase diagram with 68% iron](image)

2. PRODUCTION OF NANO POWDERS BY BALL MILLING

Ball mill is a dry and a high energy technique which comes basically under Mechanical Alloying (MA). This technique deforms the powder particles by the impact of milling balls which in turn plastically deforms the powder particles, thereby creating the new surfaces and enables the particles to weld together [4,5]. The milling techniques are categorized as:
Tumbler ball mill, Planetary ball mill, Vibratory ball mill, Attrition ball mill and High energy mill. The present study uses high energy dual planetary ball mill to consolidate metal powders [6].

FIGURE 2. Planetary Ball Mill

FIGURE 3. Spark Plasma Sintering Process

The planetary ball mill consists of a jar made of hard material such as tungsten carbide or stainless steel and sometimes nitrides and oxides are also used. The bowl cap is made of the same material and it is used for the purpose of locking. Hard metal balls are kept in the jar and these are also made from tungsten carbide or stainless steel. The bowl is mounted on the disc, which rotates in a clockwise direction and the bowl will rotate in counter clockwise direction. During the rotation the centrifugal force reaches up to 20 time’s gravitational acceleration [6]. Since the directions of rotation of the disc and bowl are opposite, the centrifugal forces are also opposite. The milling stock and powder will alternately roll to the inner wall of the bowl and are randomly spread across the bowl at high speed.

3. SPARK PLASMA SINTERING

Sintering refers to the method of firing and consolidating powders at temperatures less than their freezing point, where diffusional mass transport results in bonding between particles and therefore the formation of a dense body. SPS is an emerging powder consolidating technique that gives significant advantages within the processing of high temperature materials with poor deformability into configurations that were previously unattainable. The process referred to as a low-voltage, DC and pulsed current-activated pressure technique. It is often used to produce bulk samples that start from a broad range of powders. During sintering, external pressure and an electrical field are applied simultaneously to reinforce the densification of the powder compacts.

Several theories have been proposed for physically modelling the SPS process; among them micro-spark/plasma theory is having much attention by various researchers. During this theory, when spark discharge appears within the gap between the particles of a material, a high temperature state occurs as a result of a spark. Thus, during the SPS process, vaporization occurs and therefore the powder particle surfaces melt; constricted shapes or “necks” form gradually round the contact area between the particles [12]. Plastic transformation progresses during sintering, leading to a sintered compact of over 99% density. Because only the surface temperature of the particles rises rapidly by self-heating, particle growth of the starting powder materials is controlled.

The system consists of an SPS sintering machine with vertical single-axis pressurization and built-in water-cooled special energizing mechanism, a water-cooled chamber, atmosphere controls, vacuum exhaust unit, special sintering DC generator and an SPS controller. The powder materials are stacked between the die and punch on the sintering stage within the chamber and held between the electrodes. In the presence of pulsed electric current and pressure the temperature quickly rises to 1000 to 2500°C above the ambient temperature, leading to the assembly of a top quality sintered compact in just a couple of minutes.

4. CHARACTERIZATION

A. X-Ray Diffraction

XRD is a most useful non-destructive technique to identify phases present in specimens and this technique helps to study the physical state of the sample such as texture, grain size and crystal perfection [9]. XRD techniques are classified as single crystal and polycrystalline techniques. The information obtained can
be categorized based upon position, intensity and the shape of diffraction peaks.

X – Rays are a part of electromagnetic spectrum having wavelengths from 1-100Å. Diffraction patterns may be analysed by considering (i) diffraction angles that correspond to the obtained peak and ii) relative intensities of peaks with a diffraction standard.

Angular distributions of the peak intensities obtained in the spectrum are determined using Bragg’s equation:

\[ n\lambda = 2d \sin \Theta \]

Where ‘n’ is an integer, ‘\( \lambda \)’ is the wavelength of radiation, ‘d’ is the spacing of lattice planes obtained for diffracted beam and ‘\( \Theta \)’ is the angle of diffraction.

X- Rays are generated using diffractometer by accelerating an electron beam onto the metal target contained in vacuum tube. The high energy electrons eject ground state electrons from metal target and thereby creating holes, and refilling of ground states will be possible by the emission of X-Rays.

\[ eV = h\gamma \]

Where ‘h’ is Planck’s constant. The X-Ray wavelength ‘\( \lambda \)’ is proportional to the reciprocal of this frequency and is given by,

\[ \lambda = \frac{c}{\nu} \]

where ‘c’ is the light velocity in the medium through which the X-Rays propagate.

The minimum wavelength on the accelerating voltage of the X-Ray tube is given by,

\[ \lambda_{\text{min}} = 1.243/V \]

where ‘\( \lambda \)’ is measured in nanometres and ‘V’ is in kilovolts [10].

**B. Scanning Electron Microscopy**

In SEM the test surface of the specimen is bombarded with an electron beam to provide information for producing an image [9]. SEM reveals information regarding grain boundaries, mechanical deformations, inclusion and phase distributions, fracture surfaces and corrosion.

In SEM microscope column is kept under vacuum. Some SEMs use separate vacuum pumping and degassing system if a Field Emission Gun (FEG) is used to generate the electrons [10]. The SEM Signal detection system includes high energy backscattered electrons, low energy secondary electrons, characteristic X-Rays. The characteristic X-Rays may be detected either by Energy Dispersive Spectroscopy (EDS) or by Wavelength Dispersive Spectroscopy (WDS). In EDS the exited photons are collected and the spectrum of energy dependent photon intensity is analysed to determine the chemical composition of the sample.
Fig 6 shows the different detectors used in STEM imaging. Bright Field detector counts the number of electrons per unit time as a function of the position of the electron beam focused on the sample. Electrons scattered to larger angles can be detected using High Angle Annular Dark Field (HAADF) detector.

5. CONCLUSION

The powder metallurgy technique can be adopted to manufacture products with complicated shape and geometry. AOD and VOD processes, eliminate the disadvantages of ladle metallurgy process. Vacuum converter technology is moreover useful in production of duplex grades with high nitrogen content. Ball mill is used over the past five decades for particle size reduction and powder blending. It is the most powerful nanotechnology tool for preparing a wide range of crystalline materials used for characterization.

Sintering approach can be considered as one of the powerful technique in powder consolidation. Selective laser sintering uses laser energy to transform metal powders into useful parts. Near net shape components can be produced by pre-alloyed matrix powders. XRD and PXRD Techniques are widely used to study the diffraction
patterns of polycrystalline samples. SEM provides three
dimensional depth information on the specimen by
recording two different images and the process is called as
stereoscopic imaging.

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Rayappa Shrinivas Mahale received the
Bachelor of Engineering in Industrial and
Production Engineering and MTech in
Production Management from the
Visvesvaraya Technological University, Belagavi, Karnataka. He is
currently pursuing PhD in materials engineering from REVA University,
Bengaluru, Karnataka. His research interests include powder metallurgy,
material characterization, additive manufacturing and advanced
Mechatronics systems.

Dr Shamanth V has obtained his doctorate
degree in Metallurgical and Materials
Engineering from National Institute of
Technology Karnataka (NITK) Surathkal.
His research interests include additive
manufacturing, powder metallurgy and heat
treatment of steels. He is having 7 years of
teaching experience. He has published 14
international journal papers, 2 books and 2
international conference papers. He is
currently working as an associate professor
in school of mechanical engineering, REVA
University, Bengaluru, Karnataka, India.

Dr Sharath P C has obtained his doctorate
degree from NITK, Surathkal in 2018. He
completed his post-graduation (Process
Metallurgy) from NITK, Surathkal in 2012
and pursued graduation (Mechanical) from
Malnad College of Engineering, Hassan in
2010. He has previously served in various
reputed organizations and has 4 years of
teaching experience. He has awarded first
prize for oral presentation in processing of
automotive materials at the 70th annual
technical meeting of the Indian Institute of
Metals (NMD-ATM 2016) held at IIT
Kanpur during 11-14th November 2016.
His research interests include severe plastic
deformation, metal matrix composites and
characterization. He has published 4
international Journal papers and 5
international conference papers. He is a
reviewer for many reputed international
journals and conference proceedings. He is
currently working as an assistant professor
in the department of metallurgical and
materials engineering, JAIN Deemed to be
University, Bengaluru, Karnataka, India.
Recent Trend And Development In Natural Composite

Rushikesh Bhasme¹, Rutwik S Bhasme², Prathamesh Choudhary³, Asst Prof. M P Bauskar⁴

¹Dept. of Mechanical Engineering, All India ShriShivaji Memorial Society’s College of Engineering, Kennedy Road, Pune, Maharashtra, India, 411001
²Dept. of Mechanical Engineering, All India ShriShivaji Memorial Society’s College of Engineering, Kennedy Road, Pune, Maharashtra, India, 411001
³Dept. of Mechanical Engineering, All India ShriShivaji Memorial Society’s College of Engineering, Kennedy Road, Pune, Maharashtra, India, 411001
⁴Dept. of Mechanical Engineering, All India ShriShivaji Memorial Society’s College of Engineering, Kennedy Road, Pune, Maharashtra, India, 411001

ABSTRACT

Recently, there has been rapid growth in research and innovation in the natural fibre composite (NFC) area. Interest is warranted due to the advantage of these material compared to other, such a synthetic fibre composite, low cost and their potential across a wide range of applications. Much effort has gone into increasing their mechanical performance to extend the capabilities and applications of this group of material. This review aims to provide an overview of the factors that affect the mechanical performance of natural fibre composites.

INDEX TERMS
Natural fibre composite (NFC)

INTRODUCTION

1 Introduction

Now a days we are interested in natural fibre composite because of many reasons including to replace synthetic fibre reinforced plastics at lower cost with improved sustainability.

1.1 Main Factor Affecting mechanical properties on natural fibre:

1) fibre selection – including type, harvest time, extraction method, aspect ratio, treatment and fibre content,
2) matrix selection,
3) interfacial strength,
4) fibre dispersion
5) fibre orientation,
6) composite manufacturing process and
7) porosity.

1.2 Advantages

1) Low density and high specific strength ad stiffness.
2) Fibres are a renewable resource, for which production requires little energy, involves CO2 absorption, whilst returning oxygen to the environment
3) Fibres can be produced at lower cost than synthetic fibre
4) Low hazard manufacturing processes
5) Low emission of toxic fumes when subjected to heat and during incineration at end of life
6) Less abrasive damage to processing equipment compared with that for synthetic fibre composites

1.3 Disadvantage:

1) Lower durability than for synthetic fibre composites, but can be improved considerably with treatment
2) High moisture absorption, which results in swelling
3) Lower strength, in particular impact strength compared to synthetic fibre composites
4) Greater variability of properties
5) Lower processing temperatures limiting matrix options

1.4 Factor affecting to natural fibre:

In natural fibre there is so many types, wood, sisal, hemp, coconut, cotton, kenaf, flax, jute, abaca, banana leaf fibres, bamboo, wheat straw and There are six basic types of natural fibres. They are classified as follows: bast fibres (jute, flax, hemp, ramie and kenaf), leaf fibres (abaca, sisal and pineapple), seed fibres (coir, cotton and kapok), core fibres (kenaf, hemp and jute), grass and reed fibres (wheat, corn and rice) and all other types (wood and roots). woven fabrics, or as loops in knitted fabrics the lower its reinforcing ability.
Yazan Alrefaei1; Khaldoun Rahal2; and Mohamed Maalej3 they says In reports [1] the results of an experimental investigation of the shear behaviour of beams made using hybrid fibre–engineered cementitious composites (HFECC). The paper specifically deals with the shear behaviour of beams made using strain hardening engineered cementitious composites that incorporate relatively low volume ratios (Vf ≤2%) of discontinuous, randomly distributed hybrid fibres (steel and polyethylene) and how the strain hardening characteristics of the fibre composite impact the shear behaviour of the beam. Beams reinforced with longitudinal steel bars and with various combinations of polyethylene (PE) and steel (ST) fibres were tested in a three-point loading setup at a shear span to depth ratio of 3. The total volume fraction of the fibres in the composites ranged from 0 to 2%, and the matrix was either cementitious paste or cementitious mortar. It is shown that HFECC made using cementitious paste was effective in increasing the shear strength by up to 8 times relative to the non-fibrous matrix. In addition, the ductility, multiple cracking behaviour, and shear strain capacity of the beams were considerably improved. Improvements were also observed in the HFECC beams made with cementitious mortar but to a lesser extent, in which the shear strength increased up to 3 times relative to the non-fibrous matrix. The results also showed that when used in HFECC, the PE fibres were nearly as effective as steel fibres in increasing the shear strength. The addition of fibres allowed the beams to reach or exceed their calculated flexural capacity in spite of the relatively large longitudinal reinforcement ratio used. A fibre volume of 1% is shown to be an adequate minimum shear reinforcement for beams with compressive strengths ranging from 40 to 65 MPa, irrespective of the hybridization ratio and the binding matrix.

<table>
<thead>
<tr>
<th>Fibre</th>
<th>Density (g/cm³)</th>
<th>Elongation (%)</th>
<th>Tensile Strength (MPa)</th>
<th>Young’s Modulus (GPa)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cotton</td>
<td>1.5-1.6</td>
<td>3-10</td>
<td>287-597</td>
<td>5.5-12.6</td>
</tr>
<tr>
<td>Jute</td>
<td>1.3-1.46</td>
<td>1.5-1.8</td>
<td>393-800</td>
<td>10-30</td>
</tr>
<tr>
<td>Flux</td>
<td>1.4-1.5</td>
<td>1.2-3.2</td>
<td>345-1500</td>
<td>27.6-80</td>
</tr>
<tr>
<td>Ramie</td>
<td>1.5</td>
<td>2-3.8</td>
<td>220-938</td>
<td>44-128</td>
</tr>
<tr>
<td>Sisal</td>
<td>1.33-1.5</td>
<td>2-14</td>
<td>400-700</td>
<td>9-38</td>
</tr>
<tr>
<td>Coir</td>
<td>1.2</td>
<td>15-30</td>
<td>175-220</td>
<td>4-6</td>
</tr>
<tr>
<td>Softwood Kraft</td>
<td>1.5</td>
<td>-</td>
<td>1000</td>
<td>40</td>
</tr>
<tr>
<td>E-glass</td>
<td>2.5</td>
<td>2.5-3</td>
<td>2000-3500</td>
<td>70</td>
</tr>
<tr>
<td>S-glass</td>
<td>2.5</td>
<td>2.8</td>
<td>4570</td>
<td>86</td>
</tr>
<tr>
<td>Aramide (Normal)</td>
<td>1.4</td>
<td>3.3-3.7</td>
<td>3000-3150</td>
<td>63-67</td>
</tr>
<tr>
<td>Carbon (Standard)</td>
<td>1.4</td>
<td>1.4-1.8</td>
<td>4000</td>
<td>230-240</td>
</tr>
<tr>
<td>Hemp</td>
<td>1.48</td>
<td>1.6</td>
<td>550-900</td>
<td>70</td>
</tr>
</tbody>
</table>

And they conclude that the use of hybrid fibre–ECC enhanced the shear strength, multiple cracking behaviour, and deflection capacity of the fibrous beams compared with nonfibrous counterparts and the use of hybrid fibres in the cementitious paste matrix was effective in increasing the
shear strength by 5–8 times relative to the nonfibrous matrix. In general, the resistance of the (strain hardening) cementitious paste fibrous beams exceeded the calculated flexural capacities. This was not achieved in the beams made with the cementitious mortar, highlighting the significance of strain hardening behaviour of the fibrous composite.

Nithin Sudarsanan1; Sunil Ranjan Mohapatra, Ph.D.2; Rajagopal Karpurapu, Ph.D.3; and Veeraragavan Amirthalingam, Ph.D. [2]

They says that Reflective cracking is a major phenomenon leading to premature failure of fresh asphalt overlays. Application of a geosynthetic interlayer system to retard reflective crack propagation is a well-known technique. However, this method often fails because of debonding or inadequate interaction between the asphalt and the geosynthetic. Some of the natural geotextiles (jute and coir) have good mechanical properties comparable with those of synthetic paving fabrics.

And hence can be advantageously considered in overlay application.

Farhad Aslani, M.ASCE1; Junbo Sun2; and Guanqi Huang3[3]

they says that A new kind of Self-compacting concrete (SCC), called self-compacting rubberized concrete (SCRC), is developed when crumb-rubber aggregates from waste tires are blended with different fractions in SCC to replace part of traditional aggregates; this developed SCRC achieves a better economic benefit and recycling of wasted tires. Meanwhile, polypropylene and steel fibres are also used in SCRC to improve the mechanical properties, especially at elevated temperatures. In this study, eight polypropylene and steel-fibre-reinforced SCRC mixture designs were produced. Slump-flow and J-ring experiments (NWGTs) was due to the asphalt bonding among the randomly oriented fibres. In addition, the layers of fibre web were also bound together with asphalt impregnation. The ultimate rupture strength of OGs decreased by nearly 30% due to the presence of asphalt. The surface texture of fibres in the yarns got smoother due to asphalt, leading to slippage during the test, thereby reducing the strength mobilization. Jute nonwoven geotextile (JWGTs) have shown improvement in ultimate strength by approximately 1.8 times. The enhanced integrity through asphalt bonding between the yarns in MD and XMD resulted in stiffening of the geotextile. The addition of asphalt enhanced the ductile behaviour of the different geosynthetics. The effect was observed as an increase.

**Fig no.3.1 Retard reflection cracking**

**Fig no.3.2 Mechanism of tensile behaviour under asphalt impregnation:** (a) randomly oriented fibres in NWGT; (b) bitumen-impregnated NWGT; (c) representative view of weaving pattern in WGT; (d) sectional view of coil fibres in a yarn; (e) bitumen-coated coil fibres in a yarn; (f) cross section of WGT; (g) cross section of bitumen-impregnated WGT.
were performed to investigate the properties of fresh SCRC (flow ability, flow speed, filling ability, and passing ability). The mechanical properties of hardened SCRC (compressive strength, tensile strength, and modulus of elasticity) after 28 days of curing were also tested. In addition, high-temperature resistance for SCRC is measured as the essential performance parameter, including mass loss, spalling distribution, and residual mechanical performance at 100°C, 300°C, and 600°C. The 0.25% optimum fibre ratio for polypropylene fibre and the 0.75% optimum steel-fibre ratio in SCRC were determined to obtain high-temperature resistance for hardened and fresh SCRC.

And they conclude that in PP- and steel-fibre-reinforced SCRC mixtures with increase in fibre ratio. The increase in PP- and steel-fibre ratios significantly improved tensile strength; however, it reduced compressive strength compared with the control mixture. The 0.25% fibre ratio for both PP- and steel-fibre-reinforced SCRC mixtures had the lowest mass loss value. The average mass loss of the steel-fibre-reinforced SCRC mixtures was higher than the value of the PP-fibre-reinforced SCRC mixtures. The residual compressive strength decreased with the increase in temperature. The 0.1% and 0.2% fibre ratios for the PP fibre-reinforced SCRC mixtures resulted in higher residual compressive strength at 600°C heating. The 0.25% and 0.75% steel-fibre-reinforced SCRC mixtures exhibited better residual compressive strength and have reached the peak value after heating and increased ductile performance. The 0.25% PP-fibre-reinforced SCRC mixture exhibited the highest tensile strength, residual tensile strength at 600°C, lowest mass loss at 300°C, limited spalling, and plastic behaviour in failure mode. In addition, the 0.75% steel-fibre-reinforced SCRC mixture was found to have the highest modulus of elasticity, lowest mass loss at 600°C, considerable residual compressive and tensile strengths, good spalling performance, and plastic behaviour in the post failure phase. The optimum fibre ratio was 0.25% for PP fibre and 0.75% for steel fibre to obtain balanced fresh property, hardened property, and high temperature resistance.

Sutapa Deb1; Nilanjan Mitra2; Swati Maitra3; and Subhashish Basu Majumdar4

they evaluate cementitious mortar reinforced with natural fibres (jute) and synthetic (polypropylene) fibres is carried out in this article with respect to mechanical response and life cycle cost estimation. Uniaxial direct tensile and flexural strength of the composites made with jute fibres were higher than those of the polypropylene fibres, whereas the tensile strain and flexural displacement were higher for the polypropylene-based composites, which is in accordance with the response behaviour of individual fibres. A combination of these fibres also demonstrated an improvement in strength as well as ductility characteristics, especially with regard to tension and flexure.

**PULL OUT TEST**

Demonstrates the single fibre pull-out test results for both the JFs and PPFs and illustrates the bond characteristics of the fibres with the cementitious composite material.
THE GRAPHICAL RESULT IS

1.2 SINGLE FIBER PULL OUT TEST

Uniaxial direct tensile tests are carried out using dog-bone-shaped specimens (gauge length = 60 mm, with 30 mm at bridge, and thickness 13 mm), as shown in Fig. 5(a). A dog-bone-shaped test specimen was used in the Japan Society of Civil Engineers test (Japan Society of Civil Engineers 2008), where the ends of the test specimen had an enlarged width to provide a higher bond area.
Experimental test setups for (a) uniaxial direct tensile test; and (b) four-point bending test.

Fig no.5.5.

for the steel plates used to lock the specimen to the tensile testing apparatus. The decrease in the width of the central region concentrated the stress and was perfect for limiting the location of crack development. The test was performed on a servo hydraulic universal testing machine (UTM) of capacity 5 kN. The load was applied at a constant rate of 1 mm/min, and specimen deformations were observed and recorded continuously.

They conclude that the mechanical properties of JFs and PPFs demonstrate that, though the strength of JFs exceeded that of PPFs, the ductility of PPFs was better than that of JFs. Pull-out tests of fibres from cementitious composites demonstrated that polypropylene had a better bonding energy compared to jute, even though the bond strengths of both fibres are almost identical. The addition of JF and PPF contributed to improvements in the mechanical performance of cementitious composites, especially with regard to ductility in tension and flexure compared to the cementitious samples with no fibre reinforcements. Higher tensile and flexural strength was demonstrated for JF-reinforced samples compared to PPF-reinforced samples, whereas with respect to ductility, the polypropylene samples showed better performance. The elastic moduli of the PPF-reinforced samples were lower than those of the JF-reinforced samples.

5. Conclusion :-

Much research and progress has occurred in recent decades in the mechanical performance of NFCs. Improvement has occurred due to improved fibre selection, extraction, treatment and interfacial engineering as well as composite processing. This paper has reviewed the research that has focussed on improving strength, stiffness, tensile stress and shear stress and including the effect of temperature and weight. Natural fibre composite now compared favourably polymers in terms of stiffness and cost. As the natural fibre has the lower density, lower cost, better and easily available. Applications of Natural Fibre composite have extended dramatically including load bearing and outdoor applications such as automotive exterior underfloor panelling, sports equipment and marine structures. Further research is still required to extend their application range including improvement of moisture resistance and fire retardance. Overall, growth of NFC uptake continues at a rapid rate and there would appear to be a very positive future ahead for their application.

Acknowledgement:-

The authors would like to thank Asst Prof. M P Bauskar and Prathamesh Choudhary for their support in producing this review.

Result:-

By reading all this stuff I get that increase in PP- and steel-fibre ratios significantly improved tensile strength; however, it reduced compressive strength compared with the control mixture. The increase in wide-width tensile strength of asphalt-coated Non-woven Geotextiles (NWGTs) was due to the asphalt bonding among the randomly oriented fibres. In addition, the layers of fibre web were also bound together with asphalt impregnation, the use of hybrid fibre–ECC enhanced the shear strength, multiple cracking behaviour, and deflection capacity of the fibrous beams compared with non-fibrous counterparts. And many more by serving this I get that woven fabrics, or as loops in knitted fabrics, the lower its reinforcing ability. The hydrophilic nature of natural fibres influences the mechanical properties. By impregnated in resins and honeys with salt to prolong their useful life and many more that’s the point I get from review.

Reference:-

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2) Use of Natural Geotextiles to Retard Reflection Cracking in Highway Pavements
3) Mechanical Behaviour of Fibre-Reinforced Self-Compacting Rubberized Concrete Exposed to Elevated Temperatures
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Recent Trends and development in Hybrid Composites

Prathmesh S Choudhary1, Manoj P Bauskar2 and Rushikesh Bhasme3

1Dept. of Mechanical Engineering, All India ShriShivaji Memorial Society’s College of Engineering, Kennedy Road, Pune, Maharashtra, India, 411001
2Dept. of Mechanical Engineering, All India ShriShivaji Memorial Society’s College of Engineering, Kennedy Road, Pune, Maharashtra, India, 411001
3Dept. of Mechanical Engineering, All India ShriShivaji Memorial Society’s College of Engineering, Kennedy Road, Pune, Maharashtra, India, 411001

ABSTRACT

The paper reviews about the recent developments on the hybrid composites. Different types of natural and synthetic fibre composites will be analysed. The main aim of using a hybrid composite material is to increase the strength to weight ratio and also increases the life of the component made. Composites which intended to evaluate the performance of these materials into circumstance in loading and impact characteristic, moreover the development for future potential as new hybrid composite fibre materials from the natural/synthetic fibres reinforced composite material in employing of high-performance.

INDEX TERMS

Fibre Reinforced thermoplastic, Bamboo, banana fibre, Kevlar, Natural fibre reinforcement, Hybrid thermoplastics.

1 INTRODUCTION

In today’s era the life & weight to strength factor matter a lot. The conventional materials have a limited life. The recyclability is also an important factor considering environment. The hybrid composites can also provide multiple mechanical & chemical properties in single component. Thermoplastic Hybrid composites are the ones which have the potential to satisfy above factors.

Hybridization of thermoplastics with the synthetic and natural fibres gives it an advantage to enhance itself according to application. The hybrid composite that contains two or more types of fibre will beneficially complement with what is deficient in the other. The hybrid composite strength depends upon the properties of the fibre content, length of distinct fibres, fibres orientation, fibre to matrix bonding and fibres sequence arrangement of both the fibres. The failure strain of individual fibres will justify the strength of the hybrid composite and highly strain compatible fibres will determine the maximum hybrid results. Consequently, the concern for major applications in composites structural is the reduction in the cost of production and factor in the weight-to-strength are the main reason researchers are exploring the possibility of using hybrid synthetic and natural fibres.

2 LITRATURE SURVEY

There are various types of new technologies are being used for the development of composite ties. Different types of material compositions are being used to develop advance composite ties. This section discusses the different classifications based on the amount, length and orientation of fibres in composite railway sleepers that are currently available and including technologies that are still in the research and development stage. The combination of a thermoplastic, Glass reinforcement fibre (E-Glass or S-glass), Natural and synthetic fibres can become a hybrid composite. Variation in composition will give us variety of composites.

![Figure 1: Shows Laminate of Two Hybrid composite](image_url)

In the study by Thomas [3] of hybrid compounds, he has specified commonly one of these hybrid composites is inorganic and the other one organic in nature. Thus, the constituents of traditional composites exhibit in macroscopic level, which leads to homogeneous material characteristics in concerning the two original phases or new properties. Therefore, the hybrid composite
can be classified into properties of the mixture in a regular or random manner, the sandwich as core-shell, laminate/layering layer, and reinforcement.

High fibre content and less bubbles highly related to the easiness of resin to flow (viscosity) and density of fibre on layer A, namely S-glass or E-glass. In vacuum infusion, the resin was transferred from the top (E-glass) to bottom layer (S-glass or E-glass). The higher of fibre density used on layer A and B, the more difficult the resin for wetting all the fibres. As the top layer always used E-glass which less density than S-glass, the wettability of resin on this layer for infusion process would be better.

Thermoplastic are recyclable and solve our problem with plastic disposal. They are non-corrosive have good weatherability. Carbon black and be used in thermoplastic to make it radiation resistant. Thermoplastics can be fibereinforcement and with hybridization they can improve the composite properties. There are thermoplastics which have good flexural, Tensile and Impact strength can be used in various applications.

3 HYBRID COMPOSITES

Table 1 Categorisation mechanical Properties & Manufacturing process of hybrid composites.

<table>
<thead>
<tr>
<th>Hybrid composite</th>
<th>Flexural strength (MPa)</th>
<th>Tensile strength (MPa)</th>
<th>Manufacturing Process</th>
</tr>
</thead>
<tbody>
<tr>
<td>Banana &amp; Glass (50%), Polypropylene(70%)</td>
<td>17.5</td>
<td>34</td>
<td>Hand lay up method</td>
</tr>
<tr>
<td>Sisal, Glass (50%),Polyester (70%)</td>
<td>99</td>
<td>140</td>
<td>Hand layed followed by compression moulding</td>
</tr>
<tr>
<td>Aramid,HDPE</td>
<td>167</td>
<td>280</td>
<td>Stiring, deying, comparsion</td>
</tr>
<tr>
<td>Carbon ,St.Fiber, Boron</td>
<td>230</td>
<td>300</td>
<td>Hand lay up followed by Compression</td>
</tr>
</tbody>
</table>

Mechanical properties of hybrid fibre reinforced polymer matrix compositethe bamboo/GF-reinforced polymer composites Moe et al. investigated the mechanical properties of randomly oriented short bamboo/GF-reinforced PP composites. The percentage improvement of tensile strength after treated with MAPP fibres composites was 5.7% compared to untreated fibres composites as shown in Table 2. Similarly the tensile modulus, flexural strength and modulus have been increased to 8.3%, 23.5% and 32.3%, respectively. Carlo Santulli40 investigated the impact properties of bamboo/GFs-reinforced unsaturated polyester composites with bamboo fibre of 6.2% and GF of 18.8% weight content of 25% total fibre content. The maximum impact strength of 32 kJ/m2 was obtained. The PALF/GF-reinforced polymer composites Mishra et al[15]. investigated the tensile properties of nonwoven PALF/GF mats-reinforced polyester composites with varying GF content of 25% total fibre content as shown in . The maximum tensile and flexural strength was obtained at 8.6% and 12.3% weight content of GF in the hybrid composites. Also the higher impact strength was obtained at 12% weight content of GF.

4 3.1 The banana fibre reinforced :-

Polyester composites Thiruchirimbaalam et al.[8] investigated the woven mat and randomly oriented banana/kenaf fiber polyester based hybrid composites with 10% alkaline and sodium lauryl sulphate-treated fibers. The maximum tensile and flexural strength was found at 40% volume fraction of woven hybrid fiber composites. The mechanical properties were studied based on ASTM standards. The sodium laurylsulphate treatment improves the mechanical properties in both random mix and woven mix hybrid composites.

Pothan et al.[15] analysed the role of fibre/matrix interaction on the dynamic mechanical properties with chemical modification on the surface. In their observation they found that there are two peak values for loss modulus curve and damping curve around 80 0 C and 1300C, respectively. The peaks around 1300C are associated with the glass transition temperature ‘Tg’ of the matrix and that around 800C is due to the transition of interlayer. Further they also studied the static and dynamic mechanical properties of banana and glass fibre reinforced polyester composites. The composites were prepared in woven form and it was found that high tensile strength can be obtained using two layers of fabric, and four layers of fabric shows two peaks and one shoulder. Increasing the number of layers made the second relaxation peak visible. Damping values are found to be lowered by the incorporation of more layers.
3.2 The sisal fibre reinforced polymer composites :-
Maya Jacob et al.[9] investigated the mechanical properties of sisal/oil palm fiber reinforced hybrid rubber composites with various fiber loading, ratio and treatment. The mechanical properties of longitudinal direction were higher than transverse direction. The adhesion between the rubber/fiber was improved by the addition of aresorcinol-hexamethylenetetramine bonding system. Similarly, of chemically (sodiumhydroxide and differentsilane coupling) treated sisal fiber reinforced natural rubber green composites. The tensile strength and hardness of 4% sodium hydroxide treated fibers composites are superior than other concentration like 0.5, 1, 2 and 8%, respectively. This composite had higher tensile strength in longitudinal and transverse directions.

3.3 Aramid ,HDPE :-
According to Edison E.Haro at el [7] Hybrid bio-composites are developed for use in protective Armor through positive hybridization offered by reinforcement of high-density polyethylene (HDPE) with Kevlar short fibres and palm wood micro-fillers. The manufacturing process involved a combination of extrusion and compression moulding techniques. The Young modulus was found to increase as the weight fraction of organic micro-particles increased. However, the flexural strength decreased with increasing weight fraction of added micro-fillers.

3.4 The carbon/SiC fibre/boron fibre reinforced composites:-
Wang Mingchao et al.[11] investigated the compressive and flexural properties of Carbon/SiC fiber/boron reinforced epoxy composites. The maximum compressive strength of 991MPa was obtained for SiC FRP compared to other combination composites. The maximum flexural strength and modulus of 2096MPa and 221.3GPa was obtained for SiC FRP at fiber volume fraction 51%.

The carbon/GF reinforced composites evaluated the response and energy absorbing capacity of hybrid composite tubes made of unidirectional carbon/GF-reinforced plastic pultruded tube overwrapped .The LS-DYNA code was used to conduct the numerical simulation of crushing behaviours of tubes subject to both quasi-static compression and axial dynamic impact loadings. From the result they have concluded that the energy absorption capacity was more for carbon fiber compared with glass fiber.

![Figure 2](image_url)

Figure 2 : Model of NR/silane-treated PALF/carbon black hybrid composite

Nuttapong Hariwongsanupa et al [5] proposed the effect of fibre surface treatment on NR/PALF/carbon black hybrid composites :- From the previous results, alkali and silane treatments of PALF could be used to improve the stress transfer between NR and PALF. Alkali treatment increased the volume fraction of fibres leading to higher surface area. Moreover, the mechanical interlocking between NR and APALF improved the modulus of composites. For silane treatment, the sulfidic bonds between NR and silane-treated PALF were formed during vulcanization, which resulted in higher tensile properties in term of modulus. However, ultimate properties i.e. tensile strength and elongation at break were reduced. To improve these ultimate properties, carbon black has been incorporated into NR/PALF composites. The model of NR/PALF/carbon black hybrid composites is shown in Figure 2. Hence, tensile properties could be improved at both low and high deformation regions.

3.5 Catalysts & fillers used :-
Filler like aresorcinol-hexamethylenetetramine, Sodium laurylsulphate, micro fillers, alkali fillers, CaCO3 etc help to increment of mechanical properties and bonding. Catalysts like NaOH treatment, MPAA, Acetylation play an important role during the chemical reaction while fibre manufacturing.
3.6 Water Absorption

Alexander et al.[12] showed that flax fiber absorbed less water compared to untreated GFA-green and RFA-retted fibers. This was due to change in wax content because of the chemical treatment of fiber increased negative potentials. The green natural fibers (flax as well as hemp) are less hydrophilic due to high amount of waxes on their surfaces.

Figure 3 : Water absorption percentage verses hybrid fibres.

3.7 Thermal Properties

Boopalan et al.[13] investigated the thermal properties of hybrid raw jute/banana fiber reinforced epoxy composites with varying fiber weight ratio of 100/0, 75/25, 50/50, 25/75 and 0/100, respectively, with varying temperatures using thermo gravimetric analysis (TGA) and heat deflection temperature (HDT) analysis. In TGA curves it was shown that 50% jute and 50% banana fiber reinforced epoxy hybrid composite had higher thermal stability and the degradation temperature was shifted from 200 C to 380 C.

4 MANUFACTURING TECHNIQUES OF COMPOSITE

Basically composite material is classified in three types [14]:-

1. Metal Matrix Composites (MMCs)

Mixtures of ceramics and metals, such as cemented carbides.
Aluminium or magnesium reinforced by strong, high stiffness fibres.

2. Ceramic Matrix Composites (CMCs)
Aluminium oxide and silicon carbide are materials that can be imbedded with fibres for improved properties, especially in high temperature applications.

3. Polymer Matrix Composites (PMCs)
Thermosetting resins are the most widely used polymers in PMCs. Epoxy and polyester are commonly mixed with fibre reinforcement.

As in case of composite sleepers the polymer matrix composites (PMCs) is used widely for manufacturing and in practical applications.

There are different techniques for manufacturing of a Hybrid fiber reinforced composite.

1) Hand Lay wraping method
2) Comporession molding
3) Injection molding
4) Pultrution mehtod
5) Thermofroming

The best process among these is the Compression molding process as low cost tooling, good for small and large production runs, no gates sprues , do not change the properties of te fibers.

Figure 4 : Compression Moulding process for making Hybrid fiber reinforced thermoplastic.

5. CHALLENGES OF HYBRID COMPOSITES [14]
The hybrid composites with fiber reinforcement are difficult to manufacture as pressure and temperature are an important factor while producing hybrid composites. If pressure and temperature are not properly maintained, the properties of the composite change. Hence, hybrid composites have a complex process of manufacturing. Due to the complex manufacturing process, the cost of production is also high. Skilled labor is required. Hence, results in a high cost of composite.

5.1 Creep Deformation:
Permanent deformation due to creep, the rate of which depends on the magnitude and duration of the stress and the temperature at which the load is applied. Because of the effect of creep, the composite might fail in deformation. These effects may reduce the service life of a hybrid composite.

5.2 Formations of voids in Materials:
During the manufacturing process of hybrid composite, there is a high possibility of voids being formed inside the materials. When in-service, voids can break and transfer stresses from one part to others which creates a stress concentration and later leads to local failure of a sleeper before the end of its design life.

5.3 Fracture:
Some hybrid composites might undergo small cracks or fracture during or after fastener installation, particularly when using screw spikes. This effect has been most often observed to be related to the fastener installation method (e.g., continuous ram-driven versus hand impact-driven methods) (i.e., size and depth of a pre-drill).

6. FUTURE PROSPECTS

Figure 5: Hybrid fiber reinforced thermoplastics.

Hybrid reinforced composites are a new technology compared to the conventional metal composites. They have high weight to strength ratio. They can be used as a car’s body, steering column, helicopter blades, railway sleepers, etc. As thermoplastics are present in it which are recyclable and have good mechanical properties. They have no impact on the environment and thus have a scope in the future. The electric vehicles with can be built with such composites and can improve in performance. Other applications where weight is a major factor, the conventional material can be replaced with hybrid fiber composites.

7. CONCLUSION
The exorbitant maintenance costs and environmental problems of conventional materials and alloy materials. The Hybrid composites are non-toxic in nature and recyclable in nature. They have complex manufacturing processes involved. Creep effect and the fracture might produce voids which may affect the properties and life expectancy. Cost of hybrid reinforced composite is higher. But they solve our problem of plastic disposal. If manufactured with no errors, they can provide long-term life and performance with good strength and less weight. They are crashworthy. The addition of additives increases the impact strength and also protects from UV radiation (carbon black). The only disadvantage of natural reinforced hybrid fibers is water absorption factor. The addition of carbon fibers increases the strength of the hybrid fiber more than any of the other fibers. Comparison between different fibers also been done which compares the flexural and tensile strength of the composite. The Hybrid composite is slowly becoming a future material.

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AUTHORS

Mr. Prathamesh S Choudhary

T.E Mechanical Sandwich

All India Shri Shivaji Memorial Society’s

College of Engineering, Pune-411027.

Memberships:

SAE (Society of Automotive Engineers )

INDIA Membership

Prof. Manoj P Bauskar

Assistant Professor M P Bauskar

ME Mechanical Engineering ,

DEPARTMENT OF MECHANICAL ENGINEERING, AISSMSCOE,PUNE- 01

Mr . Rushikesh Bhasme

S.E Mechanical Sandwich All India Shri Shivaji Memorial Society’s

College of Engineering, Pune-411027
ABSTRACT

These Hybrid vehicle (i.e. IC engine and Electric energy) or Dual energy supply running vehicles are not so strange to us. Also this system is much eco-friendly and more effective for the transportation system in developing countries. This technology is a growing one now. But to overcome the increasing prices of fossil fuels, we will have to shift our conventional IC engine vehicle to electric one.

This paper is essentially targeted on developing a battery operated electric powered vehicle system which would be more surrounding friendly and zero fuel overwhelming. The system will normally use electric energy and will store it in battery pack. There are so many methods to recharge the battery like solar system or induction charging but here we are dealing with plug-in charging or wired charging at home or at charging station if any. Our centre of interest is mainly on common passenger vehicle running in Metro cities. How those can be transformed into environmentally safe ones for example- an auto rickshaw will be transformed into battery powered electric energy supply running vehicle. The system is theoretical and further experimentation is needed to develop it perfectly. Here the paper will explain the basic theory.

INDEX TERMS Environment friendly vehicle, battery powered electric source vehicle, plug-in charging, electric rickshaw

1. INTRODUCTION

Three wheeled conventional auto rickshaws are one of the cheapest means of private transportation in India. Three wheeled goods carrier are mostly preferred to transport small to medium loads within the city limits. According to a recent survey, there are on an average 50000 auto rickshaws in tier 1 cities (cities having more than 4 million population). In the financial year 2016-2017, almost 4,02,034 passenger three wheelers (8.83% drop from 2006-07) and 1,09,624 commercial three wheelers (12.75% hike from 2006-2007) were sold [1]. So it is thus clear that the three wheelers will not be out of service any time in the near future in the country. In our modified Electric Auto Rickshaw, the motor, controller and battery are the most important components as per the economic and environmental point of view. The conventional Auto Rickshaw requires more power to cover the same distance which is been covered by Electric Auto Rickshaw. Also the conventional Auto Rickshaw has 35% overall efficiency while the electric Auto Rickshaw has average 60% greater efficiency in comparison. In this work the standard design of conventional Auto Rickshaw is modified to battery powered electrical vehicle. The speed, time, economic range, pollution, power consumption are the main working parameters are under study.

Gurkaynak et al. [2] has proposed a completely unique photovoltaic-battery (PV- Battery) hybrid all-electric rickshaw especially for the Indian demand. In this proposal, the battery can be charged by solar energy using PV array and the electric powers which are flowing from a PV array are controlled using a boost type converter in order that the PV cells operate at their most effective point. Also the power which is flowing from battery is maintained by bidirectional buck-boost convertor so as to control a fixed convertor output voltage. By this proposed topology the auto rickshaws can be operated more effectively and with almost zero emission.

Alam et al. [3] analysed and designed an existing Bajaj auto rickshaw as per the requirements. He has used Hydrogen Fuel cell which is environmentally safe power source. But the limitation of Fuel cell is its durability and cost. Further he did a brief economic and environmental analysis for the proposed vehicle by calculating the payback period. This Fuel cell powered vehicle can be further implemented in the longer run on general existing vehicles; thus getting freedom from fossil fuels. His research believes that there is better future for Hydrogen
Fuel cell in environmental as well as costing aspect subject to commercial production.

Pattar et al. [4] in his paper presented a correct methodology for retrofitting electric powertrain instead of conventional IC engine power train in three wheeler rickshaw. He has developed and tested a three wheeler driving cycle for Bangalore city with various traffic conditions. In the Entrepreneurial Projects Program held at Illinois Institute of Technology.

Mulhall et al [5] has explained importance of Solar and Battery Hybrid Three-Wheel Auto Rickshaw for India. This paper gives slight inter look into the research types empowered by the researcher team during different semesters of the project and the outcomes of this research. The motto of this program was for new start-up ventures and also the parallel development of eco-friendly carrier transportation was attracted to this solar/battery prototype vehicle. The whole analysis gives a guideline to future development in vehicles and infrastructure.

Mohammed Abu Mallouh et al [6] compared ICE and hybrid fuel cell rickshaw configuration using a realistic drive cycle. The model of an IC Engine and hybrid fuel cell rickshaw were created and tested using the Power train System Analysis Toolkit (PSAT) software. Among the two drive cycles that would closely match the true demands on a rickshaw running in an urban surrounding were developed in order to simulate the performance more accurately for conventional and fuel cell hybrid rickshaws for the purpose of determining the current feasibility of fuel cells used in rickshaws.

Avijit Mallik et al [7] has discovered a newer transportation way based upon rickshaws that works in an eco-friendly way. Here, he substituted the existing vehicle by a micro cross type system redesigned in order to boost the efficiency of the vehicle. In addition, he has proposed a recharging infrastructure that will allow for the battery-packs to be charged using partly alternative energy such as solar power. The output of his research presented in this paper is to develop a much compact, robust and affordable hybrid power system as a way to significantly reducing fuel consumption and emission of auto-rickshaws.

In this paper, Sreejith R. et al [8] has mentioned basic guidelines for choosing the specific motor and battery as per the required application. To do so, he has simulated an Electric three-wheeler with all possible parameters to a acid and lithium-ion batteries powered Electric three-wheeler has been mentioned.

Necolus Shaha et al [9] has proposed the rickshaw which is based on duel energy storage system that operates in an eco-friendly way. The main source of power of his proposed electric auto rickshaw is battery and the battery bank is recharged either by the on-board plug in battery charger and/or the PV solar panel.

In this presented paper, B. Sateesh et al [10] has designed control system for the development of electric car brushless DC motor and also the numerical analysis is performed. The results illustrated that the BLDC motor had good controllability and suitable for the application to the electric car.

In this paper, Rounak Mehta et al [11] investigated some of the challenges of converting conventional internal combustion engine powered auto-rickshaw to an electric auto rickshaw.

2. MODIFIED DESIGN DETAILS OF E-AUTO RICKSHAW MODEL

In conventional Auto Rickshaw, the IC engine is a prime mover whereas BLDC motor is the main part in electric motor which rotates the wheels.

![Simple Schematic Diagram of proposed Auto Rickshaw.](image)

The battery pack is the main source of energy. The battery always delivers the power to BLDC motor through the controller. The schematic diagram is as shown above. The battery is charged by external medium with the plug in
charging in home garage or in office parking lot. The battery power is given to BLDC motor which passes through controller connections. The motor is connected on rear axle of auto rickshaw such that the power is distributed to both the wheels in best manner. In simple, when vehicle is on charging mode, Electrical charge is accumulated to the battery (i.e. energy storage device). Battery power rotates the motor shaft. Further the motor rotates the rear axle and finally the wheel of the rickshaw rotates.

A. Component and it’s specification for Auto Rickshaw

<table>
<thead>
<tr>
<th>Components</th>
<th>Specifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Motor</td>
<td>2 kW BLDC, 48v, 3000 rpm</td>
</tr>
<tr>
<td>Battery</td>
<td>48 V, 200Ah VRLA deep cycle</td>
</tr>
<tr>
<td>Controller</td>
<td>2 kW, 48 V, 3000 rpm</td>
</tr>
</tbody>
</table>

The components which are selected for the conversion and their specifications are mentioned in Table I. Unlike other state-of-the-art running electric vehicle conversions, the important selection of the two key components, the battery pack and the motor, was quite different here. Instead of choosing the most expensive Li-Ion batteries and Induction motor, Valve Regulated Deep Discharge Lead Acid batteries and Brushless DC (BLDC) motor were chosen. These choices were affected primarily by the cost and availability of the components.

a. Batteries

A market survey of selected vendors and manufacturers of some of the electrical components revealed that commercial deep discharge Li-Ion batteries are yet to make an impact in the Indian market. The traditional lead acid batteries attract an advantage both in terms of cost and availability, with a good number of Indian manufacturers which produces a wide range of lead acid batteries. Moreover, the additional cost of replacement of batteries every three years is not financially affordable for Li-ion batteries. Thus, available Valve Regulated Lead Acid (VRLA) or Sealed Leak Proof batteries were ideal option for the conversion.

b. Motor

The reason to use DC motor is that, the DC motors can produce high starting torque. However, selection of BLDC or PMDC was little difficult. As in case with Li-ion batteries, earlier days BLDC motors find few producers in India due to requirement of strong rare Earth magnets which need to be imported, but now a days BLDC motor are easily available in Indian market because of its Brushless operations. On the other hand, PMDC motors enjoy widespread acceptance with a good number of manufacturers and easily available spare parts in India, but the PMDC has a permanent brush which is again friction producing and heat generating factor. Hence, a BLDC motor was the ideal choice for this work.

B. DESIGN PROTOTYPE AND IMPLEMENTATION
The motor is to be connected to the rear wheels through a differential mechanism. As the auto rickshaw has differential, we will use retain the existing differential. So the cost will reduce. Also we will not use the separate motor for each wheel, as it is going to cost more.

The engine, gear and differential of an existing conventional auto rickshaw are enclosed in a single raw while the earlier IC engine could be removed. The allowed implementation of different gear ratios is for availing different parameters during the testing stages. A chain was used to transmit the power from the motor to the gear shaft.

3. CALCULATIONS

The proposed vehicle will run depending upon time, environmental factors, road condition mainly. Considering all these factors the vehicle electrical power will be used separately to keep the vehicle running.

Known Data:

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gross vehicle weight</td>
<td>820 kg (310 Kerb wt. + 220 battery wt+280 (3+1)+10 Luggage)</td>
</tr>
<tr>
<td>Max. vehicle speed</td>
<td>40 kmph (11.11 m/s)</td>
</tr>
<tr>
<td>Wheel Diameter</td>
<td>466.8 mm (90/90-12 54J)</td>
</tr>
<tr>
<td>Overall vehicle weight</td>
<td>1300mm</td>
</tr>
<tr>
<td>Vehicle height</td>
<td>1700mm</td>
</tr>
</tbody>
</table>

Known Data:

Gross vehicle weight= 820kg (310 Kerb+ 220 battery +280 (3+1) +10 Luggage)
Vehicle speed= 40 kmph
Wheel diameter= 46.68 cm (90/90-12 54J)
Width= 1300 mm
Height= 1700 mm
Velocity= wheel radius * angular velocity
i.e. v = r \times \omega

Therefore, 40000/60 (m/min)= .2334 (m) *\omega

so, \omega = 2856.32 \text{ rad/min}

but \omega = 2 \times \pi \times N

so N = 454.6 \text{ rpm} \………………………(1)

now, power = [(m \text{ in kg})(\text{acc. Due to gravity})(\text{vel})(Rr)]

+ [(\text{air density})(\text{Cd})(\text{frontal area})(\text{velocity})^3]

= [820 \times 9.81 \times 11.11 \times .01] + [.6465 \times .5 \times 2.21

\times 11.113]

=893.71 + 979.955

=1873.66 \text{ watts} \…………………………(2)

Now, Motor efficiency, \varepsilon = \frac{P_{out}}{P_{max}} \text{ (}\varepsilon=90\%\text{)}

P_{max}=P_{out}/\varepsilon

=1874/.9

=2082.2 \text{ watts}

But P_{max} = \tau \times \omega = \tau (2 \times 3.14 \times 455)/60 \text{———(from eq.1)}

\tau = 2082.2 / 47.647

So \tau = 43.7 \text{ Nm} \text{———(3)}

So final values are

Power = 2082.2 \text{ watt &}

Torque = 43.7 \text{ Nm}

But speed = 40 kmph

So 2082.2/40 = 52.1 Wh/Km

Above calculated value is Wh power required per Km

And our battery specifications are

12 \times 200 \text{ Ah}

So it will produce 2400 Wh

As We are using 4 batteries of such specs in series

So total power generated = 9600 Wh

So usable battery pack= 9600*8*.55(\text{Peukerts value for LA battery})

=4224 Wh

So 4224/52.1 = 81.07\approx 81 \text{ km}

Range=81 \text{ Km with single charge}

4. RESULT AND DISCUSSION

A. Fuel economy

As the vehicle range is 81 km, it means the Auto will run 2 hours a day when charged fully. Now, the total power generated in battery is 9600 to 10000 Wh.

In Maharashtra, The average power tariff is around 8 rupees per kWh.

So, To charge the battery pack it will take (8*10)=80 Rs for the battery to charge fully

And now let's do the same calculations for IC engine driven conventional Auto Rickshaw.

Typical speed of an auto rickshaw is approximately 40 km/hour.

In 2 hours it covers = 40*2=80 km

Fuel consumption of an auto rickshaw is approximately 20km/litre.

So, To run 80 km, Auto needs = (80/20) = 4 litre petrol. In Maharashtra, The average cost of 1 litre of petrol is 78 Rs.

So, Conventional Auto Rickshaw will take (78*4)=312 Rs This prototype of electrification of conventional IC engine

Driven vehicle is not only more environment safe but also much more economical to everyone’s pocket.

5. Theoretical And Actual Result

<table>
<thead>
<tr>
<th>Velocity (m/s)</th>
<th>Battery wt (kg)</th>
<th>GVW (kg)</th>
<th>Usable Battery Power (Watt)</th>
<th>Range Theoretical (km)</th>
<th>Actual (km)</th>
</tr>
</thead>
<tbody>
<tr>
<td>112</td>
<td>712</td>
<td>2112</td>
<td>43</td>
<td>32</td>
<td></td>
</tr>
<tr>
<td>160</td>
<td>760</td>
<td>3168</td>
<td>63</td>
<td>51</td>
<td></td>
</tr>
<tr>
<td>220</td>
<td>820</td>
<td>4224</td>
<td>81</td>
<td>73</td>
<td></td>
</tr>
</tbody>
</table>
6. FUTURE WORK

A major hindrance to large-scale implementation of EVs employing lead acid/ Li ion battery technology has the long charging time (almost 6-8 hours for present case)

A battery swapping technique can be promising solution to the problem.

Development of rapid charging stations at every 25 km.

7. CONCLUSION

For much more efficient operation of auto rickshaws which are commonly used for transportation in India and so many other countries, a battery operated electric power system is proposed. In order to test the performance of the proposed topology, the individual components such as battery, where its charging and discharging results, total range calculations at full given weight is been taken into considerations.

For Indian urban drive cycle, for auto rickshaws are developed and integrated which suggests that the proposed system is much more affordable once introduced into the market. For this system we will have to pay fewer amounts than the conventional fuel powered engine. The results verified the suitability of the proposed system for sudden load changes, based on the performed situation, varying load, time of testing, road conditions. The auto rickshaws can be operated more efficiently and with zero emission by using the proposed battery operated vehicle topology. The topology can be further extended in future by using PV array for simultaneous charging of battery while vehicle is running. PV array also allows the vehicle to charge the battery even if the vehicle is parked or though it is on stand still position whether in parking or in traffic.

REFERENCES


Omkar N Bhandare has completed bachelor’s degree in Mechanical Engineering and now pursuing Master’s degree in Automotive Technology from AISMMs COE Pune. The working prototype of electric Auto Rickshaw is made under guidance of Dr. A.V. Waghmare. With support from Engineering Cluster Pune.

Dr. A. V. Waghmare is an Associate Professor in AISMMs COE Pune. He has awarded Ph.D. in Thermal Engineering from Kolhapur university. He has published 7 papers and has presented in several conferences. He has taken more than 22 trainings in different organizations.
Retrofitting of profile projector for non-contact type of measurement

Rutuja A. Badve¹, Nisha R. Kolekar², Ankita H. Adsule³, Dr. Anand K. Bewoor
¹Dept. of Mechanical Engineering, MKSSS’s Cummins College of Engineering For Women, Savitribai Phule University, Pune-411052, India
²Dept. of Mechanical Engineering, MKSSS’s Cummins College of Engineering For Women, Savitribai Phule University, Pune-411052, India
³Dept. of Mechanical Engineering, MKSSS’s Cummins College of Engineering For Women, Savitribai Phule University, Pune-411052, India

ABSTRACT

The paper suggest a way of turning an opto-mechanical instrument profile projector into digital profile projector by retrofitting an adjustment on the profile projector. The paper presents a method of non-contact type of measurement by using image processing.

INDEX TERMS
Image processing, non-contact type measurement, Profile projector.

1. INTRODUCTION

This paper presents a new method for the determining the dimensions of object on profile projector using image processing. By using this method it will be more accurate, less time consuming for measuring dimension perspective for the operator and will also increase the reliability of the results. No method has been yet proposed for such non-contact type of measurement using profile projector. This method is of great help in quality control section in industries.

In conventional profile projector micrometre is used to measure the dimensions of the object. It is time consuming as well as it leads to human error. By this new method for the measurement on profile projector, accuracy will be enhanced; time consumption will be reduced and will also increase the reliability of the results irrespective of operator.

INDEX TERMS
Image processing, non-contact type measurement, Profile projector.

2. DESCRIPTION

A. METHODOLOGY

In general, an enlarged image is captured by camera which is then processed and dimensions of the object are obtained. Further the detailed flow of process will be as:

- Place object on the profile projector
- Enlarged image on screen
- Take picture of the enlarged image by camera
- Send the picture to Raspberry pi where code will be uploaded
- Image processing by the code
- Display of dimension on the screen (Ex.-laptop, computer screen, electronic display)
3. RESULTS

Images of the output:

This figure shows dimensions of a small washer.
Such type of direct dimensions of a regular shape object can be obtained by this method.

4. APPLICATIONS

1. Such type of methods can be used for direct dimensions measurement of a regular shape object.
2. This method can be used to detect whether object is within permissible limit of error or not.
3. Such method can also tell us relative errors in the manufactured component with respect to standard component required.
4. This method has great application in the quality control section of industry.

5. CONCLUSION

This method has so many advantages over convention method of measurement using profile projector

1. This method is cheap. In market digital profile projector costs in the range of 2 to 4 lakhs. But profile projector costs below 1 lakhs and retrofitting to this existing profile projector wouldn’t cost more than 10000. So, we can get direct measurement of an object at much reduced cost of equipment.
2. This method is more accurate compared to conventional method of profile projector.
3. Also as it doesn’t include human error it is more reliable irrespective of operator.
4. Reduction in the time consumption is also another advantage of this method.

ACKNOWLEDGEMENT
This present work is done under the guidance of faculty members of Cummins College, and funded by Cummins College of Engineering, Pune. I would like to express our sincere gratitude to them.

REFERENCES:

Design and Development of Multipurpose spraying and Weeding Machine for Agriculture

Nagesh S. Kendre1, Akash Pradhan2, Punam R. Khemnar 3, Jyotsna R. Mandlik4, Prof. Anup Chapale5


ABSTRACT

However the technology grows the earth revolves; agriculture is always the back bone of economic system. Agriculture was a past, Agriculture is present Agriculture is future. Our country is an Agriculture land 60% of people belong to agricultural background. Our country`s social economic benefits come from Agriculture. Any technology should come up any future plan should come out with taking care of agriculture. Adoption of modern irrigation and agriculture technologies is essential to increase the productivity of farming land but Experts say excessive use of chemical and fertilizers over time has degraded soil fertility in India.

India is a land of agriculture. Small, marginal, medium and rich farmers are there in India. Generally Small scale farmers use to traditional way that is spray carry on backpack because of its versatility, cost and design. But this type of sprayer can cause back pain. It has some disadvantages like it cannot maintain required pressure. However this equipment can also lead to inappropriate use of chemicals and ineffective control of target pest which leads to loss of pesticides due to dribbling or drift during working. This phenomenon not only increases the cost of production but also cause environmental contamination and ecological imbalance in natural system. This paper suggests a model of manually operated multi nozzle pesticides sprayer pump which will perform spraying in minimum time at maximum rate. The principles of motion of trolley which transmit its rotary motion from chain and sprocket arrangement and reciprocating piston into the cylinder for pumping the pesticides which is used to the manually operated organic fertilizers cum pesticides sprayer.

INDEX TERMS
cost, effort, time, mechanical energy, multi nozzle.

1. INTRODUCTION

In Agricultural sector use of cheap and beneficial equipment for effective weeding and spraying for increase productivity which is very important for better contribution for India’s GDP. Indian farmers are not using effective methods for farming. So we have to make machines that can help them to save time and cost to increase the productivity of land and profit. Generally knapsack sprayer comes with drawback of back pain and exertion of the user due to heavy weight and manual operation. Manual operated pump generate uneven pressure inside the cylinder which causes of uneven spraying.

This paper recommends a model of manually operated multi nozzle pesticides sprayer pump which will perform spraying in minimum time at maximum rate. The principles of motion of trolley which transmit its rotary motion from chain and sprocket arrangement and reciprocating piston into the cylinder for pumping the pesticides which is used to the manually operated organic fertilizers cum pesticides sprayer.

2. PROBLEM STATEMENT

1) For the backpack type pesticide sprayer, user has to carry the heavy tank at the back and oscillate the lever manually by hand that required more efforts.

2) Fuel operated spray pump, which is weighty than hand operated backpack pump. Also the pump produces more vibrations which are dangerous to users back muscles, these pump makes undesirable noise.

3) Moreover, while spraying very small area is covered. So, more time is consumed to spray the entire land.

4) More contact with pesticides cause health problem.

5) There is need for development of effective spraying and weeding machine for increasing productivity of land.

3. OBJECTIVE
1) To reduce human efforts due to the constant pumping action for creating pressure inside the pesticide sprayer and thereby provide suitable environment for the user reducing the fatigue load acting on the body.

2) To reduce the overall handling time for agricultural sprayer.

3) Multi nozzles are used and hence large area of field can be spread at a faster rate.

4) Making such a machine can perform weeding and spraying flexibly.

5) Save the machining time, labour cost, and operational cost.

6) Machine can be used in small farming land (5 acre).

4. METHODOLOGY

Data collection would be done by literature survey, user study and market questionnaires, videos and observation etc. then select the concept which one is economical. Then the study of research papers on online used to find the appropriate method. Then design the frame and all parts.

5. LITERATURE SURVEY

M.G.Jadha, Prof.J.K.Sawale presented Design and Fabrication of Manually Operated Weeder with Pesticides Sprayer. Principles of motion of trolley which transmit its rotary motion from chain and sprocket arrangement and reciprocating piston into the cylinder for pumping the pesticides which is used to the manually operated organic fertilizers cum pesticides sprayer [1].

Vishakha Bodke, Mahesh Gaikwad, Pratibha Patil, Karan Pawar, Prof. Firdos J. Khan This paper is about Multipurpose Manually Operated Automatic Spraying and Fertilizer Throwing Machine. This paper is about the model of manually operated multi nozzle pesticides sprayer pump which will perform spraying at maximum rate in minimum time. In electrical battery operated spray pump manually operated lever for spraying pesticides. In push operated spray pump a one trolley is there in which especially mechanism for translating rotary motion into reciprocating motion this reciprocating motion used to operate the pump lever. This lever operates pump increase the pressure of pesticides and pesticides will be sprayed. [2]

Dhiraj N. Kumbhare, Vishal Singh, Prashik Waghmare, Altaf Ansari, Vikas Tiwari, Prof. R.D. Gorle. This paper is about fabrication of automatic pesticides spraying machine. According to idea of their project, they are making a small 4 wheel kart or vehicle which is electronically operated by a wireless remote which runs on power source as a DC battery. At centre of vehicle there is one vertical arm is attached and one horizontal arm at top of the vertical arm. To spray pesticides both the sides’ nozzle is fitted to these arms. As more no of nozzle are there hence spraying is done rapidly and time and money is saved. [3]

Anupam Moon, Amar Wairagade, Chaitanya Kakade, Nikhil Pathak, Rahul Moreshiya, Vijay Giradkar. This project is carried out for the agricultural purpose which used for Design & Fabrication of Pesticide Spraying Machine. The manually operated multipoint sprayer pump is worked by operating a pedal lever by the operator. The spray liquid is kept in bucket or container and it is sucked by
a suction hose through a filter (strainer) due to piston movement used in the bicycle. [4]

B Dhirhagat makes a paper of Design, Development and Fabrication of Manually Operated Multi nozzle Pesticide Sprayer Pump and Seed Sowing Equipment. They have implemented some mechanical sprayers and seed sowing equipment getting powered by human effort. However these are fulfilling the purpose, their working range is not enough. They take considerably larger time for spraying and seed sowing. Thus what they have aimed is to design such a technology which will run on mechanical power but requiring less time for spraying and seed sowing than those which are hand operated. Thus considering today’s demand, they have come up with mechanically operated multipurpose spray pump and seed sowing equipment. As it has huge advantages so this concept should be used in agriculture. [5]

Mane Deshmukh Vijay, Bhoir Nilesh, Ghade Tushar, Patange Anand Prepared paper of design and fabrication of agriculture weeder. In this work their team made agricultural equipment which is useful for farmer, this equipment is known as weeder cycle. In India most of people are farmer. For doing fieldwork maximum human power is used, but some present year’s needs of workers are necessary but availability of workers is less for field work. So they made rotor adjustment cycle. These weeder cycle is designed by using inverter software. These weeder cycles will remove grass between two rows. It will remove multiple grasses in less time, so work will more complicated in less time. Therefore less workers are required for remove grass. [6]

Anurag Dwivedi, Ankush Doltade, Sarthak Lahane, Prof.Amol bhagat. In this paper we studied Design and Development of Solar powered Weeding machine. This paper focuses on the various techniques used for weeding purpose for agricultural implants which have a scope to be used in future. Various types of papers have been reviewed on solar powered weeder in this paper. [7]

6. CONSTRUCTION

A. THE MAIN COMPONENTS OF AGRICULTURAL RECIPROCATING MULTI SPRAYER AND WEEDER MACHINE ARE AS FOLLOWS:

1) SPROCKET- The name 'sprocket' applies generally to any wheel upon which radial projections engage a chain passing over it. It is differentiate from a gear in that sprockets are never meshed together directly, and differs from a pulley in that sprockets have teeth and pulleys are smooth. We use freewheel and chain wheel for chain and sprocket arrangement.

2) CHAIN- The chain is made of steel. The purpose of chain is to transmit power from gear sprocket to pinion sprocket, and it has a no sleep.

3) CRANK- Crank is used to transfer motion from prime mover to the connecting rod for further operation. Here the eccentric circular disc which use to convert rotary motion of crank into reciprocating/linear motion of connecting rod.

4) CONNECTING ROD- The main function of connecting rod is to convert rotary motion into reciprocating/linear motion. Here connecting rod converts rotary motion of crank to reciprocating motion of pump and extension rod.

5) PUMP- It consists of piston and cylinder arrangement, it has a lever to operate the motion of piston in reciprocating direction. The pump generates the pressure of 2 bar and discharge of 2 lpm.

6) NOZZLE - It is a device which converts the pressure energy of fluid into kinetic energy; spray
nozzle is a precision device that facilitates dispersion of liquid into a spray. Nozzle is used for purpose to distribute a liquid over an area.

7) WHEEL- Wheel is used to transfer the whole assembly and move machine from one place to another by rotary motion of it. A bicycle wheel is a wheel, most commonly a wire wheel, designed for a bicycle. Bicycle wheel is designed to fit into the frame and fork via drop outs, and hold bicycle tyre. A typical modern wheel has a metal hub, wire tension spokes and a metal or carbon fibre rim which holds a pneumatic rubber tire. We use a tubeless tire wheel.

8) FRAME- The main function of frame is to carry whole assembly on it so it must be rugged enough to hold it. The frame is made of square pipe and it is made of mild steel.

9) TANK- We wants our tank to carry as much fluid as it can be along with its self-weight as less as possible. We have taken a tank which is almost 16 litre capacity. A material for tank used is plastic fibre. Plastic fibre is very low in weight as compared to other materials. It also has very low cost.

7. WORKING OF MACHINE
- Motion transmission by chain and sprockets arrangement.
- Crank-connecting rod mechanism.
- Rotary motion converted into reciprocating motion.

Weeder is added to the machine for weeding. We can remove pesticide tank and it for weeding process. As per our requirement we can separately use weeder or sprayer.

8. DESIGN AND CALCULATIONS
1) SELECTION OF WHEEL
   i. Distance between two plants is 1 feet
   ii. = 30.43 cm.
   iii. The diameter of wheel = 30 cm
   iv. Use wheel - tubeless tyre

2) PUMP SELECTION
   i. Reciprocating pump – (pressure range 2-3 bar)
   ii. Discharge – 2 lit/min.
   iii. Pump discharge per stroke = 0.1 lit

3) NOZZLE
   i. Number of nozzle -6
   ii. Nozzle diameter – 0.28 mm
   iii. Discharge of per nozzle -0.33 lit/min.
   iv. Nozzle pressure -1.5 to 2 bar
   v. Total discharge of nozzle=6*0.33
4) SPROCKET CALCULATION.
   i. Number of teeth on sprocket toothed wheel, 
   ii. \( Z1 = 42 \),
   iii. \( Z2 = 18 \),
   iv. Pitch = 12.7 mm.
   v. Speed reduction = 1:3.
   vi. Centre distance between two
   vii. Sprocket wheel = 30 cm.

5) CONNECTING ROD
   i. Height = 350 mm.

6) FRAME
   i. Diameter = 15 mm.
   ii. Total Frame Length = 700 mm.
   iii. Width of Frame = 150 mm.

7) TANK
   i. Capacity = 16 lit
   ii. Length = 300 mm
   iii. Width = 140 mm
   iv. Height = 380 mm

8) CHAIN
   i. Use chain type = roller chain type
   ii. Length of chain
   iii. \( = \frac{(2\times(300/12.7)) + (60/2) + (24/2\pi)\times(12.7/300)}{12.7} \times 12.7 \)
   iv. \( = 1367 \text{ mm} \)

9) WEEDER (RAKE)
   i. Length = 320 mm

9. APPLICATION

1) For the insecticides application to control insect pests on crops and in stores, houses, kitchen, poultry farms, barns, etc.
2) For the fungicides and bactericides application to control the plant diseases.
3) For the herbicides application, to kill the weeds.
4) For the harmony sprays application to increase the fruit set or to prevent the premature dropping of fruits.
5) For the application of plant nutria foliar spray.

10. CONCLUSION

1) Any fuel or power is not required in this type of machine so maintenance is also less.
2) In suggested model there is no need to carry the tank (pesticides tank) on the back so it has removed the problem of back pain.
3) As suggested model has multiple nozzles which will cover maximum area of spraying in minimum time and at maximum rate.
4) Muscular pain issues are eliminated and there is no need to operate the lever manually by hand.
5) This alone pump can used for various crops.
6) It is modified design of manually operated weeder and sprayer which will be useful for small land farmers. It utilize less time and cost effective as compared with conventional spraying and weeding.
7) It does spraying and weeding simultaneously and that of conventional does separately. So this requires less time.

REFERENCES

DESIGN AND MANUFACTURING OF CONVEYOR SYSTEM FOR QUALITY ANALYSIS OF GEAR BY USING IMAGE PROCESSING

Vyankatesh Chavan¹, Snehal Jadhav², Patil Omkar³, Devidas Chintle⁴, Prof. R. S. Thombre⁵

¹,²,³,⁴Student, Department of Mechanical Engineering, Dr. D. Y. Patil School of Engineering & Technology, Pune
⁵Asst. Professor, Department of Mechanical Engineering, Dr. D. Y. Patil School of Engineering & Technology, Pune

ABSTRACT

The present work is concerned with design and manufacturing of conveyor used for quality analysis by using image processing. The objective of the work was to reduce the time, manpower. In this project, gear measurement has been carried out by focusing on two features of the gear image object. The problems are to measure the gear features of the gear image object, in the sense the measurement of the area of the gear image object and as well as the teeth of the gear will be counted. We have used MATLAB tool and development code which overcome these problems and measured the area as well as teeth of the gear image object counted. To accomplish this task we have measured five different gear image objects area and counted the teeth by using image processing.

Gear defects are a major reason for poor quality and of embarrassment for manufacturers. Inspection processes done on these industries are mostly manual and time consuming. To reduce error on identifying gear defects requires more automotive and accurate inspection process. Considering this lacking, this research implements a Gear Defect Recognizer which uses computer vision methodology with the combination of local thresholding to identify possible defects. The recognizer identifies the gear defects within economical cost and produces less error prone inspection system in real time.

In order to generate data set, primarily the recognizer captures digital gear images by image acquisition device and converts the RGB images into binary images by restoration process and local threshold techniques. Later, the outputs of the processed image are the area of the faulty portion and compute the possible defective and non-defective gear as an output.

INDEX TERMS: Machine Vision Image Processing; Dimension Measurement, Defect Detection, Image Processing, Computer Vision, Thresholding, Counting Number of Teeth’s.

1. INTRODUCTION

Gear is a widely used mechanical component whose primary use is to transmit power from one shaft to other. These gears are of many types namely spur gear, helical gears, worm gears etc.

Gear drives are used to various kinds of machines like automobiles, metal cutting tools, material handling equipment, rolling mills, marine power plants etc. The friction and other losses in this type of power transmission equipment are comparatively very low.

In this work we use a software called “MATLAB” to determine gear parameters. MATLAB is extensively used for scientific & research purposes. It is accurate & also has a number of built in functions which makes it versatile. The program is a user friendly one & when executed it ask the inputs and performs the necessary design calculations and gives necessary output values. As computers are used to perform the task of gear design becomes simple, friendly & error free.

In this world of fast paced computation where resources with time and money/capital are very important the activities in manufacturing and processing industries are day by day being performed by computers, algorithms and computing agents replacing human or semi-human
intervention. Here in the industries that require gears the filtering and classification of gears is very important and is done by human labour, precisely human labour is limited to its way of working and the time, cost required. Classification can be done with the use of imaging devices, Cameras and scanners with developing an algorithm that describes what to accept and reject.

Computer science image processing technology is gradually becoming a part of our daily life as it continues to get excellent results while promoting the technological advancement and development. As the key role of technology that presents gear size and measurement and guides to do research and develop more advanced computer technologies, such as DSP (digital signal processing) technology, and DIP (digital image processing) technology. We will measure the image object features easily by using these technologies.

### 2. PROBLEM STATEMENT

When we manufacture a lot of gear at a time it is not possible to check a dimension and profile of each and every gear. At that time we used sampling process in which for a lot of 100 gears only first and last gear check and thus we conclude that the whole lot is error free. But at the customer end sometime they find an error in the gear thus the whole lot gets rejected and this results in heavy losses to the gear manufacturer. Sometime using these faulty gears results into the accidents of system in which they use.

### 3. LITERATURE SURVEY

Gear Measurement has been carried out by focusing two features of gear image object. The problems are to measure the gear features of gear image object, in the sense the measurement of the Area of the gear image object and as well the teeth of the gear will be counted. We have used MATLAB tool and development code which overcome these problems and measured the area as well as teeth of the gear image object counted. To accomplish this task we have measured five different gear image objects area and counted the teeth by using image processing.

The gear Area calculated and teeth counted by using image processing in the MATLAB tool. This paper having the five gears image objects which are processed from developed MATLAB code, all gear image objects found having different value of area and varying teeth with another. These have been measured through the

Same developed MATLAB code. In this paper each experimental work figure of different gear objects measured with the help of MATLAB tool by using image processing. [1]

Gear defects are a major reason for poor quality and of embarrassment for manufacturers. Inspection processes done on these industries are mostly manual and time consuming. To reduce error on identifying gear defects requires more automotive and accurate inspection process. Considering this lacking, this research implements a Gear Defect Recognizer which uses computer vision methodology with the combination of local thresholding to identify possible defects. The recognizer identifies the gear defects within economical cost and produces less error prone inspection system in real time. In order to generate data set, primarily the recognizer captures digital gear images by image acquisition device and converts the RGB images into binary images by restoration process and local threshold techniques. Later, the outputs of the processed image are the area of the faulty portion and compute the possible defective and non-defective gear as an output. [2]

Gear, as one key part of mechanical system, its complicated shapes and varied features makes it very difficult to make precise measurements. As we all know, the conventional contact method is a tedious and labour-intensive work by measuring tool. With the development of industry, it gradually cannot meet the need of industrial production. Therefore, new method is urgently required to substitute the existing means.

Machine vision, with the aid of image processing technology, is a vast field of science and engineering, where the image can be anything from a continent to a nano particle. Since 1980’s, the theoretical framework in computer vision proposed by Marr, aroused the concern of many scientist and engineer to investigate. However, in the industry many machine vision applications are inspection tasks where the position, orientation or dimension of a feature is measured. Compared to traditional contact methods, noncontact measurement using vision systems offers a number of advantages: accurate measurements can be achieved from thin or soft parts, as the technique is neither invasive nor destructive. Quality control and real time feedback can be readily integrated into the manufacturing process. [3]

### 4. PROPOSE SYSTEM

The gear parameters are calculated and teeth counted by using image processing in the MATLAB tool. Computer is the main unit of the project. The I/O devices are connected across the parallel port of computer. Image processing is
any form of signal processing for which the input is an image, such as a photograph or video frame; the output of image processing may be either an image or, a set of characteristics or parameters related to the image. Most image-processing techniques involve treating the image as a two-dimensional signal and applying standard signal-processing techniques to it. Two rollers are mounted according to the required distance; the belt is mounted on the rollers on which the Gear is placed. The rollers shaft is coupled with the Motor drive hence when power is supplied to the motor rollers rotate with a certain time delay according to the Motor drive and the belt moves along the rollers. Thus material handling is carried out. With help of the Motor drive the time delay can be achieved. Initially Motor conveyor is stationary, Gear is kept on conveyor belt and the gear image is captured by the camera which is fixed at the top of the setup. The captured image is sent to the computer. MATLAB algorithm read image and processes with the help of image processing and results are displayed on command window of MATLAB.
Selected piece (right gear) is collected in a separate tray and the rejected piece (wrong gear) is collected in another tray with the help of dc gun motor. A pushing rod is mounted in front of the dc gun with help of hinge and spring arrangement. When the dc gun extends it pushes the plate hence the work piece in front is also pushed and collected in the tray. When the dc gun is retracted the plate also comes back to its position with help of spring.

5. METHODOLOGY

The methodology is followed to measure the gear image object by using image processing in scientific tool MATLAB. For to accomplish this task, we have developed the code by which a gear image object Area has been measured and teeth have been counted. The flow chart is given below.

6. RESULT

To see the qualitatively as well as quantitatively performance of the proposed algorithm, some experiments are conducted on several coloured and Gray scale images.
The effectiveness of the approach has been justified using different images. The results are computed qualitatively (visually) as well as quantitatively using quality measures.

7. APPLICATION

- Applicable in nut, gear manufacturing industries.
- Applicable in Quality Control departments.
- Industrial applications such as production inspection, sorting.
- Automatic character recognition such as zip code, bar code, licence plate recognition etc.
- Computerized photography.
- Space image recognition.
- Remote sensing e.g. aerial and satellite image interpretations.
- Medical/Biological image processing e.g. X-ray images, blood/cellular microscope images.

8. CONCLUSION

The gear Area calculated and teeth counted by using image processing in the MATLAB tool. This having the five gear image objects which are processed from developed MATLAB code, all gear image objects found having different value of area and varying teeth with another. These have been measured through the same developed MATLAB code. Gear objects can be measured with the help of MATLAB tool by using image processing.

Digital image processing processes and evaluates images through computer with particular algorithm. In future image processing techniques can been applied in various fields with great achievement. Digital image processing can divide into: image transformation, image intensification and restoration, image segmentation, image analysis, image recognition and other technique branches. MATLAB as
one kind of high-level computer language, it has a powerful data processing ability that obtains widely application in digital image processing.

With use of MATLAB and Image processing technology gear inspection is achieved in less time. It has applications in other fields such as applicable in nut, gear manufacturing industries, applicable in Quality Control departments, can be applied in gear manufacturing unit, can be used in automobile industry, used in automobile industry, used in both small scale industries as well as the large scale industries, All kinds of circular components can the tested.

We conclude that image processing technology can be effectively useful in manufacturing industries, automobile industries, space, medical and biological study, remote sensing, computerized photography etc.

9. FUTURE SCOPE

- Applicable in nut, gear manufacturing industries.
- Applicable in quality control departments in industries, etc.
- Can be applied in gear manufacturing unit.
- Used in automobile industry.
- Total error checking is done
- Used in both small scale industries as well as the large scale industries
- Its outcome can be utilized properly to a great executed in mechanical field as well as the automobile field.
- Cost of checking the error is less
- Specified to all kinds of gear.
- All kinds of circular components can the tested.
- In automobile industries.
- In hospitals.

REFERENCES


Fused Deposition Modelling Process Parameter Optimization Using Desirability Approach

Suhas Dadaso Patil¹, Second B. Puja Vishnu Thore², Third C. Abhishek Dodamani³ and Fourth D. Rachna More⁴

¹Dept. of Mechanical Engineering, D.Y. Patil College Of Engineering, Akurdi, Pune, Maharashtra, India, 411044
²Dept. of Mechanical Engineering, D.Y. Patil College Of Engineering, Akurdi, Pune, Maharashtra, India, 411044
³Dept. of Mechanical Engineering, D.Y. Patil College Of Engineering, Akurdi, Pune, Maharashtra, India, 411044
⁴Dept. of Mechanical Engineering, D.Y. Patil College Of Engineering, Akurdi, Pune, Maharashtra, India, 411044

ABSTRACT

Additive manufacturing has attracted increasing attention worldwide, especially in the healthcare, biomedical, aerospace, and construction industries. In Malaysia, insufficient acceptance of this technology by local industries has resulted in a call for government and local practitioners to promulgate the development of this technology for various industries, particularly for biomedical products. The current study intends to frame the challenges endured by biomedical industries who use 3D printing technology for their manufacturing processes. Qualitative methods, particularly in-depth interviews, were used to identify the challenges faced by manufacturing firms when producing 3D printed biomedical products. This work was able to identify twelve key challenges when deploying additive manufacturing in biomedical products and these include issues related to binder selection, poor mechanical properties, low-dimensional accuracy, high levels of powder agglomeration, nozzle size, distribution size, limited choice of materials, texture and colour, lifespan of materials, customization of fit and design, layer height, and, lastly, build-failure. Furthermore, there are six challenges in the management of manufacturing biomedical products using 3D printing technology, and these include staff re-education, product pricing, limited guidelines, cyber-security issues, marketing, and patents and copyright. This study discusses the reality faced by 3D printing players when producing biomedical products in Malaysia, and presents a primary reference for practitioners in other developing countries.

1. INTRODUCTION

Fused Deposition Modelling is an additive manufacturing process in which an object is created directly from a computer aided design (CAD) using layer by layer deposition material extruded through a nozzle. Due to its safe and efficient operation, durability, low cost and its ability to process high quality thermoplastics, it have become one of the most widely used additive manufacturing processes in industries for prototypes and low volume production. The mechanical properties of the FDM components should meet the loading conditions and operational requirements. The properties obtained should be comparable to that of the conventional manufacturing techniques such as injection moulding. In order to print an object according to the desired properties using FDM process, a good knowledge of the effect of process parameters on the mechanical properties is necessary. The main production parameters that affects the mechanical behaviour of FDM fabricated components are print speed, layer height, build orientation, extrusion temperature, infill percentage, infill pattern and raster angle.

2. METHODOLOGY

- Study of Fused Deposition Modelling and Its Process Parameters.
- Modelling and Slicing of The Part to Be Built
- One Variable At A Time Approach.
- Effect Of Individual Parameters On Mechanical Properties.
- Design Of Experiments.
- Effect Of Combination Of Process Parameters On Mechanical Properties

Validations.

3. MODELING OF TEST SPECIMENS AS PER ASTM STANDARDS

The material used to create the specimen is Poly-lactic acid(PLA) which is commonly used for FDM processed
parts. Uniaxial tensile test, Charpy impact test, bending test and surface roughness tester were used to determine the tensile strength, impact strength, flexural strength and surface roughness of the specimens. Designing of the part and converting it into STL file was done in CATIA software and was further sliced into machine readable g-code file using cure engine of repeater software. The dimension of the tensile specimens was 63.5 x 9.53 x 3.2 mm which are according to ASTM D638 standards. The dimensions of impact specimens were 63 x 12.7 x 3.2 mm which are according to ASTM D256 standards. The dimensions of flexural specimens were 125 x 12.7 x 3.2 mm which is according to ASTM D790 standards’ samples were created using reality Ender 3 machine having bed size 220 x 220 x 250 mm.

4. ONE VARIABLE AT A TIME APPROACH

Initially, the effect of individual parameters on the mechanical properties were determined. The specimens were fabricated by changing only one parameter and keeping other parameters constant.

<table>
<thead>
<tr>
<th>Process Parameter</th>
<th>Constant Value</th>
<th>Variable Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Infill Percentage (%)</td>
<td>50</td>
<td>10,33,55,78,100</td>
</tr>
<tr>
<td>Print Speed (mm/s)</td>
<td>50</td>
<td>20,35,50,65,80</td>
</tr>
</tbody>
</table>
5. DESIRABILITY APPROACH

Using RSM desirability approach, the best parameter settings were found out to obtain the optimum values of all of the mechanical properties considered. It has been found that to obtain optimum tensile strength, the infill percentage, layer height, print speed and extrusion temperature should be 100%, 0.0962mm, 20mm/sec and 230°C respectively. Optimum Impact strength can be obtained if, the infill percentage, layer height, print speed and extrusion temperature is 69.5909%, 0.08mm, 20mm/sec and 200.5051°C respectively. To obtain optimum Flexural strength, the infill percentage, layer height, print speed and extrusion temperature should be set at 100%, 0.2416mm, 52.1212mm/sec and 202.9293°C respectively. Similarly, optimum surface roughness can be obtained only if the infill percentage, layer height, print speed and extrusion temperature are set at 43.22%, 0.0962mm, 20mm/sec and 230°C respectively.

6. CONCLUSION

This work presents the measured value of impact, flexural strength and surface roughness properties of 3D printed specimens. The influence of process parameters such as infill percentage, print speed, extrusion temperature and layer height on the mechanical properties of parts have been antiliberals’ analysis of the combination of different parameters on these properties have been done. Increase in extrusion temperature decreases impact strength but considerably increases flexural strength while increase in layer height increases impact as well as flexural strength.

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Flywheel Energy Application in Commercial and Agricultural Field: A typical review

Mr. Arpit V. Pardeshi¹, Prof. S. R. Kewate²
¹Dept. of Mechanical Engineering, Govt. College of Engineering, Amravati, Maharashtra, India, 412101
²Dept. of Mechanical Engineering, Govt. College of Engineering, Amravati, Maharashtra, India 412101

ABSTRACT

Storing energy has an imperative responsibility in modern years. A flywheel is a mechanical device can be considered as more established energy storage equipment that is reliable and it has various advantages. In a flywheel based machine, a flywheel stores mechanical energy more explicitly rotational energy. A flywheel used into the machinery fills in as a repository which spares energy when the energy supply is additional than need and releases when a requisite is greater than supply. This paper presents the review of storage devices for mechanical, specifically the flywheel. The different constructional details and materials for flywheel are clarified in this investigation. The different advances in the flywheel along the particular application of flywheel in the commercial as well as the agriculture field are discussed. Flywheel discovered satisfactory to overcome the various shortage because of electricity.

1. INDEX TERMS
Applications, Flywheel, Flywheel casting, Hybrid energy storage

INTRODUCTION

A system for storing energy assumes a significant role in today's world. An upcoming world without systems for storing energy is just like a computer device with no hard disc [1]. There are several energy storage devices utilized in manufacturing like battery energy storage [2], thermal energy storage [3], air energy storage (compressed) [4], energy storage system with flywheel technology and flywheel.

Flywheel which is additionally called a mechanical battery [5] might be used as a primary system of energy storage and it is the oldest of all [6]. The flywheel is utilized in machines fills in like vault, which stores when energy supply is extra than required and releases it when the necessary energy is more prominent than a requirement. Flywheels restrict adjustment in rotational speed, which helps predictable turn of a shaft during intermittent torque is applied by the capacity source, or when the discontinuous force, like a piston pump, is set on it. The function of the engine flywheel is to make a smooth transmission to wheels. In order to ensure the constant output flywheel is attached with the same link of the shaft. Whenever a shaft receives power higher than the average value then it is received and stored by flywheel for a moment.

Energy stored is corresponding to the mass and rotational velocity square of a flywheel. This can be comprehended by equations of energy (E) and moment of inertia (I) as in equations (1) & (2) [7], respectively

\[ E = \frac{1}{2} I \omega^2 \]  
\[ I = \frac{r^2 m h}{2} \]

Where, r- radius; m-mass and h-height of the flywheel.

The flywheel is generally attached at one end of the shaft in order to have uniform torque. They store energy when it is in excess and releases it when desired. Hence a Flywheel can be considered as a reservoir of energy, which gives energy at the desired time. A flywheel is needed in two types of machines, one in which the operation is intermittent. In this type of machine, the Flywheel absorbs energy from a power source during the ideal period and delivers a large amount of stored energy in a very short useful portion of the cycle. The machines of this type include press, riveting machines, etc. So it is obvious that in these machines, a large amount of energy is required during the working period for performing the operation. Without Flywheel, one should be compiled to install a motor at very high power, but during the rest of the cycle, when no energy is required, the motor will be running at no load. So by using a flywheel, a smaller power unit can be used and large power can be obtained for a shorter period.

In the second type of machine, the necessity of Flywheel is realized where torque generated is in the form of peaks and troughs (non-uniform torque), as in the case of I.C engines,
steam engines, etc. Here flywheel smoothens out the speed fluctuations caused by the non-uniform flow of power from piston during the working stroke.

When the shaft receives the varying output the whole mechanical system becomes unstable and shaft will unable to work. To ensure the constant output flywheel is attached with the same link of shaft. Whenever a shaft receives power higher than the average value then it is received and stored by flywheel for a moment. This power is disbursed when shaft receives powerless than the average power. Usually, the power, energy, and velocity all are taken analogously with each other. Flywheel absorbs kinetic energy through its inertial mean. The storing power of kinetic energy depends upon density, volume, and distribution of mass about the axis. Many papers are reviewed in this with conventional and software methods. Due to a number of models of engine and their performance in between cycles the flywheel designed today in such a way so that the total storage capacity of flywheel can be increased for given constraints. In modern days the compactness is also one of the basic needs of life that enhances the system appearance.

Flywheel has its uses in most of the areas. Figure 2 shows the common uses of a flywheel.

![Common uses of a flywheel](image)

2. MATERIALS AND METHODS

A. FLYWHEEL MATERIALS AND SHAPES

Figure 3 shows the typical cross-section of the flywheel. In this figure Do, D and dare the outside, mean and internal diameter of the rim respectively. Also, a and b are sections of the arm and width of the flywheel.

Flywheels are produced using a wide range of materials; application decides a decision of material C.I. flywheels are utilized into older steam engines. Flywheels utilized into automobiles are of C.I., st, or al. Various materials used to make the flywheel along with their significance/drawbacks are shown in Table I

![Typical cross-section of the flywheel](image)

<table>
<thead>
<tr>
<th>MATERIALS AND METHODS</th>
<th>FLYWHEEL MATERIALS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Material Specification</td>
<td>M in kJ/kg</td>
</tr>
<tr>
<td>High strength Al, Steel, Mg, and Ti Alloy</td>
<td>100 to 200</td>
</tr>
<tr>
<td>Composites: CFRP</td>
<td>200 to 500</td>
</tr>
<tr>
<td>Composites: GFRP</td>
<td>100 to 400</td>
</tr>
<tr>
<td>Beryllium</td>
<td>300</td>
</tr>
<tr>
<td>Cast Iron</td>
<td>8 to 10</td>
</tr>
<tr>
<td>Lead Alloy</td>
<td>3</td>
</tr>
</tbody>
</table>

Various materials like alloy steel, carbon steel 1065, managing steel and stainless steel are additionally utilized to make a flywheel. Within the upcoming year, increasingly, appropriate characteristics and materials will be picked to investigate that will give progressively exact outcomes and a similar strategy of materials for different uses. The fluffy number is an amount whose worth is loose. A fluffy multi-criteria choice investigation technique dependent on the ideas of perfect and against perfect focuses utilized in a numerical model of a phonetic variable.
Table II below shows calculated values for various physical values of the flywheel required for storing 250 J.

**TABLE II**

VARIOUS PHYSICAL VALUES OF THE FLYWHEEL FOR STORING 250 J

<table>
<thead>
<tr>
<th>Material</th>
<th>R</th>
<th>M</th>
<th>ω</th>
<th>q</th>
<th>η</th>
</tr>
</thead>
<tbody>
<tr>
<td>Al. Alloy</td>
<td>153</td>
<td>3.3</td>
<td>2406</td>
<td>0.0421</td>
<td>151515</td>
</tr>
<tr>
<td>C. I.</td>
<td>104</td>
<td>16.6</td>
<td>1465</td>
<td>0.0084</td>
<td>30121</td>
</tr>
<tr>
<td>Composite: CFRP</td>
<td>195</td>
<td>1.0</td>
<td>3382</td>
<td>0.1389</td>
<td>500000</td>
</tr>
<tr>
<td>Composite: GFRP</td>
<td>150</td>
<td>3.8</td>
<td>2323</td>
<td>0.0365</td>
<td>131579</td>
</tr>
<tr>
<td>Maraging steel</td>
<td>145</td>
<td>4.4</td>
<td>2218</td>
<td>0.0316</td>
<td>113636</td>
</tr>
</tbody>
</table>

Note: R- Flywheel radius in cm; M- Flywheel mass in gm; ω- Flywheel angular velocity in rpm; ϱ- Flywheel energy density in kWh/kg and η- Flywheel efficiency in J/kg.

The various shapes of the available materials for the flywheel are as shown in Table III. Disc of lavals and solid disc is made up of metals while composites are preferred to make a thick ring and thin ring. Value of shape constant (K) for disc of lavals, solid disc, thick ring, and thin ring are 1, 0.606, 0.305 and 0.50 respectively.

**Energy stored in a flywheel can be calculated as**

Rotational Kinetic Energy, $E = \frac{1}{2} I \omega^2$

where, $I$ - moment of inertia of the flywheel (ability of an object to resist changes in its rotational velocity),

$\omega$ - rotational velocity (Rad / sec)

The moment of inertia, $I = kMr^2$

where, $M$ - mass of the flywheel, $r$ - radius of flywheel, $k$ - inertial constant.

**Coefficient of fluctuation of speed (Cs) can be calculated as**

The ratio of the max fluctuation of speed to the mean speed is called coefficient of fluctuation of speed.

$Cs = \frac{(N_1 - N_2)}{N} = \frac{2(N_1 - N_2)}{N_1 + N_2}$

Where, $N_1$ - max speed in r.p.m., $N_2$ - min speed in r.p.m., $N$ = mean speed in r.p.m.

$N = \frac{(N_1 + N_2)}{2}$

### 4. STRESSES IN A FLYWHEEL RIM

The following stresses are induced in the rim.

- Tensile stress due to centrifugal force.
- Tensile bending stress caused by the restraint of the arms.

#### A. TENSILE STRESS DUE TO THE CENTRIFUGAL FORCE

The tensile stress in the rim due to the centrifugal force, assuming that the rim is unstrained by the arms, is determined in the similar way as the thin cylinder subjected to internal pressure.

$ft = \rho.R^2.\omega^2 = \rho.v^2$ ( $v = R.\omega$ )

When $\rho$ is in kg/m³, $v$ is in m/sec, $ft$ will be in N/m² where $\rho$ = density of the flywheel material, $\omega$ = angular speed of the flywheel

$R$ = mean radius of the flywheel, $v$ = linear velocity of the flywheel

---

**3. DESIGN OF FLYWHEEL**

Several parameters are need to be considered while designing a flywheel for a sustainable machine. The flywheel geometry design selection and its contribution in the energy storage performance plays key role in the sustainability of any machine. The parameters need to be considered are:

- Energy stored in a flywheel
- Co efficient of fluctuation of speed (Cs)
- Stresses in a flywheel rim
- Stresses in flywheel arms
B. TENSILE BENDING STRESS CAUSED BY RESTRAINT OF ARMS

The tensile bending stress in the rim due to the restraint of arms is based on the assumption that each portion of the rim between a pair of arms behaves like a beam fixed at both ends and uniformly loaded, such that length between fixed ends,

\[ L = \pi \cdot \frac{D}{n} = \frac{2\pi R}{n} \]

where \( n \) - number of arms

The max bending moment, \( M = \frac{w \cdot L^2}{12} = \frac{b \cdot t \cdot \rho \cdot \omega^2 \cdot R}{12} \left(\frac{2\pi R}{n}\right) \)

Section modulus, \( Z = \frac{1}{6} (b \cdot t^2) \)

So bending stress \( fb = \frac{M}{Z} = \frac{b \cdot t \cdot \rho \cdot \omega^2 \cdot R}{12} \left(\frac{2\pi R}{n}\right) \cdot \frac{6}{(b \cdot t^2)} \)

Total stress in the rim \( f = ft + fb \)

C. STRESSES IN FLYWHEEL ARMS

The following stresses are induced in the arms of the flywheel.

- Tensile stresses due to centrifugal force acting on the rim
- Bending stress due to the torque transmitted from the rim to the shaft or from the shaft to the rim.

5. RECENT ADVANCES IN A FLYWHEEL

Ha et al. considered flywheel plans comprising numerous composite shells combined with obstruction fit so as to pre-stress a composite into pressure. A group found ideal measurements for such a structure [9] and found that the subsequent plans could be scaled [10], [11]. They additionally created and displayed plans for split-type hubs [12] and composite hubs [13], the last of which has additionally been the subject of several patents [14], [15].

Authors additionally created and displayed plans for split-type centre points [16] and composite centre points [17], the last of which has additionally been the subject of a few licenses [18]. These investigations have been joined by the assembling and testing of the subsequent plans [19], approving the discoveries.

Flywheel supportive networks have likewise observed critical advances. Flywheels are generally enclosed inside the vacuum chamber to diminish aerodynamic energy misfortunes [20]. Magnetic bearings [21] have been used on fixed flywheels and propose altogether diminished friction on customary rolling bearings [22], [23].

A. COMERCIAL APPLICATION OF FLYWHEEL

A consequence of flywheel research increases day by day and the execution of business creation and model flywheels. As per Hansen and O’Kain report depicting a review of flywheel innovation as functional for versatile applications [24]. A noticeable case of versatile flywheels into hydraulic applications is the Ricardo hybrid excavator that utilizes the energy storage flywheel for recouping energy into an activity of an excavator blast [25]. The Ricardo model likewise utilizes a novel magnetic gear design [26] with promising execution [27], testing, demonstrating the advanced flywheel innovation is adequately tough for the applications of a vehicle [27]. The plan is hence being considered for use underway Volvo traveller vehicles [28].

Flywheel energy storage system has primarily two types of energy losses. A clutch is normally utilized to constrain the misfortunes of a flywheel at the time of idling. This has been demonstrated tentatively up to fundamentally decrease sitting misfortunes of the flywheel [29]. At the point, while clutch is separated, misfortunes are constrained to bearing and aerodynamic friction. At a point, while clutch is engaged, extra misfortunes are caused, incorporating those into a siphon/engine unit, a shaft packings or magnetic gears [30] and any equipping or transmission.

B. AGRICULTURAL APPLICATION OF FLYWHEEL
Several researchers used flywheel for the storage of human energy. Dr. J. P. Modak and his team have developed several machines for agricultural mechanization. Machines which was also called as a processing unit works on the pedalling unit which mainly comprises of bicycle unit and flywheel. In this pedalling unit, flywheel stores the energy which has generated by the peddler and utilizes the same for the working of various agricultural machines. The various authors like Bhatkulkar and team, Dhale and team, Ganorkar and team, Ghuge and team, Khope and team, Khope and team, Moghe and team, Nimbarte and team, Sonawane and team, Sonde and team, Undirwade and team, and Waghmare and team have been developed the process units like Nursery Fertilizer Mixer, Oil press, Water Pump, Novel Gearbox, Chaff cutting machine, Forge Cutter, Ice-cream Making Machine, Turmeric Polishing Machine, Garlic Peeling Machine, Sugar Cane Sprout Cutter Machine, Wood Chipper Cutter, Sliver cutting machine, and Stirrup Making Machine respectively.

6. RESULTS AND DISCUSSION

The various flywheel assisted machines for agricultural purpose are given below in table IV

<table>
<thead>
<tr>
<th>S.N.</th>
<th>Agricultural Machine</th>
<th>Specification/ Significance/ Limitations</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Chaff cutting machine</td>
<td>Developed chaff cutting machine to overcome uncertainty of electricity. The developed machine is worked with the help of HPFM. The machine is proper for marginal farmers having 2 to 3 cattle.</td>
<td>Khope and team. [37]-[38]</td>
</tr>
<tr>
<td>2</td>
<td>Forge Cutter</td>
<td>A newer cutter is made-up which different than other fodder cutters that will work on the non-conventional energy source. The machine runs with the help of flywheel energy.</td>
<td>Khope and team. [39]</td>
</tr>
<tr>
<td>3</td>
<td>Garlic Peeling Machine</td>
<td>Developed Garlic Peeling Machine assisted by a flywheel. The machine is cost-effective and useful for human-operated machines having intermittted working.</td>
<td>Nimbarte and team. [42]</td>
</tr>
<tr>
<td>4</td>
<td>Ice-cream Making Machine</td>
<td>Developed human-powered Ice-cream making machine assisted by a flywheel. In machine wooden having a mixture of ice and salt, where ice cream ingredients are stirred and blended with flywheel energy.</td>
<td>Khope and team. [40]</td>
</tr>
<tr>
<td>5</td>
<td>Novel Gearbox</td>
<td>Developed a novel gearbox for the HPFM. Gearbox runs smoothly with the help of flywheel.</td>
<td>Ghuge and team.[35]-[36]</td>
</tr>
<tr>
<td>6</td>
<td>Nursery Fertilizer Mixer</td>
<td>Developed human-powered nursery fertilizer mixer assisted by flywheel (HPFM). The machine is economically feasible, can be used by a normal worker and it minimizes the time.</td>
<td>Bhatkulkar and team. [31]-[32]</td>
</tr>
<tr>
<td>7</td>
<td>Oil press</td>
<td>Developed an approximate generalized data-based model by varying independent variables for an oil press. The recognized database will be helpful for lower to medium output oil press.</td>
<td>Dhale and team.[33]</td>
</tr>
<tr>
<td>8</td>
<td>Sliver cutting machine</td>
<td>Designed and developed a sliver cutting machine assisted by a flywheel. The operation of the machine is successful and highly reliable.</td>
<td>Undirwade and team.[45]-[47]</td>
</tr>
<tr>
<td>9</td>
<td>Stirrup Making Machine</td>
<td>Developed a human-powered flywheel motor for stirrup making machine. The machine is cost-effective and useful</td>
<td>Waghmare and team. [48]</td>
</tr>
</tbody>
</table>
The above machine found cost-effective, can be used for human-operated process machines having intermitted working. The efficiency of the machine finds higher at low input.

7. CONCLUSION
The energy storing system has the prospective to employ a key role in facilitating the addition of renewable resources. Numerous advantages can be gained by utilizing efficient energy storage. This paper provides a review of storage devices especially mechanical energy with the help offlywheel. The total storage capacity of flywheel gives uniformity in speed at changing loads. This factor has been considered by many authors. Energy storage is the main scope for a flywheel. Various factors affected the performance of the flywheel like material and shapes are studied. Many machines have been developed by many researchers for the agricultural purpose with a flywheel and found efficient and reliable for work.

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Process Optimization for TRB Cup Inspection Machine

Nikhil A. Shelke¹, Vaibhav S. Sathe², Pruthviraj D.Patil³, Shubham V. Kathoke⁴, Amol V. Rane⁵

¹Dept. of Mechanical Engineering, JSPM RajarshiShahu College of Engineering, Tathawade, Pune, Maharashtra, India, 411033
²Dept. of Mechanical Engineering, JSPM RajarshiShahu College of Engineering, Tathawade, Pune, Maharashtra, India, 411033
³Dept. of Mechanical Engineering, JSPM RajarshiShahu College of Engineering, Tathawade, Pune, Maharashtra, India, 411033
⁴Dept. of Mechanical Engineering, JSPM RajarshiShahu College of Engineering, Tathawade, Pune, Maharashtra, India, 411033
⁵Dept. of Mechanical Engineering, JSPM RajarshiShahu College of Engineering, Tathawade, Pune, Maharashtra, India, 411033

ABSTRACT

Inspection is a procedure to examine whether the object is as per design specification or not. In engineering activity, inspection involves the measurements, tests and gauges applied to certain characteristics in regard to an object or activity. The results are usually compared to specified standard to determine whether the item is in line with these targets often with inspection procedure in place to ensure continuous checking. Inspection may be visual inspection or involve sensing technologies such as ultrasonic testing or remotely such as remote visual inspection and automatically such as automated optical inspection. Inspection is carried out for cost reduction, time saving, improvement in existing process, scrap reduction, etc.

INDEX TERMS Keywords – TRB, Inspection, Automation, Defect.

2. MACHINE SPECIFICATION

Bearing's cup checking.
Measure- ID (Taper): within 5 µ, OD: within 3 µ, Width: within 10 µ.
Washing of the cups.
Automatic master calibration feature.
Repeatability: OD< 1 µ, Taper< 5 µ, Width < 5 µ.
Tooling Setting time < 20 minutes.
Universal measurement station, suitable for all diameter and heights within machines operating range.

In roller bearing inspection machine, we inspect outer diameter, width and inner diameter. These parameters are checked with the help of Linear Variable Differential Transducer Probe and the linear motion is obtained with the help of pneumatic cylinders arrangement.
3. WORKING PROCESS

![Machine Flow Chart]

**INLET** – Taper roller bearing is placed on conveyer for measurement.

**SPF ASSEMBLY** – It stands for Single Piece Flow Assembly. It allows to pass only one component at a time.

**CUP WASHING STATION** – This is the first station in TRB cup inspection machine. Taper roller bearing is wash completely with the help of Mineral Turpentine Oil (MTO). It is used as general cleaning solvent as it removes oils and greases from metal surfaces. This oil consist of volatile fraction derived from petroleum. The main components of the oil are paraffin, naphthenic, and aromatic hydrocarbons in different proportions.

**MEASURING STATION**-

**WIDTH MEASUREMENT** – This is the second station in TRB cup inspection machine. In this, vertical height of Cup is measure. The accuracy required is 10 micron in 20 repeatability.

**OUTER DIAMETER MEASUREMENT** – Outer Diameter is the circumferential surface of the outer race of the bearing. The OD should be surface finished since the bearing has to be assembled in a machine. The measuring range of this machine is between 50 mm to 220 mm. The accuracy required is 3 micron in 15 repeatability.

**NG STATION** – This is third station in TRB Cup inspection machine. The bearing part which fails in width, taper, OD is stored in NG station. This station consists of box like structure to separate the failure criteria of particular cup of TRB. After this the failure part goes to rework or rejection.

**PRINTING STATION** – This is the third station in TRB cup inspection machine. It is a station which is use for making company brand and specification on respective cup and cone. This technology utilizes laser beam for marking.

**OUTLET** – If all the parameters are within limits then it goes for storage otherwise it goes for reject or rework.

4. DESIGN CALCULATION

According to company criteria,

Time required for Forward stroke of cylinder = 2 sec.

Diameter of Cylinder = 50 mm = 0.05 m.

Extension velocity = Stroke / Time

\[ V_{ext} = \frac{0.3}{2} \]

\[ V_{ext} = 0.15 \text{ m/s} \]

Force required for Extension,

\[ F_{ext} = \text{Pressure} \times \text{Area} \]

\[ F_{ext} = 4 \times 10^5 \times \left(\frac{\pi}{4}\right) \times (0.05)^2 \]

\[ F_{ext} = 785.398 \text{ N} \]
We selected Cylinder diameter as 40 mm, because

a) It is best suited for 4 bar pressure.
b) Also best suited for force ranging from 500N-510N.
c) Wide range of stroke length.
d) It is cost effective.

Calculation for Time:

We have to calculate the time required for complete inspection of Cup from start to the end of operation.

Given Parameters:

a) Stroke length = 300mm = 0.3m
b) Piston Diameter of Cylinder = 40mm = 0.04m
c) Rod Diameter of Cylinder = 20mm = 0.02m
d) Pressure = 4 bar = 4×10⁵ N/m²
e) Time required at Washing station = 2 second
f) Time required for Track measurement = 4 second
g) Time required for Outer Diameter measurement = 2 second
h) Time required for Forward stroke of cylinder = 1 second

Forward Stroke of Cylinder:

The velocity for extension \( V_{ext} \) is,

\[
V_{ext} = \frac{0.3}{1} = 0.3 \text{ m/s}
\]

Force required for Extension \( F_{ext} \):

\[
F_{ext} = 4 \times 10^5 \times \left(\frac{\pi}{4}\right) \times (0.04)^2
\]

\[
F_{ext} = 502.65 \text{ N}
\]

Flow Rate = Area × Velocity

\[
Q_{ext} = \left(\frac{\pi}{4}\right) \times (0.04)^2 \times 0.3
\]

\[
Q_{ext} = 0.003769 \text{ m}^3/\text{s}
\]

\[
Q_{ext} = 3.769 \times 10^{-4} \text{ m}^3/\text{s}
\]

\[
Q_{ext} = 22.61 \text{ lpm}
\]

Return Stroke of Cylinder:

Here to calculate return stroke, maximum flow rate is taken from forward stroke which is,

\[
Q_{ext} = Q_{ret} = 3.769 \times 10^{-4} \text{ m}^3/\text{s}
\]

The effective area is the annulus area which is \( (A_p - A_r) \).

We know,

\[
Q_{ret} = Area \times Velocity
\]

\[
Q_{ret} = \left(\frac{\pi}{4}\right) \times (A_p^2 - A_r^2) \times V_{ret}
\]

\[
0.003769 = \left(\frac{\pi}{4}\right) \times (0.04^2 - 0.02^2) \times V_{ret}
\]

\[
V_{ret} = 0.23 \text{ m/s}
\]

Time required for return stroke is,

\[
t = \frac{0.3}{0.23}
\]

\[
t = 1.3 \text{ second}
\]

Total Time Required:

a) At Conveyor assembly = 1 sec
b) Forward stroke of Cylinder = 1 sec
c) At Washing station = 2 sec
d) Forward stroke of cylinder = 1 sec
e) For Track measurement = 4 sec
f) Forward stroke of cylinder = 1 sec
g) For OD measurement = 2 sec
h) Forward stroke of cylinder = 1 sec
i) To NG station = 2 sec
Total Time = 15 sec

Therefore, Total time required for Inspection of Single Cup of bearing is 15 second.

So, as per company design, if we take diameter of cylinder as 50 mm, the force required for extension stroke will increases up to 800 N. And if we take diameter of cylinder as 40 mm, the force required will reduces up to 500 N. Hence, 40 mm diameter will be best suitable for design.

5. CURRENT PROCESS

In width measurement station, there is flat plate and probe arrangement. The plate comes down with the help of pneumatic cylinders and touches the surface of cup. Then the deflection of probe will take place which compare these with the standard value and decide whether the cup is ok or not. In outer diameter measurement station, the cup is clamped between two semi-circular arrangements in which the probe is placed. Then outer diameter is measured with the help of this probe and reading is compared with the standard value

For inspection of single cup of bearing, it takes 18 to 20 seconds from start to the end of operation.

6. DEVELOPMENT IN PROCESS

In previous roller bearing inspection machine, it takes 18 to 20 seconds for complete inspection of single bearing. So we try to reduce the cycle time as much as possible. We reduce time up to 15 seconds and hence efficiency of the cycle increases.

In previous case, there are 3 cups inspect in 1 minute. But after implementing this method, 4 cups were inspect in 1 minute.

7. CONCLUSION

The major objective of this project is to maintain the accuracy regarding and reduces the Force or use appropriate force requires for inspection procedure of bearing cup.

From this project we concluded that if, we take diameter of cylinder as 50 mm the force required for forward stroke is up to 800 N and if we take the diameter of cylinder as 40 mm then force required for extension is reduces up to 500 N.

With this, it is possible to reduce the time required for forward stroke of cylinder from 2 sec to 1 sec and hence reduces the cycle time of measurement.

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AUTHORS

Nikhil Shelke, Student, Department of Mechanical Engineering, JSPM’S RajarshiShahu College of Engineering, Pune-411 033.
Email: nikhilshelke1999@gmail.com

Shubham Kathoke, Student, Department of Mechanical Engineering, JSPM’S RajarshiShahu College of Engineering, Pune-411 033.
Email: shubhamkathoke98@gmail.com

Prathviraj D. Patil, Assistant Professor, Department of Mechanical Engineering, JSPM’S RajarshiShahu College of Engineering, Pune-411 033.
Email: prathviraj1983@gmail.com

Vaibhav Sathe, Student, Department of Mechanical Engineering, JSPM’S RajarshiShahu College of Engineering, Pune-411 033.

Amol Rane, Student, Department of Mechanical Engineering, JSPM’S RajarshiShahu College of Engineering, Pune-411 033.
DESIGN AND FABRICATION OF MULTI PURPOSE WOOD WORKING MACHINE

Maurya Rohit R.*1, Pharande Shreyas S.*2, Tonape Amruta A.*3, Rajguru Vijay G.*4 , Dr. Shende M.D.*5

*1Student, Dept. of Mechanical Engineering, JSPM’s Imperial College of Engineering and Research, Wagholi, Pune, Maharashtra, India 411060.
*2Student, Dept. of Mechanical Engineering, JSPM’s Imperial College of Engineering and Research, Wagholi, Pune, Maharashtra, India 411060.
*3Student, Dept. of Mechanical Engineering, JSPM’s Imperial College of Engineering and Research, Wagholi, Pune, Maharashtra, India 411060.
*4Student, Dept. of Mechanical Engineering, JSPM’s Imperial College of Engineering and Research, Wagholi, Pune, Maharashtra, India 411060.
*5Associate Professor, Dept. of Mechanical Engineering, JSPM’s Imperial College of Engineering and Research, Wagholi, Pune, Maharashtra, India 411060.

ABSTRACT

This paper presents the concept of Multi-Function Operating Machine mainly carried out for production based industries. Industries are basically meant for Production of useful goods and services at low production cost, machinery cost and low inventory cost. Today in this world every task have been made quicker and fast due to technology advancement but this advancement also demands huge investments and expenditure, every industry desires to make high productivity rate maintaining the quality and standard of the product at low average cost. We have developed a conceptual model of a machine which would be capable of performing different operation simultaneously, and it should be economically efficient. In this machine we are actually giving drive to the main shaft to which scotch yoke mechanism is directly attached, scotch yoke mechanism is used for sawing operation. On the main shaft we have use bevel gear system for power transmission at two locations. Through bevel gear we will give drive to drilling centre and grinding centre. The model facilitate us to get the operation performed at different working centre simultaneously as it is getting drive from single power source. Objective of this model are conservation of electricity (power supply), reduction in cost associated with power usage, increase in productivity, reduced floor space.

INDEX TERMS


1. INTRODUCTION

The present research of the design of a “Multi-Purpose wood Working Machine” which is based on the concept of concurrent engineering to perform multi-operations such as cutting, drilling, grinding, jig saw, wood planer & polishing. Same project at my college presenting a synopsis showing its basic construction & working. The project work subject is one, in which actually learning the theoretical concepts in practical way. Also the practical experience is one of the aim of this subject. For a developing industry these operating performed and the parts or components produced should have its minimum possible production cost, then only the industry runs profitably. Production industries are basically meant for production of useful goods and services at low cost. But to perform various operations on workpiece different machines required which demands huge investments and expenditure. Small scale industries required to invest huge amount in machinery which is unaffordable some times. In view of this, every industry desires to achieve a high productivity rate while maintaining the quality and standard of the product at a low cost. The idea behind this project is to develop a system which would be capable of performing different operations simultaneously while also being economically efficient. The Multi operational mechanical system have different work-stations which capable of carrying out a series of machining operations on the same machine which would otherwise require several machines in order to perform the same machining operations. The purpose of this project is to design and construct a low capital Multi operational wood working machine system for the machine shop of the industries. We made system can perform operations like Drilling, Cutting, Grinding, and Polishing some lathe operations at different working centre one by one which implies that industrialist have not to pay for machine performing above tasks individually for operating operation simultaneously. The idea behind this project is to combining various basic engineering operations in one system which runs on single power supply.

1.1 Drilling Operation : The Drilling machine is one of the most common & useful Machine employed industry for producing forming and finishing holes in a workpiece of different types of material.

Working principle :- The rotating edge of the drill exerts a large force on workpiece and the hole is generated. The removal of workpiece material in a drilling operation is by
shearing and extrusion. The machine can drill of 0.5mm to 15.5mm holes. A drill bit is a tool fitted with a cutting tool attachment, usually a drill bit used for drilling holes in various materials. The attachment is gripped by a chuck at one end of the drill and rotated while pressed against the target material. Operations and power is transmitted used in medicine, space missions and other applications. Drills are available with a wide variety of performance characteristics.

1.2 Grinding (Polishing) Operation: Polishing is a finishing process for smoothing a workpiece surface using an abrasive. Polishing is often used to enhance the appearance of an item, prevent contamination of instruments, remove oxidation. There are two types of abrasive material namely fine abrasive and coarse abrasive. Select the proper abrasive material as per the requirement. Generally the coarse abrasive material are used for the wood polishing operation. The wheels are generally made from a composite material consisting of coarse-particle aggregate pressed and bonded together by a cementing matrix (called the bond in grinding wheel terminology) to form a solid, circular shape of a grinding wheel arrangement.

1.3 Jig Saw Operation: In Jig Saw mechanism the Scotch yoke is a mechanism is used. In scotch yoke mechanism the linear motion is converted into rotatory motion and vice versa. The piston or other reciprocating part is directly coupled to a sliding yoke with a slot that engages a pin on the rotating part. The shape of the motion of the piston is a pure sine wave over time given a constant rotational speed. The Rotary motion of drilling operation performed is also used for performing other tasks like cutting and grinding simultaneously. The work pieces are to be clamped on the work table using suitable clamping device like vice for the three operations. After machining the work pieces are to be removed and cleaned.

1.4 Wood surface planning operation: It is used for smoothing of rough and irregular wood structure for their further use. It is also used to trim boards to a consistent thickness throughout their length and flat on both the surface.

1.5 Wood cutting operation: It is used for cutting the wood in straight line, angular cutting. It cannot use to cut irregular shapes.

2. PROBLEM DEFINATION

- To design and development of multipurpose wood working machine, a structured which is design for the purpose of multioperation.
  2.1 Drilling.
  2.2 Cutting.
  2.3 Jig saw.
  2.4 Wood planer.
  2.5 Polishing

3. OBJECTIVES

To develop and design the machine which fulfilled all the requirements of small scale woodworking workshop.

- To minimize the required time for machining.
- To minimize the cost of machine.
- Save the man power.
- Less carpet area.

4. WORKING METHODOLOGY

In this project we will generally give the power supply to the shaft such that the AC motor is connected at one end of the shaft and consist Scotch Yoke Mechanism at one end to carry out the cutting operation. At one end of the shaft is connected to power supply, other end is being joined to a circular disc, through this circular disc Scotch The tip of the from AC motor source to parallel shaft by means of timing chain and sprocket drive system.

The cutting tool does the work of cutting into the target material. Drills are commonly used in woodworking, metalworking and construction. Specially designed drills are also Yoke Mechanism is being performed (rotating motion is converted into reciprocating motion). Such that the parallel shaft consist of drilling chuck having drill bit and grinding wheel at other end for grinding.
4.1 WOOD SURFACE PLANNER– In small scale industries wood available are of not same size and shape. The wood have irregular structure at the surface, before starting this irregularity need to be eliminated. To eliminate this irregularity surface planer is used which makes better finish of surface.

4.2 POLISHING- Polishing is used for polish the wood. Construction is same as grinding wheel used in metal polishing but abrasive material on wheel is changed as per requirement.

4.3 DRILLING – Drilling is used for drilling the hole in wood surface. The different size of drills are available in market as per our requirements.

4.4 JIG SAW- Scotch yoke mechanism consist of 4 link namely Fixed link, Slotted link, Slider Crank. It converts rotatory motion into linear motion. It gives perfect harmonic motion.
5. CALCULATIONS

5.1 Pulley on motor --
N = Speed in RPM = 1440 rpm
P = Power in KW = 2.24 KW
ρ = Density of cast iron = 7200 kg/m³
V = Velocity in m/s σt = Centrifugal force
Assume Diameter of the pulley on motor
D = 85 mm = 0.085 m
σt = ρ*V² = 43.429 KN
b) Width of pulley
If the width of belt is known then width of pulley is
B = 1.25b
B = 17.5 mm
B = width of pulley b = width of belt From data table
b = 14 mm
C) Thickness of rim (t)
The thickness is varies from D/300+2 mm to D/200+3 for single belt Now
t = D/200+3 = 3.425 mm
The pulley less than 200 mm diameter are made with solid disc instead of arm and the thickness of the rim measured at the centre of the pulley face.
Selected pulley on motor
D = 85 mm B = 17.5 mm t = 3.425 mm
5.2 Pulley on driven shaft 1--
We want same speed on the shaft 1 so the dimensions of the pulley on shaft 1 is same
Ds1 = 85 mm Bs1 = 17.5 mm ts1 = 3.425 mm
Now the shaft 1 become a driver shaft
The shaft 1 transmit the power to shaft 2 so shaft 2 become driven shaft.
5.3 Pulley on shaft 2
We want the maximum speed of the shaft 2 is 3600 rpm.
a) To calculate diameter of second pulley
Considering from Pulley Diameter Form Design Data Book as Ds1 = 200 mm
Ds1Ns1 = Ds2Ns2
0.200*1440 = Ds2* 3600
Ds2 = 0.08 m = 80 mm
b) Width of Belt
For 80 mm & 200 mm
Bs2 = 1.25 bs2
= 1.25 * 14
Bs2 = 17.50 mm
c) Thickness of Pulley Rim for Single Belt for D = 200 mm
T = D/200 + 3 = 80/200 + 3 = 3.4 mm
d) Now Load acting on Pulley
P = (2πNT1) / 60
2.24*103 = 2πNT1/60
T1 = 14.85 Nm
T1 = F1*r
F1 = 349.51 N
V = πDN/60
V = 6.4 m/s
P = (F1 - F2)*V/1000
Here F1/F2 = e^μ
E) Now for D = 200 mm we calculate force
T = F*r
F200 = 148.5 N
Consider μ = 0.3
θ = θ - 2α
θ = 2.9057 rad
(F200/F80) = e^0.3*2.9057
F80 = 62.12 N
T80 = 2.48 N

5.4 Bearing
a) Single row Deep Groove Ball Bearing
ISI No -: 30BC02
Bearing of basic design no. (SKF) :- 6206
Inner dia. :- 30 mm
Outer dia. :- 62 mm
Dmin :- 36 mm
Dmax :- 56 mm
B :- 16 mm
Basic capacity Static C0 = 11.2 KN
Basic Capacity Dynamic C = 20.30 KN
Max. Permissible speed :- 15000 rpm
Now calculation of bearing life
L10 = (C/Pe)³
L10 = 57976.45 mil rev
n
5.5 Shaft (Maximum shear stress theory)
Material :- Mild Steel
L :- distance between two bearing on shaft = 450 mm
Assume Max. Load on shaft F = 1000 N Max. bending movement = FL/4 = (1000*450)/4 = 112500 Nmm
Equivalent twisting movement
Te = (Kb*m)² + (Kt*T)²
Combined shock and fatigue factor for bending Ks = 1.5
Combined shock and fatigue factor for torsion Kt = 1.0
Te = 14.85 * 10⁻³ Nmm
Factor of safety :- 3
Tmax = 16Te / πd³ d = 23.98 mm
Standard Dimension from Design data book is d = 30 mm
5.6 Key
Type :- Rectangular Key
Factory of Safety = 3 – 4
Key is made of harden & tempered steel of grades C30, C35, C40, C50
Width (W) :- 7.5 mm
Height (H) :- 5 mm
From Standard data table :-
Width (W) :- 10 mm
Height (H) :- 08 mm

6. PART IMPLEMENTATION

6.1 Pulley on motor

6.2 Pulley on shaft 1 (driver)

6.3 Pulley on shaft 2 (Driven)

6.4 Shaft

6.5 Bearing
7. Model

8. FUTURE SCOPE

We can perform various operation by introducing set screw shaft collar(engagement and disengagement) between them. We can perform polishing by introducing a grinding tool at main shaft.

9. CONCLUDING

From the above research paper indicate that for production industries machine installation is tricky for various operation and also power consumption issue, maintenance cost. The above operation are frequently used in all small scale industries so combine the all operation in a single frame is essential.

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Maurya Rohit R.*1 Was born in Hadapsar Pune, Maharashtra, India in 1998. He is appearing His B.E degree in Mechanical engineering form the University of PUNE. He also completed his 10th & 12th it self in Pune Form Maharashtra Board.

Pharande Shreyas S.*2 Was born in Wai village, Satra, Maharashtra, India in 1998. He is appearing for his B.E degree in Mechanical engineering form the University of PUNE. He also completed his 10th & 12th it self in Wai Form Kolhapur Board.

Tonape Amruta A.*3 Was born in Kurudwadi village, Solapur, Maharashtra, India in 1998. She is appearing for her B.E degree in Mechanical engineering form the University of PUNE. He also completed his 10th itself in Kurudwadi form Maharashtra Board & 12th in Kolhapur Form Maharashtra Board.

Rajguru Vijay G.*4 Was born in Sultanpur Village, Buldana, Maharashtra, India in 1998. He is appearing for his B.E degree in Mechanical engineering form the University of PUNE. He also completed his 10th & 12th it self in Sultanpur Form Maharashtra Board.

Dr. Shende M.D.*5 Was born in Karad Village, Maharashtra, India in 1975. He Completed his Ph.D. form Sant Gadge Baba Amravati University. He also completed his M.E. in Mechanical – Heat Power Engineering form Government college of Engineering, Karad (Shivaji University Kolhapur). He Had Total 18 years of experience in Teaching, Industry And Research.
Compost Machine: A Key towards Sustainability

Harshada A. Gaikhe¹, Lavanya A. Tumkur², Nrupali P. Lakur³, Dr. Prashant D. Deshmukh Jr⁴, and Prof Rahul A. Bhosale Jr⁵.

¹Dept. of MECH Engineering, New Horizon Institute of Technology and Management, Thane, Mumbai, Maharashtra, India, 400615
²Dept. of MECH Engineering, New Horizon Institute of Technology and Management, Thane, Mumbai, Maharashtra, India, 400615
³Dept. of MECH Engineering, New Horizon Institute of Technology and Management, Thane, Mumbai, Maharashtra, India, 400615
⁴Dept. of MECH Engineering, New Horizon Institute of Technology and Management, Thane, Mumbai, Maharashtra, India, 400615
⁵Dept. of MECH Engineering, New Horizon Institute of Technology and Management, Thane, Mumbai, Maharashtra, India, 400615

ABSTRACT

Composting aims to increase the overall sustainability and strives to be one of the most promising techniques among other traditional practices. The composting process has received much attention in recent years because of pollution concerns and the search for environmentally sound methods for treating waste. The design for a cost-effective composting machine for small-scale production of manure (compost) from kitchen wastes is presented. The aim is to decrease unscientific land filling, segregation of waste and to increase quality of compost or manure. The use of household waste for the production of compost will result in a much smaller amount of waste being sent to landfills, which in turn will reduce the costs of waste collection, transportation and burial. This paper aims to design and fabricate a cost-effective compost machine for Indian Household Kitchen, which will work towards the improvement of the present system.

INDEX TERMS Compost machine, compost parameters, shredder, Solid Waste Management (SWM), organic waste, organic fertilizer etc.

1. INTRODUCTION

Changing lifestyle in India has resulted in a high rate of industrialization and urbanization. Unscientific and uncontrolled dumping of waste has given rise to overflowing landfills. So far landfill and incineration have been the most popular practised techniques of waste disposal all over the world. Land filled gas emissions constitute a trace amount of mixtures of Carbon dioxide, methane, oxygen & nitrogen. Other components such as ammonia, hydrogen sulphide and other organic sulphur compounds produce unpleasant odour. Production of highly polluting leachate and methane gas leads to the destruction of various biological ecosystems. The average generation of Municipal Solid Waste in India is approximately 100,000 MT/day. Out of that, only 60,000-65,000 MT/day is collected by municipal corporations and councils. The rest is dispersed in an unscientific manner. Municipal Solid Waste includes commercial waste, market area waste, household waste, slaughterhouse waste, institutional waste, horticulture waste, biomedical waste, electronic waste and so on. Constraints of dense population, land availability & environmental fragility have given an alarming signal to our country. Municipal Solid Waste Management (MSWM) involves activities associated with the collection, storage, transport, processing and disposal of solid waste. Composting is a biological process that converts organic waste into a dark rich substance called compost which is a wonderful soil conditioner. Composting ensures breakdown of complex organic matter with the help of microorganisms such as bacteria and fungi. Composting is an effective and safe way to discard kitchen waste, perishable products such as fish, seafood, fruits, bread, vegetables, pastries, milk products, and other frozen products. Thus, an economically viable technique is used to improve the nutritional quality of manure at the earliest possible time.

2. LITERATURE REVIEW

M. S. Kadam, S. S. Sarawade, March (2016) [1]: The author has studied about the survey conducted by the Central Pollution Control Board (CPCB) of solid waste management in 299 cities and has given the data of waste generation for different cities. Also, the author discussed about the different techniques of composting which were used in villages.

Isher Judge Ahluwalia, Utkarsh Patel April (2018)[3]: In this study, they were concerned about the recent literature and industry practices within a regulatory context where composts may be spread to land under different regimes. Landfilling and incineration has been the most widely used means of solid waste disposal technique throughout the
world. The land filling of biodegradable waste is proven to contribute to environmental degradation. In this paper the author gave a brief study of different methods that are used for treatment of solid waste and the choice of proper method depends upon refuse characteristics, land area available and disposal costs.

Pervez Alam & Kafeel Ahmade, January (2013)[6]: As per author research there are few techniques which can be used for disposal of waste of non-combustible materials. Most of the organic substances are thermally unstable, and on heating in an oxygen-free atmosphere they change into gaseous, liquid and solid fraction.

Yesha Kotak, (2019)[9]: The purpose of the author’s article is to report a survey of the Brihan Mumbai Municipal Corporation (BMC) who collected 5,500kg of nirmalya (flower waste) from temples and 92 Navratri pandals in the N-ward (Ghatkopar) during the nine days festival. The solid Waste Management (SWM) department at Ghatkopar had undertaken a nirmalya collection drive this year in N-ward to ensure that it does not end up at landfills.

Pranab Jyoti Bhuyan, (2019)[10]: As per the authors investigation Navi Mumbai will get its first construction and demolition waste treatment plant by October end according to the plans of Navi Mumbai Municipal Corporation (NMMC). The waste generated at the construction sites and debris collected after demolishing illegal buildings will be processed by this plant. The processed materials will be used for constructing footpaths, making paver blocks and tiles, among others.

3. IMPORTANCE OF COMPOST MACHINE

The composting technique is beneficial in soil fertility enhancement, stabilizing the environment, decreasing the global warming, improving the waste management system etc. This technique is used to reduce the volume of organic waste and converts the ammonia waste into useful nitrogen rich product. The manure when used in soil increases soil fertility. For natural organic composting with the help of microorganisms, near about 30-40 days are required for the completion of the process.

Significance:

- It produces healthier plants
- This technique is practical and convenient
- It stands as a good alternative to land filling

The recycling of compost to land is a technique to maintain or restore the quality of soils, mainly because of the fertilizing or improving properties of the organic matter contained in them. Compost is rich in nutrients and is beneficial for the land in many ways, such as a soil conditioner, fertilizer, and natural pesticide/insecticide for soil. It finds its application in small gardens, agriculture, rooftop farming etc. Compost is widely known as Black gold by gardeners.

4. PARAMETERS AFFECTING PERFORMANCE OF COMPOSTING

There are a wide range of parameters which are used to monitor physical, chemical, biological, and biochemical variations during composting, such as the carbon/nitrogen (C/N) ratio, moisture content, temperature, pH, aeration rate.

C/N ratio: The Carbon/Nitrogen (C/N) ratio is one of the most important parameters to control the process of composting and to determine the degree of maturity of the end product of compost. It is found that the major factors influencing the composting process are aeration rate and C/N ratio. The nutrient that receives attention in composting systems is nitrogen since it is an essential element for plant nutrition. It has often been recognized as a limiting factor for microbial growth and activity during the decomposition process of plant residues, especially in materials with a high C/N ratio

Moisture content: Physical structure and microbial activity in the composting process is affected by moisture content and it also has a centralized influence on the biodegradation of organic matter. Moisture content is one of the critical design considerations in operating parameters used in compost engineering systems. It is very important to transport dissolved nutrients required for the physiological and metabolic activities of microorganisms/bacteria. Moisture acts as a medium to transfer dissolved nutrients absorbed through the cell
membrane of microorganisms. The water is produced as a by-product of microbial activity during composting; also, the generated heat through degradation process will dry up part of the moisture. The moisture content can be adjusted by adding water.

**Temperature:** Temperature is an important factor which can affect microbial metabolism, composition, density of microbes, and diversity of microorganisms and thus can be considered as a promising index of microbial activities and bio-oxidative stages. There are three distinct stages during composting, including the

(a) Mesophilic (below 40°C),

(b) Thermophilic (above 40°C)

(c) Cooling (ambient temperature) stage.

**pH:** Another important environmental factor is the pH value of composting matter. The presence of short chain organic acids in raw materials, mainly lactic and acetic acids, leads to low pH of Municipal Solid Waste, with the value normally ranging between 4.5 and 6. Low pH due to presence of organic acids mostly inhibits the progress of composting time

**Aeration rate:** The aeration rate is an important parameter for the composting process. The main purpose of supplying air to composting is to provide oxygen for biological decomposition, dry up the wet materials and remove excess moisture generated, and to carry off exhaust gas and generated heat. Air flow influences equal distribution of moisture, temperature, gases, and the decomposition rate of the organic matter. The aeration provides oxygen to inhibit conditions giving rise to anaerobic composting and support the aerobic microbial activity. Physical mixing of the mass, forced aeration (positive and negative modes) and natural convection are well-known ways to control effective aerobic composting. Lack of aeration can lead to anaerobic conditions and excess aeration will increase the loss of moisture and ammonia

5. **OBJECTIVES**

The main objective of the project is to develop an environmentally sound waste management system.

- To contribute the overall sustainability of the area
- To improve overall waste management in the area
- To increase recycling levels and reduction of organic waste in landfills
- To obtain a quality compost to be used as an organic amendment that contributes to improve soil fertility
- To reduce cost of compost machine
- To seek maximum economic benefits at acceptable cost

6. **PROBLEM DEFINITION**

Quantity of municipal solid waste has increased in recent years due to the increasing modernization and growing economic status of the Indian societies. By the year 2031, the volume of waste is projected to increase from 64-72 million tons to 125 million tons. Highly ineffective methods of waste collection, storage, transportation and disposal are the major factors affecting the environment. Other areas of concern to the developed and developing countries are the emission of greenhouse gases, leachate generation, air and water pollutants, etc. due to frequent dumping of waste in the outskirts of the cities. Huge costs involved in the disposal of high volume of waste and methodologies involved are the topics of our concern. Various insects get attracted due to foul smell emitted from the landfills which predominantly gives rise to diseases like Jaundice, Diarrhoea, Typhoid, Cholera and dysentery are the consequences of unscientific and chaotic waste management. According to a report of the Government of India’s Ministry of Urban Development (MoUD), in India 101066.27 MT of Municipal Solid Waste (MSW) is generated daily. Open dumping in the majority of the areas have ultimately made the land unproductive and infertile. Generated solid waste is openly thrown on roads, near water sources which become difficult for its further processing. Few challenges involved in the existing compost bins are time consumption (30-45) days, messy and smelly compost, hard cleaning, prone to insects and rodents and cost issues with automatic and high-end bins and release of greenhouse gases. Several cost issues are associated with few automatic and high-end compost bins. This project aims at designing and fabricating a sustainable compost bin for Indian household kitchen, which is easy to use, odor free, ergonomic in nature and visually appealing. In big localities, as the decomposition pace falls short; more land is taken under dumping for the burning process. Creation of huge fumes of foul smoke pollutes the urban air and also causes thermal pollution and smog. Wastes are either openly dumped which remains unattended or released into
the oceans which prove to be hazardous to marine life and other biological ecosystems.

![Diagram of Methodology]

**Fig No. 1 Methodology**

**7. DESIGN**

1. **COMPOSTING TANK:**

   Length (L) = 250 mm  
   Width (B) = 150 mm  
   Height (H) = 300 mm

   The composting tank total volume is given by
   \[ V = L \times B \times H \]
   \[ V = 250 \times 150 \times 300 \]
   \[ V = 11250000 \text{ mm}^3 \]

2. **SHREDDER:**

   Shaft diameter = 20 mm  
   Shaft length = 280 mm  
   Shredder blade thickness = 3 mm  
   Shredder blade spacing = 10 mm  
   Blade quantity = 20  
   Shredder diameter = 100 mm

   \[ V_{out} = L \times B \times H \]
   \[ V_{out} = 250 \times 150 \times 120 \]
   \[ V_{out} = 4500000 \text{ mm}^3 \]

3. **HOPPER:**

   L1 = top length of hopper = 350 mm  
   B1 = top breadth of hopper = 250 mm  
   L2 = bottom length of hopper = 250 mm  
   B2 = bottom breadth of hopper = 150 mm  
   h = height = 100 mm  
   \( \Phi \) = angle of inclination of hopper

   Volume of hopper is calculated by using following relation:
   \[ V_{h} = V_{in} - V_{out} \]
   Where,
   \[ V_{in} = \text{volume of inlet} \]
   \[ V_{out} = \text{volume of outlet} \]
   \[ V_{in} = L1 \times B1 \times H \]
   \[ V_{in} = 350 \times 250 \times 120 \]
   \[ V_{in} = 10500000 \text{ mm}^3 \]
   \[ V_{out} = L2 \times B2 \times H \]
   \[ V_{out} = 250 \times 150 \times 120 \]
   \[ V_{out} = 4500000 \text{ mm}^3 \]
   \[ V_{h} = (10500000 - 4500000) \]
   \[ V_{h} = 6000000 \text{ mm}^3 \]

4. **BELT:**

   Centre to centre distance between two shaft = 200 mm
   Perimeter of semi-circle = \( \pi r \)
   \[ = \pi \times 20 \]
Length of belt = (2 x 200) + (2 x 62.832)  
= 525.664 mm

8. CONSTRUCTION

The compost machine here designed mainly consists of three units. The top unit consists of hopper, shredder-shaft assembly and the driven pulley. Organic waste enters into the main unit (Composting Tank) through the hopper. The composting tank is made up of mild steel with sheet thickness of 1-1.5 mm. Waste then enters into the shredder-shaft assembly enclosed inside the tank. The shaft passing through the shredder is made up of mild steel with diameter of 20 mm. Length of this shaft is 320mm. The shredder diameter is of 100 mm which includes 20 equally spaced blades of thickness 3 mm. The spacing between blades is of 10 mm. The shredder shaft consists of driven pulley. The middle unit consists of a tray which collects the fine particle sized waste. The bottom unit consists of housing for single phase AC motor of 0.5 HP rotating at 500 rpm. Driver pulley is attached to the motor shaft. The belt connecting driver and driven pulley is made up of rubber with a centre to centre distance of 200 mm and length of 525.664 mm.

9. WORKING

A 20 mm diameter shaft passes through the centre of the composting tank horizontally and spans through the length of the tank inside, on which a shredder having its design like that of a worm conveyor is mounted, is being driven by a 0.5 HP geared motor with an average output speed of 500 rpm. Kitchen or the organic waste enters the composting tank through the hopper. The inclination provided in the hopper allows smooth sliding of waste in the desired direction. Waste enters the shredder assembly of the top unit. The input power required to rotate the shredder shaft is taken from the motor. The power from motor shaft (driver shaft) is transmitted to the driven shaft (Shredder shaft) through the belt conveyor. This helps in rotating the shredder assembly and blades ensure fine cutting. Volume reduction of 75-80% is achieved at this stage. The rotary motion of the shaft ensures proper or uniform mixing of the organic waste materials against the inner walls of the composting cylinder. Once the volume of the waste is reduced, the waste is collected by the tray incorporated in the middle unit of the machine. Worm/bacteria is added to the fine mixture of organic matter collected in the tray wherein the bacterial multiplication takes place. Due to the microbial activity, bio-chemical reactions occur, and the temperature of the mixture is raised. The heat evolved in the process converts waste into a fertilizer (Compost). This compost replaces the need of chemical fertilizers in the agricultural sector thereby enriching the soil nutrient.

10. STRUCTURAL ANALYSIS OF SHREDDER

![Fig No. 2 Compost Machine CAD Model](image)
Material(s)

<table>
<thead>
<tr>
<th>Name</th>
<th>Steel, Mild</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mass Density</td>
<td>0.283599 lbmass/in^3</td>
</tr>
<tr>
<td>Yield Strength</td>
<td>30022.8 psi</td>
</tr>
<tr>
<td>Ultimate Tensile Strength</td>
<td>50038 psi</td>
</tr>
<tr>
<td>Young’s Modulus</td>
<td>31908.3 ksi</td>
</tr>
<tr>
<td>Poisson’s Ratio</td>
<td>0.275 ul</td>
</tr>
<tr>
<td>Shear Modulus</td>
<td>12513.1 ksi</td>
</tr>
</tbody>
</table>

Mesh settings:

| Avg. Element Size (fraction of model diameter) | 0.1 |
| Min. Element Size (fraction of avg. size)     | 0.2 |
| Grading Factor                                | 1.5 |
| Max. Turn Angle                               | 60 deg |
| Create Curved Mesh Elements                   | No  |

Force: 1

<table>
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<tr>
<th>Load Type</th>
<th>Force</th>
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</thead>
<tbody>
<tr>
<td>Magnitude</td>
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</tr>
<tr>
<td>Vector X</td>
<td>-0.000 lbforce</td>
</tr>
<tr>
<td>Vector Y</td>
<td>0.000 lbforce</td>
</tr>
<tr>
<td>Vector Z</td>
<td>-6.750 lbforce</td>
</tr>
</tbody>
</table>

Fig No. 3 1st Principle Stress

Fig No. 4 3rd Principle Stress

Fig No. 5 X-Displacement

Fig No. 6 Y-Displacement
The Mild Steel shredder analysis has been done using FEA. A Force of 6.75lb (0.0465 N/mm²) magnitude applied along z direction over the area of 178285mm². Neglecting forces along x and y direction.

### Result Summary

<table>
<thead>
<tr>
<th>Name</th>
<th>Minimum</th>
<th>Maximum</th>
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</thead>
<tbody>
<tr>
<td>Volume</td>
<td>370769 mm³</td>
<td></td>
</tr>
<tr>
<td>Mass</td>
<td>6.41664 lbmass</td>
<td></td>
</tr>
<tr>
<td>Von Mises Stress</td>
<td>0.00000355516 MPa</td>
<td>1.13672 MPa</td>
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<tr>
<td>1st Principal Stress</td>
<td>-0.337129 MPa</td>
<td>1.36707 MPa</td>
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<td>3rd Principal Stress</td>
<td>-1.39373 MPa</td>
<td>0.341065 MPa</td>
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<tr>
<td>Displacement</td>
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<td>0.0012375 mm</td>
</tr>
<tr>
<td>Safety Factor</td>
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<td>15 ul</td>
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<td>Stress XY</td>
<td>-0.396187 MPa</td>
<td>0.434903 MPa</td>
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<tr>
<td>X Displacement</td>
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<td>0.000452024 mm</td>
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<tr>
<td>Y Displacement</td>
<td>-0.00119542 mm</td>
<td>0.00000114145 mm</td>
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<tr>
<td>Z Displacement</td>
<td>-0.000262421 mm</td>
<td>0.000264275 mm</td>
</tr>
</tbody>
</table>

### 11. BENEFITS

- Enriches soil and helps to retain moisture and suppresses plant diseases and pests
- Reduces the need for chemical fertilizers in the agriculture sector
- Increases the production of beneficial bacteria and fungi that break down organic matter to create humus, a useful rich nutrient-filled material.
- Reduces methane emissions from landfills
- It can compost all types of organic waste
- It has no secondary pollutant such as residual gases found in case of incineration and pyrolysis
- The machine ensures noiseless operation and have no foul smell, no rats or insects or flies
- Volume reduction efficiency is in the range of 80 to 90%.

### 12. CONCLUSION

In this project work, an attempt is made to design and fabricate a diligent compost machine which will be economical, environmental freely and can accommodate approximately 2kg to 3kg of organic waste. This machine can convert organic waste into fine particles with the help of shredder driven by an electric motor. A detachable tray is situated at the lower part of the compost machine to collect the shredded waste. This fine particle mixes with soil along with microorganisms or bio compost which helps to produce organic compost which will take around 4-5 days to produce organic manure. This organic manure can be used in household farming and agriculture sector as an organic fertilizer.

### 13. FUTURE SCOPE

The future of composting and compost cannot be separated from the management of waste in general and other treatment. The concept of composting facilities has changed. Waste should be treated but for the purpose of manufacturing compost. Society is informed about the problems derived from an uncontrolled consumption and excessive generation of waste (solids or liquids). Compost is placed as a competitive product on the organic fertilizer market. The
concept that waste may be a resource and that its sustainable management signifies compromise and interaction between environment, economy and society.

ACKNOWLEDGMENT
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Finally, we acknowledge our all faculties, friends and family for their contribution, continuous support and encouragement in the completion of the paper.

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Thordon (Elastomeric) Bearings for marine propeller shaft system and Water quality packaged.

Mr. A. P. Kotkar #1

#1 Mechanical Engineering, Savitribai phule pune university, Maharashtra, India, aniketkotkar1998@gmail.com

ABSTRACT—Environmental legislation is getting tougher. Material to machine. It is non-toxic and machines dust free. And even well maintained ships leak stern tube oil - a serious. Therefore there are no health hazards involved. The simplest way to eliminate oil from the stern tube is to use Thordon non-metallic seawater lubricated COMPAC shaft bearings. Thordon elastomeric bearings material is made from thermosetting resins thordon is a very hard, tough synthetic polymer alloy that has performance characteristics superior to those of most other bearing material, both non-metallic. The simplistic view of the main propeller shaft installation is that the system is set up with initial straight alignment and remains in that state during the lifetime of ship unless affected by accident or wear. Thordon has developed self-contained supply conditioning and monitoring packaged to ensure that an adequate supply of clean water is consistently being delivered both the forward seal bearings. The thordon water quality packaged can be controlled by the ship's control and monitoring system to cover auto stand by function required for unmanned machinery space notation.

INDEX TERM—Marine shaft bearing, types of bearing, problem faced by bearings, bearing life.

INTRODUCTION-

Remember is that Thordon elastomeric bearings are different from other bearing materials and therefore require slightly different handling. The securing methods common for bronze or bronze-shelled bearings must also be re-considered when fitting Thordon elastomeric bearings. For example, flanged fitting, set screwing along the outside diameter (O.D.) and welding near the bearing are not acceptable with Thordon elastomeric bearings. Alternate methods of axially securing the bearing such as bolted retaining rings must be used. Thordon is a very easy material to machine. It is non-toxic and machines dust free. Therefore there are no health hazards involved. Thordon elastomeric bearings are available in four grades for marine bearing system installations:

- XL (black)
- SXL (off white)
- COMPAC (orange)
- COMPOSITE (yellow outer shell, black wearing wear)

These four thordon grades are similar in their basic chemical composition and the same approach can be taken to installing any of them. Elastomeric bearings used in all three ships (ICGS Samar, Sangram, and Sarang) were specially designed and fabricated (by Thordon bearings Inc.). In one lab (David Taylor Research Centre, Bethesda, MD) test.

Total abrasive are removed from the seawater supply a thordon water quality packaged is used. A constant supply of relatively abrasive free water is an important element in ensuring long, predictable, bearing wear life. Thordon water quality packaged are designed with individual electric panel and can be mounted side by side.

The COMPAC propeller shaft bearing system uses seawater as the lubrication medium in place of oil. Seawater is taken from the sea, pumped through non-metallic COMPAC propeller shaft bearings and returned to the sea. To ensure that abrasives are removed from the seawater supply, a Thordon Water Quality Package is used. A constant supply of relatively abrasive free water is an important element in ensuring long, predictable, bearing wear life. With this factor in mind, Thordon has developed a self-contained supply, conditioning and monitoring package to ensure that an adequate supply of
clean water is consistently being delivered to both the forward seal and the bearings.

Following questions are essential-
- The life of bearing is 15 years can it be used by the bearing maintenance after all 15 years?
- All of u know what type of material is used in thordon bearing is polymer but specific name?
- It can be possible to control the wear by changing the dimensions of bearing and shaft?

MATERIAL AND METHODS-

Ship owners benefit of thordon propeller shaft bearing
- Eliminate stern tube oil pollution risk.
- Excellent operational and proven wear performance.
- Reduced shaft seal maintenance cost (no aft seal)
- Survivability (non catastrophic failure mode)

Thordon elastomeric bearings are available in different grades-

COMPAC-
This orange coloured bearing is specifically designed to provide the lowest friction in operation. This is achieved by using the Thordon elastomeric bearing that has the lowest friction, by not having grooves in the bottom half of the bearing and by reducing the bearing length relative to fully grooved bearings.

XL-The black XL grade provides good abrasion resistance, relatively low friction and good shock resistance. Fully grooved XL propeller shaft bearing closest to the propeller.

SXL-This off-white Thordon grade has a low coefficient of friction. Being slightly softer, it is also slightly more tolerant of abrasion than XL.

COMPOSITE-Composite (see Figure 9) is a two-component bearing (yellow outside and black inside). The black inside material (known as GM2401) is softer and tougher than the other Thordon grades. As a result, Composite is the most abrasion resistant material of all Thordon grades and is designed for vessels operating over 20% of their time in abrasive operating environments.

Material Selection-

As stated in previous section, it is critical for design engineers to select a bearing material that is able to withstand the presence of some level of abrasives as well as a material that is favourable for developing a stable hydrodynamic water film. For example, Thordon produces two grades of elastomeric materials that can be applied depending on the quality of the water that can be delivered to the bearing. Thordon SXL (off-white colour) is normally used when water filtration can remove particles larger than ~80 micron; if this is not possible, the softer and more abrasive resistant GM2401 (black colour) grade can be used for installation in smaller units where there is no dedicated water filtration available.

Thordon SXL is an elastomeric polymer bearing material with a 25-year history of long-life performance in water lubricated main shaft guide bearings. “It was certainly the right choice for us,” says Conlon. “Even if the Thordon SXL bearing were to fail, it would not fail suddenly and unexpectedly. The most that would happen is that the Thordon material would wear a little bit.”

Before making the commitment to purchase the Thordon SXL bearing, the Star Lake Hydro Partnership researched the product extensively. This included checking references in North America and Europe. “Satisfied with the experience of others,” says Conlon, “the order was eventually placed for two bearings (one plus a spare) in July 2003”.

Working with Thordon’s engineers, however, the decision was made to design and fabricate the bearing in two halves. “We simply took the two halves and bolted them together around the shaft,” says Conlon. “Once the Thordon bearing was in
place, it was positioned with a constant annulus around the shaft.” Before removing the old bearing, the turbine runner had been wedged in position so that the turbine shaft was centered on the old bearing. As a result, no time-consuming realignment was necessary.

The Thordon bearing was so simple to install, in fact, that the outage lasted just six days, which Conlon observed, “was a large saving in time and money.”

The ship's original stern tube staves made of rubber - had a history of problems that the Canadian Coast Guard inherited. Rubber bearings did not stand up well to the rigors of icebreaking operations. In fact, the staves had been replaced several times within just a decade, driving up maintenance costs, creating downtime incidents, and adversely affecting performance.

"That's why we approached the Canadian Coast Guard regarding Thordon XL bearings," says Chester McPherson, President of Avalon Marine, a long-time Thordon distributor located in Dartmouth, Nova Scotia. "We knew its track record of long life and trouble-free performance would greatly interest them."

Thordon Bearings has a long history of success in marine applications, with coast guard and naval ships in Canada and the United States, as well as vessels operating in a wide range of capacities around the globe. Thordon XL bearings have also been used on the U.S. Coast Guard icebreakers, Polar Sea and Polar Star since 1984.

Twenty million passengers a year take a ferryboat between Staten Island and Manhattan in New York. At no charge, they get a majestic view of New York Harbor on the 25-minute ride. Those five miles of water started to become a whole lot cleaner in 2004 when Thordon COMPAC propeller shaft bearings and SXL rudder bearings were installed on three Staten Island ferries.

“One difficulty,” says Sean McDermott of New York City Port Engineering, “was that after the vessels were put in service, we did a dive inspection and noted that a lower pintle bearing that supports the rudder had raised itself out of its support. It had come up about an inch (25mm). A “keeper” retaining ring to prevent that from happening should have been installed.”

When a similar problem occurred on the second vessel where a keeper had not been installed, there was enough clearance to install one. “The bearing had moved up, and it was a matter of pushing it back down to install the keeper,” says McDermott. “There wasn’t much clearance above it, but they got some small presses, hydraulic jaws and jacks and were able to press it back in place.”

As for the third vessel, it was still under construction when the shipyard learned its lesson. Keeper retaining rings were installed on that boat before its launch.

“When used in conjunction with Thordon Bearings’ COMPAC propeller shaft bearing system, seawater lubricates the bearings to ensure the smooth, effective and safe operation of the vessel. Not only do we guarantee our seawater-lubricated COMPAC system for a wear life of fifteen years, but it reduces a shipowner’s annual operating and maintenance costs substantially, compared to an EAL-lubricated metal bearing and two seal system,” continued Carter. In its recently published comparative research into the operational costs of using mineral oil, approved EALs or seawater in a propeller shaft bearing system, Thordon Bearings found that EALs – vegetable oils, synthetic esters and polyalkylene glycols – are over 7 times more expensive than the mineral oils typically used in oil-lubricated propeller shaft bearing systems. “When you take into account that between 130 million to 240 million litres (63.4 million U.S. gallons) of operational oil lubricant are leaked into the oceans each year and need to be replaced, the cost to the shipowner is simply staggering – and this is without adding any monetary penalties incurred by way of environmental fines.”

**Water Quality Packaged**

An important consideration in the wear life performance of any bearing system is the quality of the lubrication in which the bearing operates – in this case, the supplied seawater. Removal of abrasive particles significantly extends the supplied seawater. Removal of abrasive particles significantly extends the wear life of the bearing and polymer bearing experience indicates that filtration to less than 200µm, or preferably 100µm, can extend bearing life to beyond 15 or even 20 years.
A Water Quality Package includes a pump, cyclonic separator, automation and a flow sensor/alarm as a “plugn-play” unit. The separators are rated to remove particles greater than 80µm with specific density greater than 1.2. The collected debris is automatically purged overboard on a timed basis. The package can be supplied in double configuration to meet UMS requirements.

The COMPAC propeller shaft bearing system uses seawater as the lubrication medium in place of oil. Seawater is taken from the sea, pumped through non-metallic COMPAC propeller shaft bearings and returned to the sea. To ensure that abrasives are removed from the seawater supply, a Thordon Water Quality Package is used. A constant supply of relatively abrasive free water is an important element in ensuring long, predictable, bearing wear life. With this factor in mind, Thordon has developed a self-contained supply, conditioning and monitoring package to ensure that an adequate supply of clean water is consistently being delivered to both the forward seal and the bearings.

The Thordon Water Quality Package is designed to supply seawater to the propeller shaft bearings for lubrication and cooling at a minimum flow rate of 0.15 litre/minute/mm (1 US gallon/minute/inch) of shaft diameter.

Besides helping out with shipyard issues during the construction period, Thordon is equally attentive to items that could impact bearing performance after delivery. When shipyard engineers noticed premature wear on the separators of Thordon’s Water Quality Package, After-sales Service representative Jayson Stansfield replaced the separators with an upgraded unit and set up the water quality packages at an optimum flow level for the cooling water to reduce the amount of wear.

Technical Information

Electrical Requirements: 380-420 V, 50 Hz / 440-480V, 60Hz,3ph (with 110V control circuit). Other requirements can be met.

Minimum Water Flow: 0.3 litres/minute/mm (2 US gallons/minute/inch) of shaft diameter.

Water Pressure: Pipework tested to 7 bar (102 psi)

Particle Separation: Specific gravity of 1.2 or higher and greater than 80 microns in size will be removed.

Piping Requirements: The package inlet and outlet pipes have flanged connection points. The suction and discharge piping should not be smaller than the inlet and outlet connections. The suction line must maintain adequate suction pressure and allow for smooth liquid flow to ensure proper pump operation.

PROPELLER SHAFT BEARING SYSTEMS - PAST

Over fifty years ago, propeller shafts were normally supported by bearings of lignum vitae, a dense hardwood from South America. As an ‘open’ system, seawater lubricated and cooled the propeller shaft bearings. There was only one seal per shaft preventing seawater ingress to the vessel, at those times a stuffing box.

However, lignum vitae bearings did not have reliable wear life much beyond five years which meant frequent shaft withdrawals to replacing the bearings -- an expensive maintenance cycle. Bearings were somewhat unreliable –they operated in an uncontrolled environment and no one could predict when they would wear out, sometimes even lasting for only one Atlantic Ocean crossing. Additionally, the packing in the stuffing boxes tended to score the bronze shaft liner which meant frequent skimming or replacement of the packing liner -- more additional costs for the shipowner.
PROPELLER SHAFT BEARING SYSTEMS - PRESENT

The invention of the Simplex seal by Blohm& Voss in 1948 permitted the move to a ‘closed’ sterntube system using white metal bearings operating in a sealed oil system. The controlled environment offered reliability and controlled wear life. The majority of commercial ships use this system today -- the propeller shaft Ice Class Vessels, 28-29 April 2015, London, UK © 2015: Royal Institution of Naval Architects supported by oil lubricated metal bearings within a stern tube sealed by forward and aft shaft seals. However, the ‘closed’ system was and still is problematic, the two shaft seals require frequent maintenance or oil would leak into the sea or seawater would ingress and contaminate the lubricating oil. A typical commercial ship will operate 6000 – 8000 hours per year on a 5year dry-docking schedule, however scheduled seal maintenance frequency is often as short as a 2.5year cycle.

Conclusion-

Modern materials, bearing design and control of operating conditions now mean performance, reliability and longevity of water systems similar to oil.

Seawater lubricated elastomer bearing systems are installed in over 600 commercial vessels with zero risk of oil pollution from their sterntube systems – these shipowners have prevented millions of litres of sterntube oil being lost annually to our oceans. The IMO has recognized that the Polar Regions require special measures to provide adequate protection from the potential impact of vessels operating in those waters. Operational and accidental discharges of oil from a vessel’s stern tube are all-too-common occurrences. This is of special concern in Polar waters as propellers are prone to impact with ice causing increased propeller shaft movements and seals struggle to maintain a complete barrier -- to keep lubricating oil in (and seawater out from) the sterntube. This often results in a discharge of lubricating oil to the environment.

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ABSTRACT - Heat Pipe are the superconductors of heat because of their fantastic heat handling and transporting ability with minimum heat loss. A lot of research and experimentation has been carried out on heat pipes due to modernization and miniaturization of equipment’s. In this research, the effect of heat input, performance of heat pipe under different tilt angles or inclinations and inclination angle on the thermal resistance of a heat pipe under normal operation condition has been investigated, experimentally. Gravitational and capillary forces play a very important role in deciding the overall performance of a heat pipe. At every different inclination, the resultant of these two forces varies, so the efficiency of a heat pipe also varies. This is the reason why there is a need to thoroughly study the performance of heat pipes at different inclinations. A miniature cylindrical heat pipe with small outer diameter, Ø10 mm and 300 mm in length, has been chosen in the study. The results show that the orientation and heat input have significant effects on the thermal performance of the cylindrical heat pipe. The Ø10 mm heat pipe operates with good thermal performance at the heat input of 70 W - 80 W and at the inclination angle of 30° - 60°.

INDEX TERM - Heat Pipe

1. INTRODUCTION: A heat pipe is a two phase heat transfer device with a very high effective thermal conductivity. It is a vacuum tight device consisting of an envelope, a working fluid, and a wick structure. As shown in Figure 1, the heat input vaporizes the liquid working fluid inside the wick in the evaporator section. The saturated vapor, carrying the latent heat of vaporization, flows towards the colder condenser section. In the condenser, the vapor condenses and gives up its latent heat. The condensed liquid returns to the evaporator through the wick structure by capillary action. The phase change processes and two-phase flow circulation continues as long as the temperature gradient between the evaporator and condenser are maintained.

Fig.1 Basic Heat Pipe

Heat Pipes are one of the most efficient ways to move heat, or thermal energy, from one point to another. These two-phase systems are typically used to cool areas or materials, even in outer space. Today, heat pipes are used in a variety of applications from space to handheld devices that fit in your pocket. According to our market experts, heat pipes are present in the cooling and heat transfer systems found in computers, cell phones, and satellite systems. These devices are sealed vessels that are evacuated and backfilled with a working fluid, typically in a small amount. The pipes use a combination of evaporation and condensation of this working fluid to transfer heat in an extremely efficient way.

The inclination angle of the heat pipe plays a very significant role in its overall thermal performance. Another very important factor that governs the performance of the heat pipe is its wick structure and material. When a heat pipe is used under gravity conditions, and then wicks with low capillary limit work best.

2. DESIGN AND CONSTRUCTION:
The three basic components of a heat pipe are the container, working fluid and the wick or capillary structure. The function of the container is to isolate the working fluid from the outside environment. It has to therefore be leak-proof, maintain the pressure differential across its walls, and enable transfer of heat to take place from and into the working fluid. A first consideration in the identification of a suitable working fluid is the operating vapor temperature range. Within the approximate temperature band, several possible working fluids may exist, and a variety of characteristics must be examined in order to determine the most acceptable one. Prime requirements are compatibility with wick structure, thermal stability, high latent heat and thermal conductivity, low viscosity etc. The wick is a porous structure made of materials like steel, aluminium, nickel or copper in various ranges of pore sizes. The prime purpose of the wick is to generate capillary pressure to transport the working fluid from the condenser to the evaporator.[1]

**PHP Design:**
The cooling device performance depends on its structure, shape, material and length. Thermal performance of any device vastly depends on a parameter known as thermal resistance.

Thermal resistance can be defined as: \( R_{th} = \frac{T}{Q} \)

**Heat transfer mechanism in Heat pipe:**
Heat pipes rely on a temperature difference between the ends of the pipe, and cannot lower temperatures at either end beyond the ambient temperature. When one end of the heat pipe is heated the working fluid inside the pipe at that end evaporates and increases the vapor pressure inside the cavity of the heat pipe. The latent heat of evaporation absorbed by the vaporization of the working fluid reduces the temperature at the hot end of the pipe. The vapor pressure over the hot liquid working fluid at the hot end of the pipe is higher than the equilibrium vapor pressure over condensing working fluid at the cooler end of the pipe, and this pressure difference drives a rapid mass transfer to the condensing end where the excess vapor condenses, releases its latent heat, and warms the cool end of the pipe. Non-condensing gases in the vapor impede the gas flow and reduce the effectiveness of the heat pipe, particularly at low temperatures, where vapor pressures are low. In the case of vertically-oriented heat pipes the fluid may be moved by the force of gravity.[2]

An interesting property of heat pipes is the temperature over which they are effective. Initially, it might be suspected that a water-charged heat pipe would only work when the hot end reached the boiling point (100°C) and steam was transferred to the cold end. However, the boiling point of water is dependent on absolute pressure inside the pipe. In an evacuated pipe, water will boil just slightly above its melting point (0°C). The heat pipe will operate, therefore, when the hot end is just slightly warmer than the melting point of the working fluid. Similarly, a heat pipe with water as a working fluid can work well above the boiling point (100°C), if the cold end is low enough in temperature to condense the fluid.[3]

3. EXPERIMENTAL SETUP:
For a detailed experimental investigation of the heat pipes thermal performance, a test rig has been developed. The test rig is built up for measurements of various heat pipes as mentioned. The test rig developed consists of three main sections, namely heating, condensing and data acquisition. The schematic diagram of the experimental setup is shown in Fig. 1. The test section consists of three parts, evaporator, adiabatic and condenser sections. In the experiment, the thermal performance is measured for a heat pipe of outer diameter Ø10 mm, having fixed length of 300 mm and operated with sintered powder wick. The working fluid in the heat pipe is water. The evaporator section is fitted into a heating block where heat is applied by a variable power supply of 220V AC to the evaporator using rod heaters which are mounted in the block clamped around the heat pipe while the condenser section is covered and cooled using a water jacket (condenser jacket). In the experiment, the temperature distributions are measured using eight thermocouples of K-type. The thermocouples are attached over the surface of the heat pipe as shown in the below figure.

Temperatures on the surface are measured using two thermocouples located at each section of the evaporator, adiabatic and condenser. Two others thermocouples are used to measure the inlet and outlet water temperatures of the water jacket. A thermometer data logger of 4 channels DL 309 is used to record all the temperatures. The flow rate of the cooling water is measured when the heat pipe attains steady state. Heat losses to the surroundings at the evaporator and adiabatic sections are minimized by applying thermal insulation. The actual experimental setup in a laboratory is physically shown in Fig. 3(a) & 3(b).
4. EXPERIMENTAL PROCEDURE:
Once the heat pipe is fully instrumented and setup in the rig, the condenser jacket flow may be started and heat applied to the evaporator section. Preferably, heat input should be applied at first in steps, building up to design capability and allowing the temperatures along the heat pipe to achieve a steady state before adding more power. When the steady state condition is reached, temperature profile along the heat pipe should be noted.

The experimental procedure can be summarized as follows:
Warm up the heat pipe by supplying the power to the heating block until the temperature at the adiabatic section reaches a specified working temperature. Once the working temperature is obtained, increase the heat load. Repeat the above step until dry-out at the beginning of the evaporator section is observed, which can be detected by a sudden temperature rise in the evaporator section. Record all the temperatures and calculate the temperature differentials, thermal resistance and thermal conductivity. In this experiment, the thermal performance of the heat pipe is investigated at various heat inputs, 30 W – 110 W and inclination angles, 0° - 90°.

5. THERMAL ANALYSIS:
In the present work, the thermal performance of the heat pipes are measured based on the parameters; temperature differentials, $\Delta T$, thermal resistance, $R$ and thermal conductivity, $K$. The measurements are accomplished applying a simple theoretical analysis as stated below:[6]

\[ T_{\text{evap}} = \frac{T_{\text{evap}1} + T_{\text{evap}2}}{2} \] ........................................(1)

\[ T_{\text{cond}} = \frac{T_{\text{cond}1} + T_{\text{cond}2}}{2} \] ......................................(2)

\[ \text{Temperature Differential, } \Delta T \, (^\circ C) = T_{\text{evap}} - T_{\text{cond}} \] ..............(3)

\[ \text{Input Heat, } Q_{\text{in}} \, (W) = IV \cos \theta \] ...........................................(4)

\[ \text{Thermal Resistance, } R \, (^\circ C/W) = \frac{T_{\text{evap}} - T_{\text{cond}}}{Q_{\text{in}}} \] ....(5)

\[ \text{Thermal Conductivity, } K \, (W/mK) = h \times t \] ............(6)

6. RESULTS AND DISCUSSION:
Fig.4 (a) & 4(b). Indicates the temperature differential of Ø10 mm heat pipe at various inclination angles and heat inputs. At heat input of over 70 W, the highest temperature differential is shown at the inclination angle of 0° and the lowest difference is measured at 30° within the same heat input range. The pattern of the temperature difference at each inclination angle is not much differed at lower heat input of below 70 W. The temperature differential recorded the highest value of approximately 14 °C at 100 W of heat input while the lowest difference in temperature of approximately 2 °C is observed at heat input of 30 W.

Fig.5 (a) & 5(b). Represents the thermal resistance of Ø10 mm heat pipe at various inclination angles and heat inputs. At heat input of over 70 W, the highest temperature differential is shown at the inclination angle of 0° and the
The lowest value is measured at 90° within the same heat input range. The pattern of the thermal resistance at each inclination angle is not much differed at lower heat input of below 70 W. The thermal resistance recorded the highest value of approximately 0.14 °C/W at 100 W of heat input while the lowest thermal resistance of approximately by 0.06 °C/W is observed at heat input of 80 W.

Fig.6 (a) & (b). Indicates the thermal conductivity of Ø10 mm heat pipe at various inclination angles and heat inputs. At heat input of over 60 W, the highest thermal conductivity is shown at the inclination angle of 30° and the lowest value is measured at 0° within the same heat input range. The pattern of the thermal conductivity at each inclination angle is not much differed at lower heat input of below 60 W but it tends to decrease tremendously at the inclination angle of 0° when the heat input reaches 70 W. The highest thermal conductivity of approximately 50 kW/mK is observed at 80 W of heat input while the lowest thermal conductivity of approximately 20 kW/mK is recorded at heat input of 100 W.

Fig.4 (a): Temperature differential of Ø10 mm heat pipe at various inclination angles and heat inputs

Fig.4(b): Temperature differential of Ø10 mm heat pipe at various inclination angles and heat inputs

Fig.5 (a): Thermal resistance of Ø10 mm heat pipe at various inclination angles and heat inputs

Fig.5(b): Thermal resistance of Ø10 mm heat pipe at various inclination angles and heat inputs
7. CONCLUSIONS:
A miniature heat pipe of Ø10 mm has been successfully tested. Various operating characteristics of heat inputs, 30 W – 110 W and inclination angles, 0° - 90° have been chosen. The results are discussed and analysed based on the temperature differential, thermal resistance and thermal conductivity at the corresponding parameters. For a detailed experimental investigation of the heat pipes thermal performance, a test rig has been successfully designed, developed and fabricated. The heat pipe orientation and heat input have significant effects on the thermal performance of the circular heat pipe. As the heat input is increased, the temperature differential at each orientation is also increased. However, the thermal resistance and thermal conductivity at each angle show a non-consistent pattern within the same range of heat input. The Ø10 mm heat pipe operates with good thermal performance at the inclination angle of 30° - 60° within the heat input of 70 W – 80 W.

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Electronic Brake force Distribution System

Aniket Jagtap1, Prof.V.Ramanathan2

1 Student, Dept. Of Mechanical Engineering, Sinhgad Academy of Engineering, Kondhwa.BK.Pune.Maharashtra, India.
2 Prof, Dept. of Mechanical Engineering, Sinhgad Academy of Engineering, Kondhwa.BK.Pune.Maharashtra, India

ABSTRACT—Electronic brakeforce distribution (EBD or EBFD) or electronic brakeforce limitation (EBL) is an automobile brake technology that automatically varies the amount of force applied to each of a vehicle’s wheels, based on road conditions, speed, loading, etc.

Always coupled with antilock braking systems (ABS), EBD can apply more or less braking pressure to each wheel in order to maximize stopping power whilst maintaining vehicular control. Typically, the front end carries the most weight and EBD distributes less braking pressure to the rear brakes so the rear brakes do not lock up and cause a skid. In some systems, EBD distributes more braking pressure at the rear brakes during initial brake application before the effects of weight transfer become apparent.

INDEX TERM— Electronic Brakeforce Distribution, Speed Sensor, Electronic Control Unit, Brake Force Modulators.

1. INTRODUCTION

You are driving at a safe speed on a moderately busy highway. It has not been snowing for long, but already the pavement is dusted with snow and becoming slippery. Suddenly, another motorist signals to enter your lane and makes a sharp veering motion. You are forced to slam on the brakes to avoid hitting the encroaching vehicle. The weight of your car is thrust forward from the heavy braking, putting added pressure on the front wheels to stop the car. Meanwhile, the sudden shift in weight has sign can reduced the amount of traction available for the back wheels. After a few seconds, the back wheels lock completely. You feel the back end of your car start to shall into the lanes on either side of you. Finally, the back-and-forth motion of the rear of the car overcomes the braking power of the front wheels and you spin around, face-to-face with oncoming track.

Situations like this are potentially very dangerous. Electronic brake-force distribution is a vehicle safety feature that can prevent this kind of event.

Electronic brake force distribution is an automobile brake technology that automatically varies the amount of force applied to each of a vehicle brakes, based on road conditions, speed, loading, etc. Always coupled with anti-lock braking systems, EBD can apply more or less braking pressure to each wheel in order to maximize stopping power.

Vehicle wheels may lock-up due to excessive wheel torque over tire road friction forces available, caused by too much hydraulic line pressure. The ABS monitor wheel speed and releases pressure on individual wheel brake lines, rapidly pulsing individual brakes to prevent lock-up. During heavy braking, preventing wheel lock up helps the driver maintain steering control. Four channel ABS systems have an individual brake line for each of the four wheels, enabling different braking pressure on different road surfaces. Three channel systems are equipped with a sensor for each wheel, but control the rear brakes as a single unit.
EBD is basically a subsystem of ABS and it always works in conjunction with an ABS system. The main job of EBD is to optimise brake force on each wheel individually so to get maximum breaking power without losing control. It can alter braking pressure on each wheel individually depending on the conditions and weight distribution of the vehicle at that moment.

2. What is Electronic Brakeforce Distribution System (EBFD)?

Electronic brake-force distribution system (EBFD) is an active vehicle safety feature designed to make braking as efficient as possible. A special function of antilock braking systems (ABS), EBFD makes the amount of brake force applied to a wheel proportional to that wheel’s load at the time. Just like how slamming on the brakes makes your body move forward, heavy braking pushes the weight of your vehicle forward onto its front wheels. When this happens, the rear wheels may not have enough weight on them to grip the road. This can cause the rear wheels to begin to spin and eventually lock up. Locked wheels are generally very dangerous because once your wheels lock you lose all steering power. Locked-up back wheels not only increase your risk of stalling, but they also force the front wheels to do all the work with only half of the total braking force available (because the other half of your brake force is still being applied uselessly to the locked rear wheels). This can result in longer stopping distances, spinning, and possibly loss of control.

EBFD reduces these dangers by automatically balancing the brake force applied to each wheel according to the overall weight distribution of the vehicle. When your EBFD system senses that one or more of your wheels is at risk of locking, it will reduce the brake force applied to the acted wheel(s), and, if necessary, apply more brake force to wheels that are not at risk of locking. Electronic brake-force distribution is also sometimes also called electronic brake distribution (EBD), or dynamic rear proportioning (DRP).

EBFD is similar in many ways to antilock braking systems (ABS), and the two are usually installed together. ABS help to prevent wheels from locking by sensing the threat of wheel lockage and then releasing and apply the brakes in rapid succession.

The difference between EBFD and ABS is that EBFD actually changes the amount of brake-force being applied to any given wheel according to the likelihood of that wheel locking. The added benefit of being able to redistribute brake-force makes EBFD a particularly useful extension of standard ABS setups.

3. Components of EBFD

3.1 Speed Sensor

The speed sensor not only calculates the speed of the car, but the speed of the engine also (RPM). One of the scenarios can be that the speed of the wheel might not be the same as the speed of the car. Such a situation can lead to the slip ratio skidding. The speed sensors calculate the slip ratio and relay it to ECU.

3.2 Electronic Control Unit

It is a small chip which collects the data from the speed sensors in each wheel and uses the data to calculate the slip ratio difference between the speed of the car and the rotation of the tyre). Once the slip ratio is determined, it makes use of the brake force modulators to keep the slip ratio within limits.

3.3 Brake Force Modulators
It is the job of these modulators to pump brake fluid into the brake lines and activate the brake cylinders. The brake force applied on each wheel can be modulated.

All these three components work in tandem and make the EBD work and save your day, every time you brake hard.

4. Working of Electronic Brakeforce Distribution System

Electronic brake-force distribution is often installed with antilock braking systems (ABS). ABS installations that are supplemented with EBFD react more quickly and deliver more situation-special braking commands than older ABS setups.

EBFD systems are usually made up of three subcomponents that are monitored and guided by an electronic control unit (ECU). These components include speed sensors for each wheel (sensors that Electronic Brake-Force Distribution (EBFD) monitor how fast the wheel is rotating), brake-force modulators (a mechanism that increases or decreases brake-force applied to a wheel), an acceleration/deceleration sensor that detects the vehicles forward and sideways acceleration/deceleration, and usually a yaw sensor (a sensor that monitors a vehicles movement along its vertical axis). The electronic control unit interprets the information from the speed and yaw sensors, and then sends commands to the brake-force modulators. Similar to how ABS setups operate; the ECU in EBFD systems is attached to the hydraulic brake-force modulator.

So, while the ECU and brake modulator serve different purposes, they are physically combined into one electro-hydraulic unit.

EBFD works by monitoring each wheel’s responsiveness to the brake, and then tailoring the amount of brake-force applied to each wheel. In vehicles without EBFD, when you apply the brakes the brake-force is evenly distributed across all four wheels. The danger here is that if, for example, one of your wheels is on ice and locks up, you lose 25 percent of your braking power. On a vehicle with EBFD, the system would sense that one of the wheels is not braking properly, and would redistribute the brake-force to the unexcited wheels to obtain optimal braking power. This way,
you retain the maximum amount of braking power possible and reduce the risk of stalling or spinning around.

Both front and rear tires have equal braking force i.e. 25% of total per tire.

Figure 3.3: Brakeforce Distribution without EBFD

The yaw sensor installed with most EBFD systems also helps prevent oversteering and understeering. Oversteering occurs when a vehicle continues to turn beyond the steering input of the driver, while understeering refers to cases where the vehicle does not turn enough in response to driver commands. Both oversteering and understeering are the result of insufficient traction on the road. If you begin to over-steer or understeer, the yaw sensor will record unusual movement along the vehicle's vertical axis, and your EBFD system will react by applying either the brakes on the inner wheel (to correct understeering) or the brakes on the outer wheel (to correct oversteering).

The front tires have more braking force than rear tires.

Figure 3.4: Brakeforce Distribution with EBFD

The above graph shows brake pressure distribution on rear wheel vs front wheel without and with the Electronic Brake force Distribution system. In addition, it also represents the fixed distribution and Ideal distribution of brakeforce on the same graph without and with the Electronic Brake force Distribution system.

Figure 3.5: Graph

4. Situations Where EBFD Is Most Useful
While driving it may seem like all four wheels are working in the same way. However, this is often not the case. Road conditions, weather conditions, and weight within the vehicle can all result in the vehicle's weight being unevenly distributed across its four wheels which can affect how each wheel is working individually. EBFD would be useful in the following scenarios:

1. While braking, one wheel goes over a pothole in the road, destabilizing the vehicle and making braking less effective.

2. One of your wheels is on ice, making it more likely that it will lock and cause your car to spin out.

3. An animal comes out onto the road and you need to brake and swerve.

4. Another motorist does not notice you when making a lane change, and you are forced to brake hard. Since EBFD works together with ABS, it is useful in every situation where ABS is useful.

These situations include those listed above, and generally cover any time a driver has to slam on the brakes to avoid a collision.

5. ABS With EBFD

Vehicles equipped with standard ABS setups (i.e., without EBFD) show a reduced stopping distance in low-traction conditions and a significant lower risk of being involved in frontal collisions. Since EBFD makes braking as efficient as possible, it will likely help lower stopping distance in slippery conditions. Optimal braking efficiency should also help further reduce the incidence of frontal collisions.

6. How much does EBFD cost?

EBFD is a standard part of modern ABS setups. Therefore, equipping a vehicle with EBFD costs the same as installing ABS approximately 240.00 Dollar (approximately 17000.00 RS) in the factory. In addition, installing EBFD on a vehicle has virtually no impact on overall fuel efficiency.

7. Advantages, Disadvantages and Application

7.1 Advantages

1. Heavy braking will be more comfortable: since braking is more effective with EBFD, your vehicle will stop faster, which will mitigate the effect that heavy braking has on your own body (i.e., throwing your body forward towards the steering column).
2. Enhanced overall vehicle safety: EBFD will help reduce your risk of stalling, spinning, oversteering, and understeering. Since braking is more effective on vehicles with EBFD, you will likely notice a reduction in stopping distance.

3. Improved braking predictability: the way your vehicle brakes constantly change depending on the condition of the road, the total weight of the vehicle, and the distribution of weight within the vehicle. By automatically adjusting brake-force to its optimal distribution, EBFD can help reduce the effects of these factors and make braking more predictable.

### 7.2 Disadvantages

1. EBFD is only useful at speeds under a certain threshold. The faster you drive, the longer it will take to stop safely. Beyond a certain speed, you may not be able to combine EBFD braking power with safe steering input. Excessive speed can seriously limit the benefit of EBFD and, in worse case scenarios, make it impossible for your vehicle to be stabilized in an emergency.

2. Makes the braking system more expensive, hence increase in overall cost of vehicles.

3. The benefits of EBFD depends on whether drivers understand its design limits and primary function, and can interact appropriately with it.

### 7.3 Applications

1. Electronic brakeforce distribution system is used in automobiles (Cars such as Maruti Ignis, Mahindra KUV, Tata Tiago, Maruti Swift, Ford Figo, Maruti Baleno, Nissan Micra Active, Maruti Swift Dzire, Ford Aspire, Toyota Etios Liva, etc).

### 8. Conclusion

The goal of Electronic Brakeforce Distribution System (EBFD) is to give you optimal braking efficiency by distributing the brake-force proportionally to the braking power of each wheel. EBFD cannot warn you of impending collisions or of bad road conditions, so it is up to you to assess road conditions and notice any potential hazards.

EBFD can help make braking on poor road conditions as safe as possible, but this does not mean that its completely safe. There are still many dangers associated with driving in bad weather conditions, including low visibility and less overall traction. Whether or not EBFD helps also depends on how quickly you react to a potential hazard and how safely you can steer to avoid it. Given both of these limiting factors, you are always encouraged to use vehicle safety features like EBFD to complement your responsible driving practices, and not as a reason for driving less attentively or less cautiously.
Review of Autonomous Vehicles: Concept, Barriers and Opportunities

Aakash D. Dabade¹, Ramanathan Venkatachalam²

¹Department of Mechanical Engineering, Sinhgad Academy of Engineering, Kondhwa (BK), Pune, Maharashtra, India 411048
²Department of Mechanical Engineering, Sinhgad Academy of Engineering, Kondhwa (BK), Pune, Maharashtra, India 411048

ABSTRACT

Autonomous vehicles are the vehicles anticipated to be driver less, efficient and crash avoiding ideal vehicles of the future. Autonomous vehicles can guide it or take decision while driving without human’s interaction. This kind of vehicle has a correct reality and it is a way to the futuristic smart cars. This paper explains some of the human factors challenges associated with the transition from manually driven to self-driving vehicles. The major benefits of autonomous vehicles are reduction in accidents, traffic congestion, CO2 emission, fuel consumption, travel time, transportation costs. But it increases cost, loss in driver jobs. A computer malfunction can cause the worst accident than human error. The human factors are dependent on levels of autonomy.


1. INTRODUCTION

Autonomous Vehicles (AVs) will be the technology of future. It is a very hot discussion topic today. New technologies in communication and robotics have had a substantial influence on our daily lifestyle of which transportation is no exception. These technologies have given rise to the prospect of autonomous vehicle (AV) technology which aims to reduce number of accidents, more fluent, reduce crashes, energy consumption, pollution, congestion, autonomy for people who cannot drive, etc.

The technical challenges are also very high. Thus, the vehicle has to be able to detect in real time and on all weather conditions the lanes and the shape of the road, the other vehicles, the pedestrians, the traffic lights (and the road signs) and to make real-time decisions to respond to all these traffic conditions, while maintaining an optimal route towards its destination.

The combination of these technologies and other systems such as video based line analysis, steering and brake actuation systems, and the programs necessary to control all of the components will become a fully autonomous system.

FIGURE 1 Features of Autonomous Vehicles

2. CONCEPT OF AUTONOMOUS VEHICLES

A completely autonomous vehicle is one in which a computer performs all the tasks that the human driver normally would. Ultimately, this would mean getting in a car, entering the destination into a computer, and enabling the system. From there, the car would take over and drive to the destination with no human input. The car would be able to sense its environment and make steering and speed changes as necessary. This scenario would require all of the
automotive technologies mentioned above: lane detection to aid in passing slower vehicles or exiting a highway; obstacle detection to locate other cars, pedestrians, animals, etc.; adaptive cruise control to maintain a safe speed; collision avoidance to avoid hitting obstacles in the road way; and lateral control to maintain the cars position on the roadway. In addition, sensors would be needed to alert the car to road or weather conditions to ensure safe traveling speeds.

3. DEFINITIONS

- Autonomous vehicles are “such vehicles that are able to perceive their environment and to move on without any intervention of a human driver (Gehrig S. K. and Stein F. J.).”
- The term autonomous ground vehicles (AGVs) refer to vehicles that are able to navigate without human intervention as part of the highway or urban traffic, and/or off-road (T. Luettel, M. Himmelshach, H-J Wuensche).

4. LEVEL OF AUTONOMY

Levels of automation it is important to note that the level of automation can vary from zero to full automation. Levels of autonomy simply explain us how autonomous vehicle is.

1. No-Automation (Level 0)
2. Function-specific automation (Level 1)
3. Combined function automation (Level 2)
4. Limited self-driving automation (Level 3)
5. Full self-driving automation (Level 4)
6. Full Automation (Level 5)

5. WORKING OF AUTONOMOUS VEHICLE

Generally speaking, AVs operate on a three-phase design known as “sense-plan-act” which is the premise of many robotic systems. A substantial challenge for AVs rests in making sense of the complex and dynamic driving environment. To this end, the AVs are equipped with a variety of sensors, camera, radars, etc., which obtains raw data and information from the surrounding environment. These data would then serve as input for software which would recommend the appropriate courses of action, such as acceleration, lane changing, and overtaking. A combination of surveillance technologies is employed to cope with such a challenging job. Typically, this task is solved by a combination of radar, Lidar, and mono or stereo camera systems.

A. GOOGLE MAPS

A Google map provides the car with information of road and interacts with GPS to act like a database through GPS and Google maps navigate.

B. LIDAR

(Light Detection And Ranging also LADAR) is an optical remote sensing technology which is used to measure the distance of target with illumination to light in the form of pulsed laser. It is a laser range finder also known as “heart of system”, mounted on the top of the spoiler. Its scanning distance is of 60 meters (~ 197 feet). A LIDAR instrument consists of a Laser, Scanner and a specialized GPS receiver, principally.
C. VIDEO CAMERA
A sensor is positioned near to the rear-view mirror that detects the upcoming traffic light. It performs the same function as the mildly interested human motorist performs. It reads the read signs and keeps an eye out for cyclists, other motorists and for pedestrians.

D. POSITION ESTIMATOR
An ultrasonic sensor also known as (Wheel Encoder) mounted on the rear wheels of vehicle, determines the location and keeps track of its movements. By using this information it automatically update the position of vehicle on Google Map.

E. DISTANCE SENSOR (RADAR)
Distance sensors which include four radars, mounted on both front and rear bumpers are also carried by this autonomous vehicle that allows the car to “see” far enough to Detect Nearly or Upcoming Cars or Obstacles and Deal with Fast Traffic on Freeways.

F. COMPUTER
Car’s central computer holds all the information that is fed from various sensors so to analyze the data, steering and acceleration and brakes are adjusted accordingly.

G. ARTIFICIAL INTELLIGENCE
Artificial Intelligence provides the autonomous car with real time decisions. Data obtained from the Hardware Sensors and Google Maps sent to A.I for determining the acceleration i.e. how fast it is; when to slow down/stop and to steer the wheel. The main goal of A.I is to drive the passenger safely and legally to his destination.

H. AERIAL
A highly accurate positioning data is demanded by a self – navigating car. Readings from the car’s onboard instruments (i.e. Altimeters, Tachometers and Gyroscopes) are combined with information received from GPS satellites to make sure the car knows exactly where it is.

6. DRIVE BY WIRE TECHNOLOGY
This technology in the automotive industry replaces the traditional mechanical control systems with electronic control systems using electromechanical actuators and human-machine interfaces such as pedal and steering wheel.

7. HUMAN FACTORS

A. INTERNAL FACTORS
1) DRIVER INATTENTION AND DISTRACTION: Although automation is usually intended to lighten driver workload, this is not necessarily beneficial for driving and does not always lead to increased road safety. If the workload on the driver is too little during periods of automation, the driver may experience passive fatigue, which is argued to stem from situations in which cognitive load is low and there a lack of direct control over the task at hand (Desmon and Hancock, 2001). Moreover, research has shown that passive fatigue can degrade overall driver performance. Several studies have demonstrated the adverse effects of secondary task demands on take-over time and quality in automated driving (e.g., Merat et al., 2012).

2) SITUATIONAL AWARENESS: Situational awareness is an operator’s dynamic understanding of what is happening around them (Salmon, Stanton, Walker, & Jenkins, 2009). When drivers divert attention away from the automated driving task (i.e., distraction) or attention is diminished in the absence of a competing activity (i.e., inattention; Regan, Lee and Young, 2009), their level of SA will likely diminish as attentional resources are not being devoted to maintaining awareness of the vehicle state and road situation (de Winter, Happee, Martens, & Stanton, 2014). This reduction in SA in periods of automation can be dangerous as automation actions and alerts will likely be unexpected and come as a surprise to the driver (creating an ‘automation surprise’; Wiener, 1989; Hollnagel& Woods, 2005).

3) OVERRELIANCE AND TRUST: As automated systems take over control of many driving tasks, drivers may learn to overestimate and over-rely on automation performance. Overreliance occurs when a driver does not question the performance of automation and insufficiently counterchecks the automation status (Saffarian, de Winter, &Happee, 2012). The phenomenon is synonymous with a sense of over-trusting automated systems, in which an operator’s trust in the automation exceeds its actual capabilities, resulting in the operator over-utilising it (Lee and See, 2004).

These consequences of over-reliance in the automation are known as negative behavioural adaptation effects and can be detrimental to safe driving (Regan, 2004).
4) **SKILL DEGRADATION**: Drivers that over-rely on highly automated driving systems may fail to use their manual driving skills over long periods of time (Parasuraman, Sheridan, & Wickens, 2000). The neglect of manual driving skills may, in turn, may degrade both the psychomotor dexterity and cognitive skills required to manually complete a task successfully and safely (e.g., Parasuraman et al., 2000). Ironically, this loss of skill may further encourage reliance on automation (Lee & Moray, 1994).

5) **MOTION SICKNESS**: Motion sickness is a condition marked by symptoms of nausea, dizziness, and other physical discomfort (Golding, 1992) and can be associated with various modes of transportation (e.g., boats; Byrne & Parasuraman, 1996).

The condition is most frequently caused by a conflict between visual and vestibular inputs (Benson, 1999), loss of control over one’s movements (Rolnick & Lubow, 1991) and reduced ability to anticipate the direction of movement (Golding & Gresty, 2005).

6) **RE-ENGAGING THE DRIVER**: The process of how to efficiently and quickly re-engage the driver from automated driving in Level 2 and Level 3 autonomous vehicles is emerging as one of the key topics requiring research. Fundamental to this issue is the time frame required by drivers to successfully regain manual control of the vehicle. In reality, there is no optimal single or general take-over time; the time is likely to be influenced by a combination of variables such as traffic density, driver experience and driver engagement in secondary tasks at the time takeover is required (Zeeb, Buchner, & Schrauf, 2015).

B. **EXTERNAL FACTORS**

The Chart I describes that how Autonomous vehicles deal with External factors.

### CHART I

**EXTERNAL FACTORS IN AUTONOMOUS VEHICLES**

8. **MERITS AND DEMERITS**

A. **MERITS**

1) **SAFETY**: Implementation of autonomous vehicles can greatly reduce the number of crashes, since 90 percent of the traffic accidents are caused by human error. Intelligent safety systems that are currently in use have already proven their success in helping drivers avoid accidents.

2) **IMPACTS ON TRAFFIC**: With the introduction of a fully autonomous vehicle, traffic flow would drastically change. The autonomous vehicles would be following all traffic laws while human drivers have the choice to break the law. As time progresses and the autonomous car becomes a more commonly used vehicle on the road, traffic would become far less congested. Cars would be able to seamlessly merge into moving traffic and then exit the highway just as easily. With the reduction of traffic, there is a chance that there could be economic improvements. Also, with less stop and go traffic, average fuel economy would be improved. Vehicles are also following each other consistently which would help with fuel usage as well.

3) **FUEL ECONOMY**: Autonomous vehicles will eliminate ineffective speeding up and braking, operating at an optimum performance level in order to achieve best possible fuel efficiency. It is possible to obtain superior fuel efficiency as a result of the implementation of autonomous safety systems.
4) **TIME COSTS:** The phrase “time is money” is true for most situations in modern life and the monetary value of time is increasing every day. Using automated cars could save considerable amount of time in a person’s life, especially if the person resides in a busy city. Lowering the amount of time lost will also enable people to be on time and more dynamic, resulting in a significant improvement in work efficiency. One of the biggest advantages of this technology will be the elimination of traffic problems in cities, which are at the top of the most frustrating problems list for most people.

**B. DEMERITS**

1) **COST OF SENSORS:** The equipments and technologies used are costly the main equipments used in this technology are radar, LIDAR, position sensor, GPS module, Multicore heterogeneous processor, JAUS interoperable communication systems, high resolution cameras are very costly now.

2) **COMPLEX SOFTWARE:** Complex artificial intelligence software the brain of the robotic car is its intelligent real time decision making software the design and implementation of this part of the system is much more complicated.

3) **CONFUSION WITH OTHER NON-AUTONOMOUS VEHICLES:** Present road conditions may vary and which will affect the decisions made by the software since our system is mainly based on pure artificial intelligence, the non-ideal conditions and decisions made by other human drivers may vary. This may affect the ideal operation of the robotic car.

4) **UNEMPLOYMENT:** Professional drivers will be jobless

**9. CONCLUSION**

Currently, there are many different technologies available that can assist in creating autonomous vehicle systems. Items such as GPS, automated cruise control, and lane keeping assistance are available to consumers on some luxury vehicles. The combination of these technologies and other systems such as video based lane analysis, steering and brake actuation systems, and the programs necessary to control all of the components will become a fully autonomous system.

The problem is winning the trust of the people to allow a computer to drive a vehicle for them, because of this, there must be research and testing done over and over again to assure a near fool proof final product. The product will not be accepted instantly, but overtime as the systems become more widely used people will realize the benefits of it. The implementation of autonomous vehicles will bring up the problem of replacing humans with computers that can do the work for them. There will not be an instant change in society, but it will become more apparent over time as they are integrated into society. The human factors are dependent on levels of autonomy. As we increases the Autonomy level of vehicle then the driver efforts wills decreases.

Mechatronics will not only be a complementary part of the automobile industry but an indispensable part of it. However, it seems that the current regulations do not keep up with the development of technology and sometimes hinder the development and testing of autonomous technologies.

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**REFERENCES**


AAKASH D. DABADE 4th year B.E. Mechanical Engineering student of Sinhgad Academy of Engineering, Kondhwa BK, Pune, Maharashtra, India 411048. Active Member of Mechanical Engineering Student Association (MESA) in SAE, Kondhawa

RAMANATHAN VENKATACHALAM is working as an Assistant Professor in Department of Mechanical Engineering, Sinhgad Academy of Engineering, Kondhwa BK, Pune, Maharashtra, India 411048.
Develop and Implement Preventive Maintenance System for Hydraulic Baling Machine to Enhance Productivity

Mr. Akshay Gajanan Vaidya¹, Mr. PravinHLokhande², Mr. Aditya Prakash Naswale³, Mr. Viraj Arvind Patil⁴, Mr. Pavan Purushottam Adhao⁵

₁,₂,₃,⁴ Department of Mechanical Engineering, Sinhgad College of Engineering, Vadgaon, Savitribai Phule Pune University, Pune, Maharashtra, India

¹akshayvaidya3097@gmail.com, ²pravinlokhande07@rediffmail.com, ³adityanaswale111@gmail.com, ⁴virajpatil165@gmail.com, ⁵pavanadhao123@gmail.com

ABSTRACT:

Madhuban Trade Steels Pvt. Ltd is a scrap dealing unit, having its major vendors from automobile sector. The backbone of the industry is the Hydraulic Baling Machines used to mould the metal scrap into cubical ingots. All these machines during Breakdown Maintenance, create many problems like production halt, untimely delivery of ingots, repairs of breakdown parts etc. Affecting the productivity of company. These problems encourage due to develop and implement a Preventive Maintenance Manual for the machine Preventive Maintenance System plays a fundamental role in keeping and improving the operational condition of machine and the output product quality. This project includes inspection, repairs, replacements of breakdown parts, detailed drawing of each component, Standard Operating Procedure (SOP), Standard Maintenance Practice (SMP), Handover-Takeover reports, daily, weekly, monthly checklists, tools and spare parts required, leading to creation of a complete Preventive Maintenance Manual for the Hydraulic Baling Machine. Through this project we will be able to determine the cause of breakdown and ways to troubleshoot these breakdowns. This will shift the machine from breakdown maintenance system to preventive maintenance system, increase in the productivity of company.


I. INTRODUCTION

MTC GROUP is a 4 decades old business group based in Mumbai-India, with domestic and International business operations in Scrap (Ferrous & Non-Ferrous), Ferro Alloys, base Metals, Minor Metals, Iron Ore, Steel Flat & Long products and Automobiles. The company gets its scrap from its major vendors of automobile industry. Material composition being one of the major aspects helping to segregate the scrap and that’s why its spectro analysis is important. Material is tested in spectro lab and its composition is verified asper requirement. Segregation of scrap into value added being traded to vendors and non-value added is taken to hydraulic baling machines. These machines are backbone of the company, which converts scrap to bales of various sizes (8*8, 9*9, 10*10, 12*12, 14*14). These bales after their inspection are then transported to foundries across Maharashtra.

The hydraulic baling machines working 24*7, gives rise to many problems like oil leakages, tampered pipes, loose fittings, noise leading to production of unsized product, untimely delivery, production halt, breakdowns etc. These factor hampers the overall productivity of plant. To avoid these failures and to have a smooth & proper working of machines preventive maintenance plays an important role.

Thus, as per company’s need to develop and implement preventive maintenance culture. This project deals with important aspects of PMS and its implementation on baling machine. Preventive maintenance involves the systematic inspection of equipment where potential problems are detected and corrected in order to prevent equipment failure before it happens. In practice, a preventive maintenance schedule may include things such as cleaning, lubrication, oil changes, adjustments, repairs, inspecting and replacing parts, and partial or complete overhauls that are regularly scheduled.
A. Need

Hydraulic circuits are increasingly present on current equipment and are now part of the daily routine of maintenance teams. By their very own nature, hydraulic equipment, which have also undergone many improvements in recent years, require specific monitoring methods and good practices, which must be monitored to ensure the safety of the operator and avoid potential breakdowns. This equipment represent risk for operators, particularly pressure hydraulic liquid, and are increasingly complex. The main causes of accidents caused by hydraulic fluids under pressure are related to maintenance defects, oil leaks, a rupture of a circuit element or the irregular movement of a component of the piece of equipment.

In order to maintain the piece of equipment in its intended function without damage to itself or its environment, and to optimize the safety of its operation, it is preferable to implement preventive maintenance strategy. Suitable for all types of installations (electrical, mechanical, pneumatic or hydraulic), preventive maintenance ensures the company better reliability and machine availability and, as a result, better overall performance. Some regular little time-consuming planned actions make it possible to increase efficiency and avoid downtime.

B. Aim

To develop and implement preventive maintenance system for hydraulic baling machine to enhance productivity.

C. Objectives

1. To develop detailed preventive maintenance manual.
2. To minimize or eliminate frequent unwanted breakdowns and to reduce production down time by 60%.
3. To plan all the maintenance related jobs so that the maintenance cost is reduced by 60%.
4. Enhance productivity by 50%.
5. To complete bailing operation within 45 seconds as mentioned in the machine specification.
6. To enhance safety & reliability in operation.

II. LITERATURE REVIEW

Alessio Angius et al [1] have carried out an analytical approach for the analysis of the impact of preventive maintenance on the service level of manufacturing system characterized by degrading machines. The actual degradation state of critical machines is inferred from condition monitoring information gathered by sensor networks. The results obtained from the application of the method to a real industrial case in the aeronautics industry show that the decisions on the optimal maintenance policies depend on both the actual status of machines and the target lot completion time, thus paving the way to new service level maintenance policies.

AdeSupriatna et al [2] studied many approaches in determining optimal maintenance policy. The proposed classification is based on the practical cases presented in references. Discussion about comprehensive thinking in PM strategy is also elaborated. Based on authors’ knowledge, there papers work on our concern beforehand. This feature, makes this paper different from others. This paper offers useful new insights for both academics and practitioners in the area of PM.

Praveen Kumar R and Rudramurthy [3] has described about project on hydraulic press where all repeated breakdowns were analysed along with the critical parts, which were under breakdown condition and was also identified and analysed, also the reasons for the breakdown were analysed and inspected by the method of fish bone diagram and why-why analysis. This analysis and methods helped to develop and improve a new preventive maintenance checklist for the machine.

Cijo Mathew et al [4] have studied major breakdowns causing production losses to the company and to suggest counter measures by which these problems can be reduced. In the study a Root cause analysis is conducted to find the root cause of breakdowns and some parallel improvement opportunities were also identified for implementation so as to reduce the downtime.

III. METHODOLOGY

This project is about shifting the work culture from breakdown maintenance to preventive maintenance culture. The literature survey gives collected views and opinion of authors for the continuous improvement, machine breakdown analysis and effective preventive maintenance strategies to reduce machine down time in the industry.
gives brief idea about the techniques required to implement preventive maintenance strategies.

This project also contains development of comprehensive preventive maintenance manual with all troubleshooting guidelines, so that it gets easier for maintenance team to know exactly the causes of failure are and how they can be solved out.

Methodology proposed to implement preventive maintenance culture is as follows –

![Methodology Diagram]

A. Line Tracing & Part Drawing

Line tracing of hydraulic system means following the path of hydraulic oil flow through the machine. It helps to understand the sequence of actuation of various components of machine. By having a line tracing diagram at hand one can easily go through the circuit of machine. If problem occurs in hydraulic flow lines, the diagram can help to find it & verify it.

Part drawing involves detailed drawing of each part of machine along with its dimensions.

B. Techniques involved in Preventive Maintenance System

1. Generating standard operating procedure [SOP]: SOP is a set of step-by-step instructions compiled to help workers carry out complex routine operations. SOP’s aim to achieve efficiency, quality output and uniformity of performance while reducing failure chances. SOP is used to improve productivity of system reduce downtime cause by failure.

2. Generating standard maintenance practice [SMP]: SMP is a written set of instructions that specifies how a maintenance procedure is to be performed. It should be specific and detailed enough so that qualified maintenance technician who has never before performed the task can do so successfully by reading and following the instructions contained in it.

3. Preparing One Point Lesson charts [OPL]: One Point Lesson is a 5 to 10 minutes learning tool, which normally consists of 80% diagram & 20% words. An OPL quickly enables a term to share key learning & builds a common understanding of the system and standard that apply to work area. It strengthens the understanding for function of machine and line. Improve knowledge about maintenance defect prevention.

4. Daily-weekly-monthly-forms/checklists: Daily-weekly-monthly forms or checklist ensures whether required work is done in specific way or not. These forms specify operations of machine and scheduling task required on the machine.

C. Identification & Analysis of Machine Breakdown

In an effective analysis of machine breakdown, it is imperative that problem solvers be able to find the root cause of the problem. With this we will be able to arrive to a best possible actions or solutions that will mitigate the risk & to prevent the problem occurrence.
Fig. 2: Analysis of machine breakdown

Data collection is also an important aspect of any research study. Data is essential for investigating the root cause of any problem. To improve machine uptime, it is essential to find out root causes of failure of the machine. There are several techniques to identify that machine needs to go through maintenance activity, as productivity of machine reduces and downtime increases. These techniques are as follows:

1. **Mean Time Between Failures (MTBF):** It is time between two failures of machine and it is given by,
   
   $$MTBF = \frac{\text{total available hours} - \text{breakdown hours}}{\text{no. of breakdowns}}.$$ 

   If MTBF is high then machine is considered as OK and if low then considered that it requires maintenance.

2. **Mean Time to Repair (MTTR):** It is the average time that machine takes to repair after failure.
   
   $$MTTR = \frac{\text{total breakdown hours}}{\text{no. of breakdowns}}.$$ 

3. **Availability/Operational availability (uptime):** Availability is the total time of utilization of machine. Availability is the ratio of difference between total available hours and total breakdown hours.
   
   $$\text{Availability} = \frac{\text{total available hours} - \text{breakdown hours}}{\text{total available hours}}.$$ 

   From the data collection and analysis of data, these factors can be found out, which gives specific information about machine maintenance requirements.

**D. Preparing troubleshooting guidelines**

Troubleshooting guideline is a systematic approach to problem solving that is often used to find correct issue with complex machine systems. The first step of troubleshooting is gathering information of the problem, such as understanding mode of breakdown.

**E. Development & Implementation of Preventive Maintenance System**

1. **Operators Training Program:** Operators and worker should be familiar with the machine operations and a right way of performing required task on machine. Operators training program will help to understand the operations and carry out the same in a systematic manner.

2. **Preventive Maintenance Manual:** All the techniques mentioned above leads to generation of detailed preventive maintenance manual. This manual will help to create a preventive maintenance culture in company.

**IV. RESULTS & CALCULATION**

**A. Calculations**

1. **Availability:**
   
   $$\frac{\text{Total Available Hrs} - \text{Total Breakdown Hrs}}{\text{Total Available Hrs}}$$

2. **Mean Time Between Failure (MTBF):**
   
   $$\frac{\text{Total Available Hrs} - \text{Breakdown Hrs}}{\text{No of Breakdowns}} \text{ (In Hrs.)}$$

3. **Mean Time to Repair (MTTR):**
   
   $$\frac{\text{Total Breakdown Hours}}{\text{No of Breakdowns}} \text{ (In Hrs.)}$$

**TABLE I**

After Implementation of Preventive Maintenance System

### Monthly Downtime Report

<table>
<thead>
<tr>
<th>Machine Name:</th>
<th>ADVANCED HYDRAULIC BALING MACHINE (8 X 8)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sr. N o.</td>
<td>Month</td>
</tr>
<tr>
<td>1</td>
<td>OCT – 19</td>
</tr>
<tr>
<td>2</td>
<td>NOV - 19</td>
</tr>
</tbody>
</table>

### Table II


<table>
<thead>
<tr>
<th>Monthly Downtime Report</th>
</tr>
</thead>
<tbody>
<tr>
<td>Machine Name:</td>
</tr>
<tr>
<td>Sr. N o.</td>
</tr>
<tr>
<td>1</td>
</tr>
<tr>
<td>2</td>
</tr>
</tbody>
</table>

---

*Others: 1) No Material
2) Idle
3) Reconditioning
4) Holiday

**Before Applying Preventive Maintenance System (PMS):**

1. *For the month of October:*

   \[
   Availability = \frac{604.5 - 103.8}{604.5} \times 100
   \]

   \[\therefore Availability = 82.82 \%\]

   \[
   MTBF = \frac{604.5 - 103.8}{6}
   \]

   \[\therefore MTBF = 83.45 Hrs.\]

   \[
   MTTR = \frac{103.8}{6}
   \]

   \[\therefore MTTR = 17.3 Hrs.\]

2. *For the month of November:*

   \[
   Availability = \frac{585 - 101.5}{585} \times 100
   \]

   \[\therefore Availability = 82.64 \%\]

   \[
   MTBF = \frac{585 - 101.5}{7}
   \]

   \[\therefore MTBF = 69.07 Hrs.\]

   \[
   MTTR = \frac{101.5}{7}
   \]

   \[\therefore MTTR = 14.5 Hrs.\]
1. For the month of January:

\[ \text{Availability} = \frac{604.5 - 16}{604.5} \times 100 \]

\[ \therefore \text{Availability} = 97.3 \% \]

\[ MTBF = \frac{604.5 - 16}{4} \]

\[ \therefore MTBF = 147.12 \text{ Hrs.} \]

\[ MTTR = \frac{16}{4} \]

\[ \therefore MTTR = 4 \text{ Hrs.} \]

2. For the month of February:

\[ \text{Availability} = \frac{604.5 - 8.5}{604.5} \times 100 \]

\[ \therefore \text{Availability} = 98.59 \% \]

\[ MTBF = \frac{604.5 - 8.5}{5} \]

\[ \therefore MTBF = 119.2 \text{ Hrs.} \]

\[ MTTR = \frac{8.5}{5} \]

\[ \therefore MTTR = 1.7 \text{ Hrs.} \]

Average values of Availability, MTBF, MTTR before and after PMS for period (October 2019 to February 2020)

### TABLE III

<table>
<thead>
<tr>
<th>Before PMS</th>
<th>After PMS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Avg. value of % Availability</td>
<td>Avg. value of % Availability</td>
</tr>
<tr>
<td>Avg. value of MTBF (Hrs.)</td>
<td>Avg. value of MTBF (Hrs.)</td>
</tr>
<tr>
<td>Avg. value of MTTR (Hrs.)</td>
<td>Avg. value of MTTR (Hrs.)</td>
</tr>
<tr>
<td>82.72</td>
<td>76.26</td>
</tr>
<tr>
<td>15.9</td>
<td>97.94</td>
</tr>
<tr>
<td>2.85</td>
<td>133.1</td>
</tr>
</tbody>
</table>

B. Results

1. Percentage Increase in Availability:

\[ \text{Final Avg. Availability after PMS} - \text{Initial Avg. Availability before PMS} \]
\[ \text{Initial Avg. Availability before PMS} \times 100 \]

\[ = \frac{97.94 - 82.72}{82.72} \times 100 \]

\[ \therefore \text{Percentage Increase} = 18.39 \% \]
2. **Percentage Increase In MTBF:**

\[
\text{Final Avg. MTBF after PMS} - \frac{\text{Initial Avg. MTBF before PMS}}{\text{Initial Avg. MTBF before PMS}} \times 100
\]

\[
= \frac{133.16 - 76.26}{76.26} \times 100
\]

\[
\therefore \text{Percentage Increase} = 74.61\%
\]

3. **Percentage Reduction In MTTR:**

\[
\text{Initial Avg. MTTR before PMS} - \frac{\text{Final Avg. MTTR after PMS}}{\text{Initial Avg. MTTR before PMS}} \times 100
\]

\[
= \frac{15.9 - 2.85}{15.9} \times 100
\]

\[
\therefore \text{Percentage Reduction} = 82\%
\]

4. **Percentage increase in Productivity:**

Avg. time required for 1 bale = 60 sec. (before PMS)

\[
\text{Avg. No. of bales} = \frac{\text{Total Utilized Hours}}{\text{Time Required For Single Bale}}
\]

\[
= \frac{426.95 \times 60 \times 60}{60}
\]

\[
= 549.45 \times 60 \times 60
\]

\[
\therefore \text{Productivity} = 25617 \text{ bales (before PMS)}
\]

Avg. time required for 1 bale = 48 sec. (after PMS)

\[
\text{Avg. No. of bales} = \frac{\text{Total Utilized Hours}}{\text{Time Required For Single Bale}}
\]

\[
= \frac{549.45 \times 60 \times 60}{48}
\]

\[
\therefore \text{Productivity} = 41209 \text{ bales (after PMS)}
\]

Therefore, Percentage Increase in Productivity,

\[
\text{Final Productivity after PMS} - \frac{\text{Initial Productivity before PMS}}{\text{Initial Productivity before PMS}} \times 100
\]

\[
= \frac{41209 - 25617}{25617} \times 100
\]

\[
\therefore \text{Percentage Increase in Productivity} = 60.86\%
\]
V. CONCLUSION

This project deals with developing and implementing a preventive maintenance system for hydraulic baling machine. The project work comprises all preventions over breakdowns, various preventive maintenance measures like SOP, SMP, Monthly check-lists, troubleshooting guidelines, detailed study and drawings of each components, spare part & tool lists, OPL, LOTO, instruction regarding safety. All these parameters are compiled together to form a Preventive Maintenance Manual for 8*8 Hydraulic Baling Machine.

Parameters like MTTR, MTBF, AVAILABILITY, helps in determining the performance of machine and to evaluate the % productivity increase, which is the ultimate goal.

The objective of shifting the company’s maintenance culture from Breakdown to Preventive is achieved as the proposed outcomes are fulfilled through various analytical data and figures.

1. The availability of machine is 97.94%.
2. The productivity is increased by 60.86%.
3. The cycle time of operation is reduced to 48 seconds.
4. Thus, detailed Preventive Maintenance Manual is developed shifting Breakdown Maintenance culture to Preventive Maintenance culture.

ACKNOWLEDGEMENT

The satisfaction and euphoria on the success of any task would be incomplete without the mention of the people who made it possible, whose constant guidance and encouragement crowned our effort with success. We would like to take the opportunity to express our respect, deep gratitude and genuine regard to our guide Prof. Mr. P. H. Lokhande and all Mechanical Engineering Department Staff Members, who directly or indirectly helped us in completion of this work.

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Design and Fabrication of Wheel Conveyor for Boxer Headlamp Assembly

Mr. Pravin H. Lokhande1, Ms Gatika Kandarikar2, Mr. Akash Mali3, Mr. Shubham Mahajan4, Mr. Sachin Mahajan5

1 Dept. of Mechanical Engineering, Sinhgad College of Engineering Vadgaon BK Pune, Pune, Maharashtra, India, 411041
2 Dept. of Mechanical Engineering, Sinhgad College of Engineering Vadgaon BK Pune, Pune, Maharashtra, India, 411041
3 Dept. of Mechanical Engineering, Sinhgad College of Engineering Vadgaon BK Pune, Pune, Maharashtra, India, 411041
4 Dept. of Mechanical Engineering, Sinhgad College of Engineering Vadgaon BK Pune, Pune, Maharashtra, India, 411041
5 Dept. of Mechanical Engineering, Sinhgad College of Engineering Vadgaon BK Pune, Pune, Maharashtra, India, 411041

ABSTRACT

In a manufacturing industry, the material needs to be transported from one manufacturing stage to another. Material handling equipment are designed such that they facilitate easy, fast and safe loading with least human interference. The increasing manufacture rate in industry, it is necessary to transport material faster with maintaining the product quality. In the industry there is problem of scratches while transporting the boxer head lamps. Hence, we are trying to overcome this problem by using wheel conveyor. Product to be moved as well as its maximum loading capacity in order to ensure fast, continuous and efficient movement of boxer head lamps while avoiding problems like rejections of products due to scratches during loading and unloading.

Key words: Manufacture, Material transportation, Rejection of Products, Scratches on components, Wheel conveyor system

14. INTRODUCTION

A conveyor system is a common part of mechanical handling equipment that moves material from one location to another. Conveyors are especially useful in applications involving transportation of heavy and massive materials. Conveyor systems allow rapid and efficient transportation for a wide variety of materials, which make them very popular in the material handling and wrapping industries. They also have popular consumer applications, as they are often found in store and airports, constituting the items or bag delivery to customers. Many types of conveying systems are available and used according to the various needs of different industries. Although a varied change of materials can be conveyed, some of the greatest common include food items such as beans and nuts, bottles and cans, automotive components, scrap metal, pills and powders, wood and furniture and grain and animal feed. Many factors are important in the
accurate selection of a conveyor system. Some individual areas that are helpful to consider are the required conveyor operations, such as the transportation, accumulation and sorting, the material sizes, weights and shapes and where the loading and pickup ideas need to be. The present invention relates to a wheel conveyor constructed by installing a wheel assembly, which includes wheels and support plates arranged on both sides and rotatable supporting axles of wheels, in a groove of frame material the wheel conveyor being easily disassembled and cleaned provided with a damping function and also provided with a dust-trapping function.

Conveyor systems are used widespread across a range of industries due to numerous benefits:

- Conveyors are able to safely transport materials from one level to another, which when done by human labour would be required great effort and expensive.
- They can be installed almost anywhere, and are much safer than using a forklift or other machine to move materials.
- They can move loads of all shapes, sizes and weights. Also, many have advanced safety features that help to prevent accident.

Fig. 1 Wheel conveyor system

A. Need

Overview of wheel conveyor system in manufacturing industries is for saving the travelling time and it is also used for easy, smooth and efficient transportation.

In the industry there is a problem of stocking of components occurs due to which components may collide on one another which results in scratches on components.

Wheel conveyor system designed with an inclination due to which components can transport from one stage to another. Due to inclination, here external power supply does not require.

Conveyor system allow careful control of the speed at which materials are to be transported and because of that fewer chances of breaking and defects due to manual handling.

B. Scope

This system can be use in any work place where the sorting of the any object that can be essential to transfer from one work place to another work place without any external cause of energy.

The various fields in which this system can be used are:

i. Manufacturing Industries
ii. Shop floors  
iii. Warehouses  
iv. Store rooms  
v. Auto industry  

C. Aim and Objective  
To Design and Fabrication of wheel conveyor for Boxer Head Lamp Assembly.

- To minimize the rejection of head lamp assembly by 70%.
- To minimize the cycle time by 1000 seconds in a shift.
- To avoid stocking of components.
- To give smooth flow to material

15. LITERATURE REVIEW AND BACKGROUND  

A. Introduction  
The research papers that are studied, contains a list of the information which is useful for the work to be carried out during the entire duration of the project. The main content of research papers studied contain information of wheel conveyor. All research works carried out by the various academia has been reviewed and they are presented as follows:

B. Literature Review  

Makalu Sandro Masaki, Lijun Zang August 2017 [1]  
In this paper there is comparative study on cost effective wheel conveyor for bulk material handling. Among the various types of conveyors, the multi-drive technology has gained worldwide popularity in recent years because of the cost saving opportunities as a result of the possible reduction of the wheel weight. Until recently, however, limited knowledge on the cost-effective design of such conveyor systems was reported in the literature.

Aniket A Jagtap, Shubham D Vaidya April 2015[2]  
In the process or manufacturing industry raw materials need to be transported from one manufacturing stage to another. This paper discusses the design calculations and considerations of wheel conveyor system. This paper discusses the design calculations and considerations of wheel conveyor system for biomass wood using 3 rolls idlers, in terms of size, length, capacity and speed, roller diameter, power and tension, idler spacing, type of drive unit, diameter, location and arrangement of pulley, angle and axis of the rotation, control mode, intended application, product to be handled as well as its maximum loading capacity in order ensure fast, continuous and efficient movement of crushed biomass wood while avoiding fatalities during loading and unloading.

Atsuhiko Yazaki, Fumio Uematsu September 2009 [3]  
These research paper relates to a wheel conveyor constructed by installing a wheel assembly, which includes wheels and support plates arranged on both sides and rotatable supporting axles of the wheels, in a groove of a frame material, the wheel conveyor being easily disassembled and cleaned, provided with a damping function, and also provided with a dust-trapping function. Wheels have axle pins, and support plates are provided with pin holes. A wheel assembly is constructed by inserting the axle pins into the pin holes to be rotatable supported.

The art field is that of conveying system for containers, more especially containers of circular or near circular sections, in a star wheel typical of the type use to guide and convey bottles, use is made of radially adjustable push rod to distance the container from centre of wheel according to its diameter, in conjunction with and essentially circular guide, also adjustable providing external restraint. The peculiarities of a belt conveyor is that it is easy and cheap to maintain, it has high loading and unloading capacity and can transport dense materials economically and at very high efficiency over long distance allowing relative movement of material.

George H. Bensen September 1959 [5]  
This research paper relates to a novel construction of wheel conveyors fabricated as a standard unit which may be readily adjusted and modified without use of tools, to varying requirements of use and assembled and disassembled without use of tools, nuts, rings, rivets, retaining caps or other separate attachment devices. The drawings, illustrating procedures and devices useful in carrying out the invention and the description are exemplary only of the invention which shall be deemed to cover all other devices and procedures. The conveyer belt installations have been used for moving a wide variety of goods and materials for many decades.
A. Introduction

The most significant aim of this study is to apply the principles of engineering to expose their proficiency in industries. Although designed for simplicity of our project consists of one system working to handle material in industry to complete exact requirements. The material handling by conveyor without energy reflects the combined effort of all the team members who worked hard to come up with ideal design in accordance with the theory knowledge learnt so far. The design concentrations towards explaining the procedure and methodology used for designing the conveyor. The design process of this conveyor is iterative and based on several engineering and reverse engineering processes. The focal area of this report is about study and manufacturing methodology for frame and wheel bracket of conveyor. The frame and trolley of conveyor is designed for its application requirements keeping in mind its feasibility of use and sustainability to various loads.

B. Time Analysis

<table>
<thead>
<tr>
<th>Station No.</th>
<th>Operation</th>
<th>Cycle Time</th>
<th>Travelling Time between stations</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Sealing Operation</td>
<td>17 sec</td>
<td>Without Conveyor =7 Sec</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>With Conveyor =4 Sec</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Time Saved =3 Sec</td>
</tr>
<tr>
<td>2</td>
<td>Bulb and Socket Fitment</td>
<td>4 sec</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Locking Clip Fitment</td>
<td>15 sec</td>
<td>2 sec</td>
</tr>
<tr>
<td>4</td>
<td>Housing Sub assembly</td>
<td>15 sec</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Testing</td>
<td>20 sec</td>
<td>2 sec</td>
</tr>
<tr>
<td>6</td>
<td>Packaging</td>
<td>10 sec</td>
<td></td>
</tr>
</tbody>
</table>

The time required for manufactured a single component is 81 sec and 11 sec travel time. Hence total time required to manufacture a single component is 92 sec. After installation of wheel Conveyor system overall travel time will reduce by 3 sec.

- Total component manufactured without use of wheel conveyor during a shift of 8 hours = 320 products
- Total component manufactured with use of wheel conveyor during a shift of 8 hours = 336 products

C. Analysis of Rejection

Because of Conventional material handling of components defects like scratches are occurred, due to this 6% components rejected in a shift i.e. approximately 20 components.

By using wheel conveyor, material handling gets smooth and easy to transport object, due to this 4% components will be saved that is 14 components will save.

D. Design Process

All the structural drawings are prepared by using solid works software. The platform of wheel conveyor system is design by providing an elevation so that the incoming component is slides downwards to another end smoothly.

The wheel conveyor system has a tray below the brackets to accommodates excess lamp in case of stocking.
1. Components of Wheel Conveyor System

- Platform

The mild steel hollow square bar platform is used to give support to bracket. MS is a fast and flexible middleware-oriented server framework that provides a small but robust foundation for creating complex applications. A steel sheet tray is provided to platform for store extra components to avoid stocking of components. According to need of application here the design of an iron platform with following dimensions.

- Height 1 = 1060 mm  C/s area = 40*40 mm
- Height 2 = 915 mm  Thickness = 2 mm
- Width = 290 mm  Length = 1000 mm

- Bracket / C type Channel

Aluminium bracket offered precision designed and growth using superior grade, Aluminium metal that provides durable finish support as well as highly attractive finish appeal. Aluminium has suitable physical properties and good corrosion resistance properties it also available in various types. According to need of application here design a bracket with following dimensions.

- Length = 1000 mm
- Width = 70 mm

- Nylon Wheel

White nylon caster wheels are made with a solid nylon material. These wheels weigh very little yet they have a load capacity comparable to most motor wheels. Nylon wheels are a better choice in wet and corrosive applications which required both chemical resistance and higher load capacity. According to need of application we design a nylon wheel with following dimensions.

- Outer diameter = 40 mm
- Thickness of wheel = 25 mm
- Bore diameter = 5 mm
- Weight = 90 gm
- Half edge curve radius = 15 mm

- Double end threaded stud bolts

The double end threaded stud bolts are used for to attach the wheels on the bracket using studs. There are 22 wheels are used in a single bracket so 22 studs are used. The material used for stud is M5 Stainless Steel. According to need of application we design a Double end threaded stud bolt with following dimensions.

- Overall Length = 50 mm
- Threaded Length = 12 mm

- Nut and Bolt

Nut and bolts are used for the tightening of the bracket on the platform. The material used for the nut and bolts is carbon and alloy steel. According to need of application to need of application we design a double end threaded stud bolt with following dimensions.

- Bolt size:
  - Metric size: M10
- Thickness of bolt head = 5 mm
- Nut size = Metric size: M10
Thickness: 5 mm

Overall length = 85 mm

- Clamp

The Clamp is made up of Stainless steel which is used to support the nylon wheel. The Clamps are linearly mounted on the aluminium bracket which is further riveted to the platform. The C clamp have 5 mm diameter hole on both sides to insert a pin which supports and allows to freely rotate the wheel.

17. CONCLUSION

A study on the design of wheel conveyor for a specific material handling application is presented in this paper. Wheel conveyor system maintain the quality of the products and also reduce the travelling time between two stations. In the industry it was identified through the observation on the assembly line, that due to bad handling of products, there may cause of scratches on the product, due to which rejections of products are in between 15-20 components per day.

When this solution will be applying on the assembly line, outcomes will be rejections are decreases nearly 70 % and also maintain the quality of the product, travelling time also reduces. Also, this solution may help to the workers.

ACKNOWLEDGMENT

The satisfaction and euphoria on the success of any task would be incomplete without mention of the people who made it possible whose constant guidance and encouragement crowned our effort with the success. We would like to take the opportunity to express our respect, deep gratitude and genuine regard to our guide Mr. Pravin H. Lokhande and all the Mechanical Engineering Department Staff Member, who directly or indirectly helped us in completion of this work.

360 Degree Conveyor With Up Down Mechanism

Shrikant Kale, Pranay Bawane, Piyush Gupta

Mechanical Department Of Engineering, SKN Sinhgad Institute Of Science and Technology, Lonavala, Pune, Maharashtra, India

ABSTRACT

The 360 degree belt conveyor system is the transport of material from one place to another with a mechanism of rotation and top to bottom movement. This conveyor has a high load capacity, a long transport path, simple design, easy maintenance and

REFERENCES

high operational safety. The 360-degree belt conveyor system is also used in material handling in the foundry, such as the delivery and distribution of foundry sand, molds and waste disposal. This project work consists of design the conveyor system, motor selection, belt specification, shaft diameter, pulley, bearing selection and specification using the standard model calculation.

INDEX TERM—360° turn mechanism; actuator gear motor system turn the system in circular path material handling system.

1. Introduction

A conveyor system is a part of mechanical handling equipment that moves materials from one location to another. Conveyors are especially useful in applications involving the transportation of heavy or bulky materials. Conveyor systems allow quick and efficient transportation for a wide variety of materials, which make them very popular in the material handling and packaging. Material handling is an important sector of industry, which is consuming a considerable proportion of the total power supply.

Belt conveyors are being employed to form the most important parts of material handling systems because of their high efficiency of transportation. It is significant to reduce the energy consumption or energy cost of material handling sector. This task mainly depends on the improvement of the energy efficiency of belt conveyors. Now in industries only fixed type belt conveyors are available. But a prototype model of a 3600 rotating belt conveyor belt with up down mechanism is designed.

Bulk material transportation requirements have continued to press the belt conveyor industry to carry higher tonnages some distances and more diverse routes. In ordered keep up, significant technology advances have been required in the field of system design, analysis and numerical simulation. The application of traditional components in non-traditional applications requiring horizontal curves and intermediate drives have changed and expanded belt conveyor possibilities. Example of complex conveying applications along with numerical tools require insuring reliability and availability will be reviewed.

2. Working Principle

The two motor attached in bottom and with shaft of the conveyor belt. When 12v dc supply provide the shaft motor then belt is rotated. So the material handling is complete one place. If you move conveyor belt any degree then you provide the supply bottom motor. And the motor shaft is rotated in this way you select any degree movement of conveyor belt. And you complete the material handling in other place. So the conveyor belt is rotated by using of motor easily. The motor attached with shaft of the conveyor belt. When 12v dc supply provide the shaft motor then belt is rotated. So the material handling is complete one floor.

Fig. 360 Degree conveyor with up down mechanism

3. Literature Review

He has discussed the work for the development of a belt conveyor system for small scale industry. The conveyor is of height 0.75 m at 0° angle of inclination, 35° troughing angle and a surcharge angle of 25°. It also consists of a belt whose width is 410 mm, length 2.4 m and a basic length 4.54 m. The conveyor has an average capacity of 43.75 tones/hr.

He concluded that, a belt conveyor system with 3 roll idlers for conveying packs of bottled water was developed. The peculiarities of the belt conveyor is that it is easy and cheap to maintain, it has high loading and unloading capacity and can transport materials economically and at very high efficiency.

The construction of a belt conveyor system requires high capital base. The evaluation of the conveyor system is limited to a conveyor speed of 200 rpm and as such the evaluation cannot be carried out at different speed of operation.

The followings are recommended:
- The use of variable speed electric motor which will allow for evaluation of the system performance at different speeds.
- The developed system is subjected to test throughout the year for more performance evaluation.

B. MeshramPradnyaratna A. (2016)

In his paper, he is suggesting a conveyor system for the company who are in a process of atomization of a plant and they are in a need of a dedicated conveyor system for the continuous filling of liquid in the cartons having chamber of two types 1 X 16 (4 X 4) and 1 X 25 (5 X 5). With the proposed conveyor system the labour cost will be reduced also the transportation and material handling cost will be reduced. With this conveyor system the 420 cartons can be filled with the help of programmable filling machine each chamber can be filled in 3 seconds.

C. Aniket A Jagtap (2015)

Transported from one manufacturing stage to another. Material handling equipment are designed such that they facilitate easy, cheap, fast and safe loading and unloading. He explained that, In the process or manufacturing industry, raw materials need to be with least human interference. For instance, belt conveyor system can be employed for easy handling of materials beyond human capacity in terms of weight and height. This paper discusses the design calculations and considerations of belt conveyor system for biomass wood using 3 rolls idlers, in terms of size, length, capacity and speed, roller diameter, power and tension, idler spacing, type of drive unit, diameter, location and arrangement of pulley, angle and axis of rotation, control mode, intended application, product to be handled as well as its maximum loading capacity in order ensure fast, continuous and efficient movement of crushed biomass wood while avoiding fatalities during loading and unloading. The successful completion of this research work has generated design data for industrial uses in the development of an automated belt conveyor system which is fast, safe and efficient.


He has explained that, a conveyor system is a common piece of mechanical handling equipment that moves materials from one location to another. Conveyors are especially useful in applications involving the transportation of heavy or bulky materials. Conveyor systems allow quick and efficient transportation for a wide variety of materials, which make them very popular in the material handling and packaging industries. Many kinds of conveying systems are available, and are used according to the various needs of different industries. There are chain conveyors (floor and overhead) as well. Chain conveyors consist of enclosed tracks, I-Beam, towline, power & free, and hand pushed trolleys. Conveyor systems are used widespread across a range of industries due to the
numerous benefits they provide. Conveyors are able to safely transport materials from one level to another, which when done by human labour would be strenuous and expensive.

**E. Ananth K N (2013)**
He has explained a review of design the conveyor system used for transportation of material from one location to another. This includes belt speed, belt width, motor selection, and belt Specification, shaft diameter, pulley, gear box selection, with the help of standard model calculation.

**F. A. W. Roberts**
He has explained a review of design trends associated with long overland conveyors is presented indicating the influence of economic and technical considerations in the design methodology. Aspects of conveyor dynamics are discussed and research and development work concerned with specific subjects including belt drum friction, rolling resistance and bulk solid and conveyor belt interaction. A test rig for examining stability between bulk solids and conveyor belts during transportation is described.

**G. Sunderesh S. Heragu**
He has explained Material handling systems consist of discrete or continuous resources to move entities from one location to another. They are more common in manufacturing systems compared to service systems. Material movement occurs everywhere in a factory or warehouse before, during, and after processing.

Apple (1977) noted that material handling can account for up to 80 percent of production activity. Although material movement does not add value in the manufacturing process, half of the company’s operation costs are material handling costs.

**H. Michael G. Kay**
He has explained Material handling (MH) involves “short-distance movement that usually takes place within the confines of a building such as a plant or a warehouse and between a building and a transportation agency.” It can be used to create “time and place utility” through the handling, storage, and control of material, as distinct from manufacturing (i.e., fabrication and assembly operations), which creates “form utility” by changing the shape, form, and makeup of material. It is often said that MH only adds to the cost of a product, it does not add to the value of a product. Although MH does not provide a product with form utility, the time and place utility provided by MH can add real value to a product, i.e., the value of a product can increase after MH has taken place.

**I. N. Sivakumar**
He explained that there has been a serious demand for intermittent movement of packages in the industries right from the start. Though the continuous movement is more or less important in the same field the sporadic motion has become essential. The objective of our project is to produce a mechanism that delivers this stop and move motion using mechanical linkages.

The advantage of our system over the conveyor system is that the system has a time delay between moving packages and this delay can be used to introduce any alterations in the package or move the package for any other purpose and likewise. While in conveyor system such actions cannot be performed unless programmed module is used to produce intermittent stopping of the belt which basically is costly. The prototype design requires electric motor, shafts and the frame of which the frame and platform on which the packages are moved is fabricated. All the links are being made of Aluminum which reduces the weight of the whole system including the head which has a direct contact with the boxes being moved. The system is expected to move as heavy packages as 2 to 3kgs approximately.
J. G. Velmurugan (2014)

He explained that, there are two main industrial classes of belt conveyors; those in general material handling such as those moving boxes along inside a factory and bulk material handling such as those used to transport large volume of resource and agricultural materials. Conveyor belt maintenance not only includes proper care of the belt itself but also includes care and maintenance of the frame and accessories.

4. Parameters For Designing Of Belt

- Belt Speed
- Belt Type
- Power Delivered
- Factor Of Safety

5. Conclusion

The equipment consists of a base plate supported with 4 wheels for mobile operation. The wheels attached to the base will be used to carry and deliver the material with it. This plate is fitted with a clamping arrangement over which a belt conveyor is arranged. The clamp can be rotated for 360 degrees movement. There is an arrangement for the conveyor belt to tilt up and down which will help conveyor to achieve the desired angle from the horizontal. All the movements of the equipment are controlled by the D.C motor which is connected to the battery support or the power supply as per the need of the machine. Four motors are assembled for these operations. To turn the conveyor belt in 360 degrees rotation a vertical motor is arranged which is to be operated with the help of controller. All the equipment used in this assembly are run with the help of battery eliminator. In this assembly the components arranged can be handled with a hand held device.

6. Applications

- Can be applied in gear manufacturing unit.
- Used in automobile industry.
- Used in airport.
- Also used in stone crushing industry.
- Used in both small-scale industries as well as the large-scale industries.
- Its outcome can be utilized properly to a great executed in mechanical field as well
- as the automobile field.
- Also used in Warehouses.
- In coal industry.
- Food and packaging industry.

7. References


6. A. W. Roberts and a. Harrison “Recent Research Developments In Belt Conveyor Technology”


IIoT (Industrial Internet of Things) implementation using 10 WCM (World Class Manufacturing) Tools

Soham Satish Deshpande

Industrial Engineering Department, Vishwakarma Institute of Technology, 666, Bibwewadi, Pune, Maharashtra, India
ABSTRACT - Industrial Internet of Things (IIoT) is providing an opportunity and resources to industries to increase their productivity and optimize processes to reduce throughput time and manage their demand. Industrial Internet of Things is a part of Internet of Things (IoT) and has wide range of applications in industries. There are many WCM (World Class Manufacturing) tools available to increase productivity and reduce defects. If we integrate both Industrial Internet of Things and World Class Manufacturing Tools with each other, they should help industries to achieve more productivity and less defects.

INDEX TERMS-Industrial Internet of Things, Internet of Things, World Class Manufacturing, Automation, Industry 4.0, Cloud Computing, Artificial Intelligence, Machine Learning

1. INTRODUCTION
Industrial Internet of Things is a new way to improve the industrial productivity. Many manufacturing organizations have started to implement IIoT. There are many ways to increase organizational productivity and manage recourses. Integrating Industrial Internet of Things with the tools that gives higher amount of efficiency and consumption of all recourses could really help manufacturing organizations to manage and improve their operational efficiency as well as organizational productivity.

2. INDUSTRIAL INTERNET OF THINGS
Industrial Internet of Things is a part of Internet of Things, which is an integrated highway to manage all information and resources together. Industrial Internet of Things is an integration between computer devices, digital machines and mechanical machines with ability to transfer information over a network without requiring manual interactions.

3. INTERNET OF THINGS
Internet of Things is an integration between computer devices, digital machines and mechanical machines with ability to transfer information over a network without requiring manual interactions. Internet of Things has wide applications including 3D Printer, AI (Artificial Intelligence), ML (Machine Learning) etc.

4. WORLD CLASS MANUFACTURING
World Class Manufacturing is a philosophy of being the best, fastest and lowest cost producer of that product. It involves production process, managing process and entire organization from leadership to shop floor. It's useful for both manufacturing and service organizations.

5. INDUSTRY 4.0
Industry 4.0 is fourth industrial revolution. Industry 4.0 is a smart manufacturing system which enables the communication between machine to machine and helps industries and organizations to increase their performance and productivity. Industry 4.0 provides digital layer to transmit that data and share the information with devices related to it. Industry 4.0 has made machine to machine and human to machine communication easier and more reliable.

<table>
<thead>
<tr>
<th>TABLE I: INDUSTRY 4.0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Industry 4.0</td>
</tr>
<tr>
<td>Internet of Things</td>
</tr>
<tr>
<td>Big Data analytics</td>
</tr>
<tr>
<td>Simulation and Prototype</td>
</tr>
<tr>
<td>3D Printing</td>
</tr>
<tr>
<td>Augmented Reality</td>
</tr>
<tr>
<td>Advanced Robotics</td>
</tr>
</tbody>
</table>

6. FUTURE COMMUNICATION
Implementation of Industrial Internet of Things enables digital communication. IIoT has made the communication between machines to machines and human to machines much easier and reliable to do tasks and interference. Future Communication between machines and humans will be less human interference and more machine interference by deploying machine algorithms and instructions. So, the machine can change and improve its performance on the basis of recorded inputs and feedbacks, and enable automatic digital communication. In future all communicable devices like telephone, digital telephone, mobile phones, LANs (Local Area Network), WANs (Wireless Area Network) and other communication enabling devices are connected to one single network to perform information transfer and wireless communication.

7. ACCELERATING PRODUCTIVITY AND PERFORMANCE
Industries are focused on improving their efficiency and overall productivity. But it doesn't happen overnight. Industries perform various operations and run all types diagnostics and analysis to find out the problem and fix it. This was the traditional approach of industries to solve their problems and increase
productivity and performance. Industrial internet of things gives different and easy approach to solve problems and increase productivity by eliminating all types of unnecessary elements. Implementing Industrial Internet of Things can accelerate performance and optimization of the processes, and gives better productivity which helps industries and organizations to achieve their goal.

8. ELEMENTS OF INDUSTRIAL INTERNET OF THINGS

TABLE II: ELEMENTS OF IOT

<table>
<thead>
<tr>
<th>No.</th>
<th>Element</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Cyber Physical Systems</td>
</tr>
<tr>
<td>2.</td>
<td>Cloud Computing</td>
</tr>
<tr>
<td>3.</td>
<td>Data analytics</td>
</tr>
<tr>
<td>4.</td>
<td>Edge Computing</td>
</tr>
<tr>
<td>5.</td>
<td>AI (Artificial Intelligence) and ML (Machine Learning)</td>
</tr>
</tbody>
</table>

a. Cyber Physical Systems: it’s a physical system connected to one unique network to share and receive commands and instructions. Data can be transferred from both sides. All industry equipment's like Network Computers, Industry/Organizational Servers, ERPs, Wireless Printers, CNC Machines, Security Cameras, Simulators/Emulators etc. All are connected to one unique network to allow information/data sharing among them.

b. Cloud Computing: Many industries/organizations are now storing their data on cloud servers. Storing their data/information physically, it's more reliable and secure to save data/information on cloud servers.

c. Data analytics: Data Analytics can give industries/organizations proper and reliable solutions. Industries/organizations are saving their data, so they could analyse and categorize data according to their preferences and performance. Data could also help the industry/organization to predict their performances.

d. Edge Computing: It’s a distributed computing system which brings computer data storage closer to preferred location considering accessibility and flexibility.

e. AI (Artificial Intelligence) and ML (Machine Learning): Implementation of AI and ML can help Industries/Organizations to find right solution to the problem. AI and ML can help industries/organizations to optimise their performances according to the given work.

9. UNDERSTANDING INDUSTRIES PERSPECTIVE

Implementing Industrial internet of Things Is a costly process. To implement Industrial Internet of Things, require long term investments and objective. Many industries are running on a traditional manufacturing approach and they are using traditional approach to solve problems to increase their productivity and performance. That’s why some industries and organizations are busy solving their problems rather than focusing on future opportunities. On the other hand, there are some industries who have implemented Industrial internet of Things and getting benefits to focus on industrial need and increasing overall industrial and organizational productivity. Industrial Internet of Things is a long-term investment but it also gives the approach to focus on terms which are responsible to improve efficiency and it also allows industries to achieve and get new opportunities.

10. IMPLEMENTATION

IIoT (Industrial Internet of Things) implementation is easy because it's an upgradation to traditional machines and techniques and installation of cyber physical devices to enable the communication between them. Enabling IIoT in industries or organizations is little expensive but worth if we look at long term industrial perspective.

11. GETTING THREE KEYS

Implementation of IIoT gives organizations three major keys which are,

a. Performance: IIoT gives improved performance and helps to get new and correct results.

b. Data: It generates high amounts of data, which enables industries or organizations to perform scientific analysis.

c. Future Prediction: Performance analysis and deploying algorithms can help to predict the future opportunities.

12. CONNECTIVITY

IoT Network: It’s a network which is shared among all wirelessly accessible and network connected elements to share data/information within the network. All industry equipment's like CNC Machines, Sensors, SCADA, DCS (Distributed Control System), Computers, Network Computers, Printers, Mobile Vehicles, Servers etc. Can connect to their unique industry network and share their information among each other.

5G IoT for Manufacturing Sector: High speed connectivity can really solve the issue of sharing big
and data consuming files. All elements of manufacturing industries like CNC Machines, CMM Co-ordinate Measuring Machines, Security Cameras, Printers and other wirelessly accessible things can share information with high speed, which can save time and optimize processes.

IIoT Network: Many industries/factories now use many digital and cyber physical devices to transfer the data or enabling communication with each other. Devices like Printers, Machines, PLCs, Computers, Servers, Cameras, Wi-Fi, are now connected with each other through LAN (Local Area Network) or WAN (Wireless Area Network). IIoT offers a digital space to enable these things to share or transfer data or communicate with each other and even perform some tasks together.

13. SELECTION OF WCM TOOLS

World Class Manufacturing is a structured and integrated production system which involve engineering and manufacturing processes to eliminate waste and helps to improve industrial and organizational productivity and performance. There are many World Class Manufacturing tools which can be implemented in the industries or organizations. There are 10 technical pillars and 10 managerial pillars of WCM which has main objective of increase quality and reduce production costs.

TABLE III: MAIN RULES OF WCM

<table>
<thead>
<tr>
<th>The Main Rules of WCM</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Zero Defects</td>
</tr>
<tr>
<td>2. Zero Waste</td>
</tr>
<tr>
<td>3. Zero Breakdown</td>
</tr>
<tr>
<td>4. Zero Inventory</td>
</tr>
</tbody>
</table>

14. WCM TOOLS

TABLE IV: SELECTED WCM TOOLS AND THEIR DESCRIPTION

<table>
<thead>
<tr>
<th>Selected WCM Tools</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. JIT (Just in Time)</td>
<td>Store less operate more.</td>
</tr>
<tr>
<td>2. Kanban</td>
<td>Tag system use for Production Scheduling.</td>
</tr>
<tr>
<td>3. OEE (Overall Equipment)</td>
<td>Measuring efficiency of operations.</td>
</tr>
</tbody>
</table>

IMPLEMENTING IIoT WITH 10 WCM TOOLS

(1) JIT: We can implement IIoT on JIT tool to automate and accurate the inventory system by operating more and storing less. For example, if we connect our ERP system to IIoT module and implement JIT based algorithms to resource check and dynamic scheduling functions; it can give us timely material delivery status sharing between the company and suppliers; timely resource and scheduling information sharing among departments within the company.

(2) Kanban: It is a tag used for production scheduling. If we implement this tool using IIOT we can automate our Kanban tags, i.e. implementing digital Kanban systems. Which basically has two sides front and back. For example, many companies have customized company software's. If we implement digital Kanban module on software by deploying Kanban digital format, we can update status of tags automatically and digitally.

(3) OEE: OEE is Overall Equipment Effectiveness which is a standard to improve manufacturing productivity. Using sensor analytics to monitor and predict the quality of the product. The machine may be running fine, but if the product is not meeting specs, you really shouldn’t be counting this toward a good OEE measure. Implementing IIoT with OEE is easy by placing sensors to monitor or record the tasks and perform scientific analysis on them. Elements and their work are mentioned in Table II.

TABLE V: ELEMENTS FOR IMPLEMENTING OEE WITH IIOT PLATFORM

| Machine | Giving Input to Machine. |
• Getting Output from Machine.

Sensors/Cameras

• Sensors for tracking machine movements.
• Cameras for recording motions.

Monitoring Platform

• Viewing the recorded tasks/machine movements.
• Recording for further use.

Scientific Analysis

• Applying paradigm.
• Getting scientific analysis of tasks.

Corrected Pattern/Feedback

• Getting corrected pattern.
• Getting proper feedback.

(4) TOC: Theory of Constraints is a tool that organizations can be measured and controlled by variations on three measures: throughput, operational expense, and inventory. Inventory is all the money that the system has invested in purchasing things which it intends to sell. For example, if we thought to implement IIOT for TOC first thing we can monitor using sensors and other electronics is overall production time. And after monitoring we can perform time study and reduce the total production time or throughput.

(5) Equipment ABC Prioritization: This is one of simplest tool of WCM, its basically prioritization of the equipment's which have high, medium and less demand. A stand for A class equipment's, B stands for B class equipment's and C stands for C class equipment. If we thought to implement IIoT for this process is very simple. We can input our data in standard data sheet which can perform complex instructions (like MS-Excel) and the equipment which have more and rapid use can prioritize as A class equipment and those who have medium demand can be prioritize as B class equipment and those who have less use can be prioritize as C class equipment.

(6) Maintenance cycles: It's easy to keep track of our maintenance schedule but easier if we implement IIOT for this process. Implementing IIOT is very simple for this one, we can automatically come to know our next maintenance cycle for any machine. If we have standard input module with IoT platform connectivity we can share and input our previous maintenance cycles and get to know when and where is our next maintenance cycle.

(7) FMEA-. Failure Mode and Effect Analysis: Computers are getting smarter and smarter they can even simulate complex things now. IIOT also has computer programmed simulation platform which can simulate complex structure and environments. We use traditional form to do failure mode and effect analysis, but if we have proper simulation platform, we can even do this using IIOT platform.

(8) SOP (Standard Operation Procedure): SOP is a standard operation procedure which tells us the proper and standard way to do operation and its use. Many industries and organizations have typical SOP boards, we can use digital boards to update their status automatically. Digital SOP boards which can change their status and signs with respect to product or machine upgradation.

(9) Visual Aid: This is way to visually representing the status of operation or machine status. There is a traditional way to present visual aid in industries and organizations. But if we implement IIOT for this we can use digital forms of visual aid which can change their status according to the information send by the computer or digital information module.

(10) Poka Yoke: Poka Yoke is mistake proofing. We can relate Machine Learning with this. Machine Learning is all about improving performances and avoiding mistakes. So, we can implement Machine Learning to avoid mistakes happening while performing some tasks. For example, if CNCs/Special Purpose machines are handling equipment's from one machine to another machine and changing their tools from tool magazine time to time with respect to task/machining operation, but because absence of Machine Learning there is no way that machine is going to improve or avoid mistake by itself. But, IIoT platform also has Machine Learning modules and if we integrate both with each other we can avoid mistakes happening by the machine.

16. UNDERSTANDING USE

It is more important to understand the use of Industrial Internet of Things. It may require industries or organizations to upgrade knowledge of workers to operate things and respective devices. Many industries are now trying to upgrade themselves according to the surrounding conditions. There are also many industries and organizations which are helping their workers and employees to get access to new technical knowledge by arranging workshops or contracting with third
parties. The right use of right things with right path or method may unlock the targets and helps them to achieve more productivity and improvement in industrial or organizational performance.

17. CONCLUSIONS

Industrial Internet of Things (IIoT) is a multidisciplinary approach which is improving industrial/organizational efficiency, productivity and performance. It’s helping them to achieve specific targets which are not possible to achieve by traditional methods. Implementing IIoT in industries/organizations is a long-term investment for them. But, implementing IIoT using 10 popular World Class Manufacturing (WCM) tools can help to reduce the implementation cost and also to improve overall efficiency of the industries/organizations. It can also help industries/organizations to monitor their KPIs (Key Performance Indicator).

REFERENCES


Experimental Study of New Chamber Design for OWC

Pavan C. Dhawale¹, Kaustubh S. Gathe¹, Manish R. Mohekar¹, Shubham A. Gaikwad¹ Neeraj Mohite²

¹Student, Department of Mechanical Engineering, PCET’s Nutan Maharashtra Institute of Engineering and Technology, Talegaon Dabhade/Pune, India, ²Assistant Professor, Department of Mechanical Engineering, PCET’s Nutan Maharashtra Institute of Engineering and Research, Talegaon Dabhade/Pune, India

ABSTRACT- The Wave energy is one of the important form of renewable energy and different devices are available to harness this energy. Of which Oscillating Water Column (OWC) is most widely studied device for its simplicity. An acrylic OWC chamber model is designed to study random wave force on the chamber. This study first introduces concept design of the chamber structure for a laboratory based model. The chamber is with 30, 45 & 60 degree front and back adjustable deflector plate is tested at random wave condition in laboratory. Set of experiments has been carried out with one dimensional of convergence and 2 dimensional convergence. Based on the result of experiments two dimensional convergence for the given chamber size trap air effectively than one dimensional convergence.

INDEX TERM= Ocean energy; Wave energy conversion; oscillating water column; Wells turbine; Savonius turbine, Geometrical Variation

I. Introduction

When thinking about renewable energies, wind, solar and hydro energy typically comes to our mind. To tackle the continuous increase in the temperature of earth and other challenges we have to harvest on renewable resources, there's one major resources that has demanded until and till now and that's Wave energy.

The wave energy is an important renewable energy source, it can contribute significantly to electrical supply of countries which have their boundaries with the ocean. These waves can travel thousands of Miles without loss of the energy. The major losses of energies are while braking and the friction of waves with the seabed, so the less amount of energy we get at the seashore.

A wave can have both kinetic and gravitational potential energy. The amount of energy depends on two factors, the height average wave energy of 50 KW of power each meter. Talking about India, India has an average of 10-20 KW of power at seashore. It is possible to extract 20% of energy at the seashore from the waves. This energy was a direct reply for the energy increasing demand of the crude oil.

A. Oscillating Water Column (OWC)

The oscillating water column (OWC) concept is perhaps unique among the myriad systems proposed for extracting power from ocean waves therein it's the sole technology where a key part of the system are often seen as a present structure. An OWC comprises two key elements: a collector chamber, which takes power from the waves and transfers it to the air within the chamber, and a power take off (PTO) system, which converts the pneumatic power into electricity or some other usable form. The pressure in the collector is alternately pressurized as the water column rises and rarefied as the water column falls.
Fig. 1 Oscillating water column (OWC) device

II. Literature

Snadeep K Patel, Use of Savonius turbine, Alternative for Wells and Impulse turbine as they have disadvantage of self-starting and stalling. Krishnil Ram, This experiment carries out the study of air flow characteristics of OWC device. Zhen Liu, This paper works on the waves movement and it gives better performance at short domain and long domain. K. Mala, Use of two rotor turbine increasing the efficiency and reducing the waste of energy. David G Dorrell, To improve the performance of the turbine by using Savanious turbine in place of wells turbine at low capacity this turbines gives higher outputs as compared to wells turbine. Manabu Takao, The performances of twin unidirectional impulse turbine has been analysed using experimental result. S Santhakumar, The comparison of impulse turbine with self pitch controlled guide vanes and fixed guide vanes on basis of experimental & numerical study. W.M. Kusumawinahyu, Linear wavemaker theory is developed based on fully dispersive water wave equation. Nazanin Ansarifard, The numerical investigation on the design of a unidirectional radial inflow turbine using various blade design of turbine Antonio F.O. Falcao, For the working of OWC by wells turbine several stages are required for acceptable performance by the turbine. Toshiaki Setoguchi, The author has compared five different turbine with guide vanes by comparing their viewpoints of their starting and running characteristics.

III. Methodology

Fig. 2 Three dimensional modelling of experimental setup

A. Construction

A model which will have a (1200 x 350 x 400) mm tank made up of polycarbonate wave deflectors at 30°, 45°, 60°. A wave maker mechanism which will have single flap and will be controlled by a controller for high and low waves generation. Savanious rotor is used which is made up of thermoplastic polymer. A DC motor is connected at the shaft of the rotor. A digital voltmeter is connected at the end of the motor shaft to calculate readings.

B. Components

1) Tank: The polycarbonate tank with length 1200 mm, width 350 mm and height 400 mm was used. The column structure was set at one end of the tank with length 340 mm, width 300 mm and height 150 mm above the tank height.
2) Deflector plates: Defective plate where kept below the column to create the vacuum in the column. The deflector plate were made of polycarbonate plastic with length 350 mm, width 400 mm and thickness 5 mm there are three letter plates kept at the angle of 30°, 45° and 60°.

3) Wave Maker: Wave maker mechanism was made using single slider crank mechanism this help to convert the rotary motion of DC motor into to reciprocating motion of the flap. The flap was hinged at the bottom side to the tank to create sensorial motion of the wave.

4) Flap: The flap is made up of polycarbonate plastic with length 330 mm width 400 mm and thickness 5 mm the wave maker & was kept on opposite side of the column.

5) Savonius rotor turbine: Savonius rotor turbine is a wind turbine it consists of two aero foil shape blades mounted on shaft. This turbine is made of plastic material. One end of the shaft is connected to generator

6) Generator: Current is generated due to rotation of shaft. This current is measured with the help of digital multi-meter. Generator is mounted on one side of the shaft.

7) Tachometer: This Instrument is used to measure torque of the shaft and wave maker motor.

8) Digital Multimeter: This instrument is used to calculate current and voltage.
9) **Anemometer**: This instrument is used to measure velocity

![Anemometer Image](image-url)

**C. Working**

Waves are created using wave maker, the wave maker creates the wave in sinusoidal motion. The tank is filled with water up to height 200mm. When the waves are created using wave maker the water is trap below the column, due to the motion of the waves it collides on deflector plate and the air trap inside the column helps the turbine to rotate. The DC motor acts as a generator and stores energy in it with the help of voltmeter we can find out the actual voltage produced by the turbine after rotation.

![Block diagram](image-url)

**IV. Geometrical Variations & Results**

**A. One Dimensional setup with 30 degree Deflector plate**

In this setup deflector plates were placed at 30 degree, wooden reflector plates are used, water height is 200 mm. 3D printer Savonius rotor is used as a rotor.

![Experimental setup image](image-url)

Result- No air was trapped to rotate the turbine and weight of rotor is more. So this construction of setup failed.

**B. One Dimensional setup with 45 degree Deflector plate**

In this construction now the deflector plates were kept at 45 degree, wooden reflectors are used same as previous construction, 3D printed Savonius rotor is used as rotor. Results are observed with 200 & 250 mm height.

![Experimental setup image](image-url)

Result- We could recognize the air trapped in the tank but was not sufficient to rotate the rotor. The weight of rotor is more but before that we thought of checking at 60 degree deflectors.

**C. One Dimensional setup with 60 degree deflector plate**
In this construction now the deflector plates were kept at 60 degree, wooden reflectors are used same as previous construction, 3D printed Savonius rotor is used as rotor. Results are observed with 200 & 250 mm height.

**E. Two Dimensional Funnel setup**

As the turbine was place at the middle side there was air losses in the corner portions of the tank. So, due to the air loss in the 1 dimensions chamber this conversion diversion funnel type chamber was created. At one end which was near to the bottom of the tank the dimensions of chamber are 230 × 260 mm conversing to another end at dimensions of 95 × 40 mm. The height of the chamber is 250 mm. The chamber is made up of polycarbonate plastic. This chamber trapped more amount of air than the previous 1 dimensional chamber which helps to increase the velocity of air coming through the chamber.

In this setup tilted Funnel structure is made at 45 degree & the funnel is packed in such a way that no air losses will be observed. Wooden reflector is also placed seeing that convergence and divergence theory must be followed. Light weight plastic material Savonius rotor is used.

![Fig. 14 Two Dimensional Funnel setup](image)

Result– Very good amount of air is trapped so that Savonius rotor rotates.

**V. Conclusion**

After investigation of various parameters of turbine using experimentation and simulation under different working environment, it has been found that two dimensional funnel type constructions has good capacity to...
Trappe air and turbine also rotes, compared to one dimensional construction

VI. Future Work

Taking readings of various parameters such as Voltage, Current, and RPM of turbine shaft & wave maker motor & Velocity at different water heights. After taking various readings calculating Efficiency & power generated by the model.

Reference


Advances in nanotechnology in solar cell - A Review

Tejas G Kolhe#1, Prof. R.K. Bawane#2

1Student of Dept. of Mechanical Engineering, Pimpri Chinchwad College Of Engineering and Research, Ravet, Pune, Maharashtra, India, 412101, tejkolhel999@gmail.com

2Prof. Dept. of Mechanical Engineering, Pimpri Chinchwad College Of Engineering and Research, Ravet, Pune, Maharashtra, India, 412101, rahul.bawane@pccoer.in

ABSTRACT

Due to rapid increase in population the need of the electrical energy has been increased. In order to feed the need of the people there should be enough power that would drive the various electrical devices. Presently we produce electrical energy using water power plant, steam power plant, etc. But in future these resources won't be able to produce the power as per the requirement so we need to shift towards the renewable sources. One of the best energy sources is solar energy.

Solar energy can be converted into electrical energy using devices such as solar cells. Solar cell is a device which converts the incident solar energy on it into electrical energy. Basically, this report we have discussed about the nanotechnology used in the production of nano solar cells. Also, we have discussed about the efficiencies of the different nano solar cells. So, we have discussed about TiO2 films, Carbon nanotubes, Silicon nanowires, DSSCs dye sensitized solar cell, etc. Also, the comparison of different nano solar cells has been discussed in this report.

INDEX TERMS

Solar energy, solar cell, nanotechnology, nano solar cells

INTRODUCTION

In order to feed the increasing need of electrical we need to shift towards solar energy. The energy consumption of the world predicted to be increased at the rate of 1.5% annum from the year 2010 to 2040 and it is estimated that 30TW of energy is needed globally by the year 2050. Fig 1. shows the energy consumption of the world from year 2010 to 2050. [1]

Figure 1. World energy consumption 2010-2040

Within the range of renewable energy resource solar energy plays an effective role and strong efforts are put up by the researchers in order to improve the efficiency of the solar cell. Basically the efficiency of the solar cell is based on the light absorption process that generates electron hole pairs as well as the subsequent extraction of the charge carriers.

Today 80-90% of the solar technology is command by silicon-based materials and has proven the powerful technology in the PV modules. The reason behind this is that silicon is the leading material used in bulk (1st generation), thin film (2nd generation) and some of the nano-structured (3rd generation) solar cells for photovoltaics. However, the highest efficiency for non-concentrated silicon solar cell design reported so far is 25% only. [2]

The efficiency of the solar cells depends on the light absorbing ability of the material. The different methods use for light absorption are the use of anti-reflection coating, layers surface texturing, the addition of intermediate reflective layers, the usage of various majorly nanoparticles and quantum dots in the absorber layer, external light-trapping and using photonic crystals and plasmonic principles. [3]

Nanotechnology can be defined as application of scientific knowledge to manipulate and control matter predominantly in the nanoscale (length range approximately from 1 nm to 100 nm) to make use of size and structure-dependent properties and phenomena distinct from those associated with individual atoms or molecules, or extrapolation from larger sizes of the same.
Nanotechnology is the study and application of extremely small things and can be used across all the other science fields such as chemistry, biology, physics, material science and engineering. The concept behind the nanoscience and nanotechnology started with the talk entitled “There’s a Plenty of Room at the Bottom” by the physicist Richard Feynman at an American Physical Society meeting at the California Institute of Technology on December 29, 1959. Use of nanotechnology in solar cell offers reduced manufacturing cost as a result of use of low temperature process, reduced installation cost achieved by producing flexible rolls instead of rigid crystalline panels and also it is able to increase the efficiency of solar cell.

In this report we have focused on the first generation and second-generation solar cells and mainly on the nanostructured solar cells.

- **FIRST GENERATION SOLAR CELL**

The first-generation solar cell technology mainly uses the crystalline structure silicon to produce solar cell. But constantly it is needed to increase the capability as well as the efficiency of the solar cell.

1) **Monocrystalline cell** is mostly used and it constitutes 80% of the market. It necessarily uses Si p-n junction. The maximum efficiency of this solar cell is reached to 23% under Standard test condition but the highest reached efficiency is 24.7%. [6]

2) **Polycrystalline cell** is basically used to form a highly transmissive surface and to increase the absorption of light. Polycrystalline is produced by melting silicon and solidifying it to oriented crystals in a fixed direction producing a rectangular ingot of polycrystalline silicon cell is low but its efficiency is low as compared to monocrystalline silicon solar cell. [7]

- **SECOND GENERATION SOLAR CELL**

**Kuang et al.** resulted that the properties of the DSSCs are influenced by the length of TiO2 nanotubes and they studied 5–14 mm long nanotube arrays whose length was controlled by the anodization duration. As the surface area of the nanotubes is decreased the absorption of dyes on the TiO2 surface is also reduced which ultimately reduces the properties of the DSSCs. [8]

**Chou et al.:** ZnO nanoparticles has average size of 50–60 nm. ZnO nanowires with an average length of 6 mm and diameter of 100 nm where immersed in an inert solution of ethanol containing ZnO nanoparticles which served as a semiconductor layer and CdS (or CdS/CdSe) as sensitizing layer for fabrication of the DSSCs. The efficiency of composite layer ZnO/CdS showed an efficiency of 0.24%, which is twice as high as that of the bare ZNW/CdS (0.12%) and 33% higher than with bare ZNP/CdS (0.18%). [9]

**National Science Lab report:** Wet chemical Etching process was adopted by NREL to produce Black Silicon Nano catalytic. Black Silicon is chemically etched to have a black texture and to absorb sun’s energy. The research team created nanoscale features in silicon using catalytic etching of metals by nanoparticles. The energy conversion efficiency of black silicon cells is 18.2% [10]
CdSe nanorods and CdTe nanocrystals. The efficiency of those devices reached nearly 3%. More recently, CdTe nanocrystal PVs made by layer-by-layer deposition of dispersions dropped onto heated (300–350°C) substrates under ambient conditions have been reported with 7.3% PCE [11]

WonjeOha, Jisu Parka: The research team printed rear Ag pad on the Al contact to obtain large back surface field (BSF) layer. It was found that the power-conversion efficiency of the solar cells with the rear Ag pad on the Al contact exhibited the higher efficiency compared to the cells with the Ag pad printed on the region without Al contact.[12]

Ito et al. (2006): reported a new method for fabricating DSSCs with Ti metal foil (0.2 mm thickness), which has been proposed in order to use high temperature TiO2 sintering, resulting in high photo-conversion efficiency (7.2%). The flexible PV cells are sensitive to TiO2 thickness. Ito and co-workers also determined the optimized required TiO2 thickness (14–15 μm). [13]

William Ghann: The carbon dots were synthesized using hydrothermal treatment of sodium citrate and urea. The efficiency of only the carbon dots sensitized solar cells as 0.10% while that of the N719 together carbon dots was 0.19%. [14]

Malik Abdul Rehman: In this work, multilayer graphene of 4nm thickness was directly grown on Si and the efficiency obtain was 5.51% on bare silicon cell which was improved to 9.18% after the process of PMMA and doping. [15]

<table>
<thead>
<tr>
<th>Sr. No</th>
<th>Type</th>
<th>Benefits</th>
<th>Efficiency</th>
<th>Challenges</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Nano Si</td>
<td>Nano Si Thin film, Flexible substrate, potential for roll to roll processing</td>
<td>8-10%</td>
<td>Constant degradation, low efficiency</td>
</tr>
<tr>
<td>2.</td>
<td>CdTe</td>
<td>Fairly high efficiency</td>
<td>9-11%</td>
<td>Cd is toxic, not tightly roll able</td>
</tr>
</tbody>
</table>

**CONCLUSION**

From this study it is concluded that we can use nano solar cells as its efficiency is good as compared to traditional simple Si based solar cells. Nano material solar cells can be easily rolled up and take the shape as per the required design. Traditional solar cells are firm and they cannot be rolled up. As we use different nano materials for manufacturing of nano solar cells, they can be obtained in different colors and also, they are transparent. Nano solar cells are reliable and can be easily manufactured. Manufacturing cost depends upon the material used for producing nano solar cell and the different process used in their manufacturing. Thus, we can conclude that nano solar cells possess properties such as they are transparent, reliable, its manufacturing cost is low, can be rolled up and also their efficiencies are high.

**ACKNOWLEDGEMENT**

My seminar guide Prof. Mrs. R.K. Bawane, assistant professor in the Mechanical Engineering department of PCCOE&R gave me a great deal of support for making this report. My guide encouraged me to take this challenging subject as my seminar topic.

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Design and Development Of Car Seat Constrain System

Siddhant T. Chaudhary

1Department of Mechanical Engineering, Marathwada Mitra Mandal College of Engineering, Karvenagar, Pune, Maharashtra, India

ABSTRACT

Seats are one of the most important and essential components of vehicles. Seating comfort is a major concern for drivers and other passengers as they are exposed to extended periods of sitting. As a result of which the customer’s expectations for comfort in automobile seats are rising continuously.

In India, the careless driving of vehicles is commonly seen on roads. This raises important aspect of safety of driver as well as passengers. In most of the accident cases, the reason for accident is unexpected potholes, loosening drivers focus. To minimise this, automotive industries are doing much research work on safety. We have discussed about the efficiencies of the different nano solar cells. So, we have discussed about TiO2 films, Carbon nanotubes, Silicon nanowires, DSSCs dye sensitized solar cell, etc. Also, the comparison of different nano solar cells has been discussed in this report.

INDEX TERM— Seat Design, Seat modification, Driver safety.

1. INTRODUCTION

The Automotive seat design has always been a challenge for design engineers as design parameters are complex and increasing on daily basis. Thus for safety of the driver and other passenger, we have to design that type of seat arrangement where when the vehicle is in motion, the driver is unable to adjust the seat. It has been already adjusted when driver seated.[1]

Driver Safety is most important part in car manufacturing. As we are known that now in automotive industry there are many researches have been done on the safety of driver like as airbags, Antilock braking system. Our project is also on the safety of the driver and also the passengers in the car. There are two types of safety active, safety and passive safety. Active safety means safety of the driver as well as passenger before the accident happens. This include seat belt which fuctions in both normal operating condition as position of the seat. This enables safety of driver if he try to adjust the seat while ignition switch is ON. This project cover design of helical torsional spring and lever. CAD well as accidents. Passive safety means safety of driver and passenger after accident. This includes airbags which function when vehicle experiences sudden impact. In this project, we are mainly focusing on active safety of vehicle.[2]

In this project we are introducing a new concept which is related to the driver seat’s back and fourth arrangement. In the actual running condition driver cannot adjust the seat movement. When the ignition switch of the car is ON, the supply of the battery is given to the mechanism which restrict the movement of the drive seat back and forth adjuster and hence the movement of the seat in the running condition is not done.[2]

In the automotive industry innovation is vital. The industries are not trying to keep up with competitors but also have to maintain (or expand) market share and meet the increasingly stringent emission regulations to demonstrate a committed “green” responsibility in the ongoing public environmental debate.

Car manufacturers have to produce environmental friendly cars. Most of them are already proactively working toward reducing fuel consumption and emission levels and developing alternative technologies e.g., efficiency programs like Blue Lion of Peugeot, Efficient Dynamics of BMW and Blue efficiency of Mercedes Benz. Mercedes’ Blue efficiency is a package of fuel saving technologies. Advancements include improved aerodynamics, weight reduction, lower-displacement engines and ECO start/stop to help save energy. Their ultimate goal is emission free driving.[3]

In this project, the solution for the problem statement is done by using electric plunger, ignition switch, mounting track, lever side rail, battery, helical torsional spring, driver seat, etc. When the ignition switch of vehicle is switched ON, electric supply will be done to the electric plunger. The plunger will restrict the movement of adjustment rod of seat. This will cause in stationary modelling and analysis is done with the help of CAD softwares like CATIA and ANSYS 18.1.[4]
This project includes manufacturing of suggested safety mechanism. Shaft of electric plunger is welded with the spring operated lever of seat. This welding is done by arc welding.

2. SELECTION OF COMPONENT
For this project the following list of component are required:

I.A.1 Mounting track
I.A.2 Lever
I.A.3 Side rail
I.A.4 Helical Torsion spring
I.A.5 Battery
I.A.6 Ignition system modules
I.A.7 Electric Plunger mechanism for locking purpose

3. DESCRIPTION OF COMPONENT

1) Mounting track

A seat track assembly includes first and second tracks. The second track includes a detent. A roller engages the first and second tracks for facilitating movement of the first track relative to the second track. Movement of the first track relative to the second track at a predetermined position causes the roller to engage with the detent such that the detent resists rotation of the roller, thereby temporarily retaining the first track relative to the second track at the predetermined position.[4]

2) Base frame

Base frame is used to mount the overall mechanism of seat. This frame is made of hollow rod. There are slots in frame where the seat is mounted. Base frame is made in this way that the weight will be balanced perfectly. It is designed by considering the weight of seat and driver.[9]

3) Torsion helical spring

When a load is placed on one or both of the helical torsion spring's legs, they will travel in a rotational form. This is called torque. The function of Helical Torsional Spring is for its legs to travel a certain amount of degrees under a certain load and for it to return to its original state once the load is released.[9]

4) Side Rail

The ejection guide is the next part. It is this part which moves in the base sliding guider during the time of crash. The ejection guide is placed over the slider providing a coefficient of friction.[7]
4. MECHANISM

When an electrical current is passed through the coils windings, it behaves like an electromagnet and the plunger, which is located inside the coil, is attracted towards the centre of the coil by the magnetic flux setup within the coils body, which in turn compresses a small spring attached to one end of the plunger.

Electric plunger is a device used for the locking of the lever hence spring movement is restricted. Another type of electromagnetic actuator that converts an electrical signal into a magnetic field producing a linear motion is called the **Linear Solenoid**.[10]

5. DESIGN OF COMPONENT

A. Design of spring :-

Torsion springs exert a torque when they are twisted or deflected. The spring torque and the length of the legs together create a force. Torsion springs can be made out of round, rectangular or shaped wire.

A simple torsion spring has straight, but any bends or shapes can be formed. Double torsion springs can be used when twice the force is required or when you need an even distribution of torque.
Fig. Basic design of spring

**Spring Terms**

- **ID** = Inside Diameter
- **Dm** = Mean Diameter
- **Θ** = Deflection angle
- **d** = wire diameter
- **L** = leg length
- **Na** = number of active coils
- **Nt** = number of total coils
- **R** = Spring Rate
- **P** = applied force
- **M** = Moment or Torque
- **σ_b** = bending stress
- **c** = spring index
- **ΔL** = deflection
- **UTS** = Ultimate Tensile Strength

**Formulae**

1) Bending moment \( (M_b) \)

\[
M_b = P \times r
\]

\( P \) = External force acting on the spring (N)

\( r \) = Leg length

2) Bending stress

\[
σ_b = K \times \left( \frac{32M_b}{\pi d^3} \right)
\]

\( K \) = stress concentration factor due to curvature

3) Angular Deflection of spring \( (Θ) \)

\[
Θ = \frac{64PrDmNa}{Ed^4}
\]

\( D \) = mean coil diameter (mm)

4) Stiffness of helical torsion spring \( (k) \)

\[
k = \frac{Ed^4}{64DNa}
\]

\( D \) = Mean coil diameter (mm)

**B. Calculation**

We have from our model of this project, the following parameters are measured:

- Number of Coil in spring \( (Na) \) = 14
- Diameter of wire \( (d) \) = 1 m
- Outside diameter of spring = 5 m
- Inside diameter of spring = 4 mm
- Pitch in coil
- Iteration no. 1
- Material – Steel (Grade 1, Cold drawn)
Tensile strength = 1570 N/mm²

Young Modulus (E) = 2.08*10⁵ N/mm²s

FOS = 1.5 to 2

Spring Index

\[ C = \frac{D_m}{d} \]

= 4.5

\[ S_{yt} = 0.6 \times \text{UTS} = 942 \text{N/mm}² \]

Considering FOS is 2 because for higher load

The permissible stress is given by

\[ \sigma_t = 0.6 \times \text{UTS} / \text{FOS} = 471 \text{ N/mm}² \]

Stress concentration factor \( K_i \)

\[ K_i = \frac{4C^2-C-1}{4C(C-1)} = 1.19 \]

Deflection of spring, \( \varnothing = 45° \)

\[ \varnothing = \frac{64PPrD_mN}{E d^4} = 10.79 \text{ N} \]

Stiffness of spring

\[ k = \frac{Ed^4}{64 D_mN} = 51.08 \text{ N/mm}² \]

Bending Moment (\( M_b \))

\[ M_b = P \times r = 26.97 \text{ N-mm} \]

\[ \sigma_b = K_i (32M_b / \pi d^3) = 326.90 \text{ N-mm} \]

\[ \sigma_b < \sigma_t \]

Thus the design is safe

Design of Lever

\[ L_1 = 150 \text{ mm}, \quad L_2 = 70 \text{ mm} \]

The load acting on the lever is =10.79 N

Because the lever is on pivoted hence the force which required is 10.79 N.

6. CONCLUSION

Driver safety is the main highlight nowadays. Electric plunger system is the most effective system can be used here. As there are so many safety regulations considered nowadays, this mechanism saves the life of the driver. In the automotive industry innovation is vital. The industries are not trying to keep up with competitors but also have to maintain (or expand) market share and meet the increasingly stringent emission regulations to demonstrate a committed “green” responsibility in the ongoing public environmental debate. From this we have concluded that this project should be implemented in each and every car for safety.

7. REFERENCES


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Submersible Plunger Pump Lifting System in the Xinjiang Oilfield.


Siddhant T Chaudhary, the student of Marathwada Mitra Mandal College Engineering, Pune, Maharashtra. I am pursuing bachelor of engineering degree from Pune University.
ABSTRACT:

This is a paper on 3D printing which has become a notable topic in today’s technological discussion. In this paper, we will look at additive manufacturing or 3D printing. We will firstly define what we mean by this term and what is so significant about it. Then we shall see about the process of 3D printing and the materials used in the manufacture of 3D printed objects. We shall also see the advantages of 3D printing as compared to conventional methods of manufacturing. We shall observe the numerous applications it is being out to use today. 3D printing, additionally referred to as additive manufacturing, may be a method of basically making a three-dimensional object from a package model. The thing may be of just about any form. The method of making these objects in largely additive. Within the additive method, an object to be written is built from the base-up by in turn adding it to layers of the development material. The additive method may be contrasted with the subtractive process, where material is removed from a block by methods such as sculpting or drilling. The main material utilized in the development of 3D objects is plastic, though recently, there has additionally been a slew of innovation toward using alternative materials like metals of various sorts and additionally organic matter like carbon and its varied derivatives.

Index Term-3D printing, Additive Manufacturing
Complete Approach for Industrial Safety Measures and Precautions

Suraj Chaudhary#1, Chetan Chavan#2, Prasad Jamdar#3

#1surajchaudhary0707@gmail.com  
#2chetanchvn44@gmail.com  
#3prasadjamdar7@gmail.com

1 Student of Dept. of Mechanical Engineering, Pimpri Chinchwad College Of Engineering and Research, Ravet, Pune, Maharashtra, India, 412101  
2 Student of Dept. of Mechanical Engineering, Pimpri Chinchwad College Of Engineering and Research, Ravet, Pune, Maharashtra, India, 412101  
3 Student of Dept. of Mechanical Engineering, Pimpri Chinchwad College Of Engineering and Research, Ravet, Pune, Maharashtra, India, 412101

ABSTRACT

Number accidents recorded in industries are increasing year by year. Different types of industries require following different safety measures and guidelines to ensure the safety and health of their workers. In industries different processes are carried in which different process parameters are needed to be controlled. If by any means controlling of these parameters fails then it causes loss of control over the process which results in an emergency situation which may result in disaster if it is not controlled immediately. In this paper, we have reviewed different types of literature to study Industrial Safety measures which are followed by different Industries.

INDEX TERMS  Industrial safety, health, hazards, accidents, failures, breakage, precautions.

INTRODUCTION

To ensure that the workers, employees, staff work with their best potency and skill, safety of the workers should be observed to prevent organizational failure and unexpected halt in the company. Today large numbers of companies are adapting safety measure in the favor of each person working there in order to maintain a friendly and comfortable ambient environment for working professionals. It has been observed that most accident is caused by human behaviour followed by industrial errors and remaining least accidents are caused by other factors. Thus it is observed that the human fatigue and disorientation of any mental or physical parameter can cause accidents in large forms. The accidents not only lead to personal damage to the worker but also the damage is largely associated to the company’s overall performance and efficiency.

It can also cause monetary losses which can be more devastating if the company is small or medium scaled.

Thus safety is ensured in order to avoid maximum possible losses that are caused in a company and see different tools and techniques to avoid them effectively.

HISTORY

In the 17th century, the industrial revolution started, and around the 18th century it was at its top because of revolution in steam engines. Because of no Industry Safety Measures at that time, which resulted in bad working conditions for workers. This resulted in various accidents in the industry. Concerns about Industry Safety Measures begun in Europe with the labour movement.

Because of this movement workers formed their unions and began to demand better working conditions.[1]

Because of this Government organizations imposed some safety rules and regulations on industries. By the time these rules and regulations developed.

CAUSE OF ACCIDENTS

Industrial accidents can be caused during operation or in any normal condition when worker is not present on machine site physically.
Causes generally involve human error generally when a worker is less conscious due to fatigue or any other health parameter or any psychological condition.

Second most common cause is on industrial level which is caused due to failure of machines, improper tool position, wearing out of machines, mechanical failures, electrical failures like short circuit etc.

Third most common factor is generally unavoidable as the reason can be variable every time, it causes least accidents. Factors like natural calamities are included in this.

Fig.1 Cause of Accidents

A. HUMAN FACTORS
The main focus in occupational health is on three different objectives:

(i) The maintenance and promotion of workers’ health and working capacity;
(ii) The improvement of working environment and work to become conducive to safety and health and
(iii) Development of work organizations and working cultures in a direction which supports health and safety at work and in doing so also promotes a positive social climate and smooth operation and may enhance productivity of the undertakings.

The concept of working culture is intended in this context to mean a reflection of the essential value systems adopted by the undertaking concerned. Such a culture is reflected in practice in the managerial systems, personnel policy, principles for participation, training policies and quality management of the undertaking.[2]

— Joint ILO/WHO Committee on Occupational Health

Following precautions and safety procedures concerned to the employees physical and mental health.

- Use of common sense, concentration, until the job gets done.
- Ensuring timely payment and incentives for workers depending on performance, experience, skills, etc. this ensures that workers maintain a calm and composed attitude when assigned a task and don’t feel burdened or inferior under any chance, this will make sure that that workers give their best possible performance as they are paid adequate.
- Working hours should be flexible and must be depending on age, physical attributes, and must include proper posture, work environment, and adequate amount of rest.
- Proper environment for working conditions that include proper air ventilation, working posture, safety gears, sanitizations, refreshment facilities, etc.
- Proper education and awareness about all the machineries in the organization, and safety drills.
- Occasional meetings of employee’s peers and management staff to constantly improve work environment and to take feedback from the employees.
- Ensuring adequate work life balance.
- Ensuring basic reading and writing capabilities of workers to ensure they can read warnings and symbols on the equipment and machineries.
- Ensuring there is minimum communication barrier between colleagues to deliver messages properly.
- Upgrading machines and technologies to avoid fatigue and work stress.
- Allowing everyone to make decisions on individual level.
- Boycotting traditional management.
- Ensuring communication and maximizing productivity by allowing them to take charge on
individual level and also build sense of confidence among them.

- Promoting workers for different job to avoid boredom.
- Occasional trips, and reasonable holidays.
- Avoiding smoking, alcohol, or any other drug before work.
- Implementing kaizen, TPM, 5S whenever required.
- Respect and dignity to every individual in the company.

Some companies in the world work on non-hierarchical structure and have no bosses or management bodies. Such companies have the best work life balance and projects are generally self-paced. These organizations have high revenues. These companies are generally startups or IT companies. Thus this ensures optimum mental health of the people and staff. Which further improves overall profits of the companies? No proper dress code and designation is offered. Work is distributed by self-willed and capabilities only. Thus above things can be done in order to avoid failure on human level.

B. INDUSTRIAL FAILURE
The biggest industrial disaster in human history is the Bhopal Disaster at Union carbide factory, Bhopal, Madhya Pradesh, India. It was found that tragedy occurs because of many valves and lines were in poor conditions. In addition of that safety systems used were malfunctioning. Around 19000 people lost their lives of this gas tragedy. This is a great example of industry-level failure. [3]

The following precautions are needed to be followed to avoid any industrial level emergency situations.

- Industry must follow the Safety rules and regulations given by government organizations.
- The position of the tools should be in the right position and should be easily accessible by workers.
- Continuous maintenance of equipment should be done to avoid any emergency situation.
- There should always be a fire extinguisher in the industrial workplace for fire-related situations.
- Industry should ensure to have a backup of electricity because the sudden shut down of some machines can lead to accidents.
- Industry should ensure to have better lighting in the workplace.
- Industry should inform the workers about the procedure they need to follow in emergency situations to avoid any accident.
- Companies safety officers should ensure that all the types of equipment that are used in the industry should be in good condition and the worker should inform the officer if they found any problem with the equipment.[4]
- Industry should ensure that there should be enough space for the free moment of material and equipment.
- Continuous maintenance of equipment should be done to avoid any emergency situation.
- Make sure that chemicals that are being used in industries should be named properly.[5]
- Industry Safety officers should ensure that all types of equipment must be shut down if not required.[6]

All machinery used in the industry should have manufactures’ installed safety guard.

C. OTHER FAILURE
These are the unpredictable failures. Some examples are:

- Coronavirus Impact on Industries
  The coronavirus outbreak, which was first detected in China, has infected people in 185 countries. Its spread has left businesses round the world counting the prices. Worried by the effects of corona virus Industries are closed.

- Earthquake
  It destroy the industry both physically and mentally. It can lead to a short term employment for the repair and reconstruction.

- Flood
  The overflow of water can destroy the machines running on electricity. It can even leads to fire from short circuit.

CONCLUSION
We have above discussed causes and solution for industrial safety to ensure maximum output of a company and to reduce monetary losses. Accordingly we conclude that human behaviour and errors are largely responsible for failures and accident in organization. Thus we primarily focus on it as first priority to be considered taking in account so that the industrial safety should not be compromised.

ACKNOWLEDGEMENT

We would like to take opportunity to express our heartfelt thanks to all those peoples who encouraged us during this Manuscript completion path. I feel great pleasure to present the Manuscript entitled “Complete Approach for Industrial Safety Measures and Precautions” But it would be unfair on our part if we do not acknowledge efforts of all the some people who helped us with this project. Most importantly we would like to express our sincere gratitude towards or Friends & Family for always being there when we needed them most.

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Rajashri G. Chaudhari¹, Prof. Dr. R.K. Rathod²

¹Dept. of Mechanical Engineering, Pimpri Chinchwad College Of Engineering and Research, Ravet, Pune, Maharashtra, India, 412101
²Dept. of Mechanical Engineering, Pimpri Chinchwad College Of Engineering and Research, Ravet, Pune, Maharashtra, India, 412101

ABSTRACT

The Fuel Energizer has been tested and developed for the lot of vehicles and household component Market. The combustion efficiency in most internal combustion engines/petrol engines/diesel engines do not exceed (90%) so that part of the fuel does not burn and comes out with the exhaust gases, and also leading to increase flowing fuel consumption and emissions in the atmosphere. Therefore, several work have been made to increase the combustion efficiency engine and reduce emissions through engine exhaust. In this era of increasing fuel prices, here a device called Magnetic Fuel Energizer help us to Reduce Petrol /Diesel /consumption in IC engines and reduces exhaust emission gases. The Fuel Energizer has been developed and adapted using the Indian conditions in mind and it is also the first device that make this claim. “FUEL ENERGIZER” helps to reduce fuel consumption up to 30%. When fuel flows through strong magnetic field created by Magnetizer(Fuel Energizer) the intermolecular forces is considerably reduced or depressed and hence oil particles are finely divided. This has the effect on combustion of ensuring that fuel actively interlocks with oxygen producing an more complete burn in the combustion chamber. This result in higher efficiency, increase in output, and also reducing the fuel economy, reducing in emission of carbon dioxide, nitrogen, carbon monoxide, etc in atmosphere. The magnetic ionization of the fuel also helps to dissolve the carbon build-up in carburetor, jets, fuel injector and combustion chamber, thereby keeping the engine in a cleaner condition.

INDEX TERMS Fuel Energizer, Emission, Fuel consumption, ortho, Para, Realignment, etc.

1. INTRODUCTION

Today, the need of improvement of engine thermal efficiency is dominant approach to improve engine efficiency. The hydrocarbon fuels leave their natural deposit of carbon residue that locked the carburetor, fuel injector, leading to reduced the output, efficiency and fuel economy. This clogs in carburetor, Pinging, stalling, loss of power(HP) and greatly reduced in mileage on cars are very noticeable. Generally most of fuels for internal combustion engine are liquid, fuels do not combust until they are vaporized and mixed with air. Most of emission by motor vehicle consists of unburned hydrocarbons, carbon monoxide and oxides of nitrogen. The residue Unburned hydrocarbon and oxides of nitrogen react in the atmosphere and create smog. Smog is dangerous to living being as it effects prime cause of eye and throat irritation, noxious smell, flat damage and decreased visibility. Generally an fuel used for internal combustion engine is compound of molecules including hydrocarbons, nitrogen, etc. And each molecules consists of number of atoms made up neutrons and electrons, which orbit there nucleus. Magnetic movements already present in their molecules and they therefore already have positive and negative electrical charges. However these molecules are random, have not been realigned, the fuel is not actively interlocked with oxygen during combustion of fuel in engine, hence for this the fuel molecule or hydrocarbon chains must be ionized and realigned. The ionization and realignment is achieved through the application of magnetic field created by „Fuel Energizer“. Fuel mainly consists of hydrocarbon and when fuel flows through an strong magnetic field, such as the one created by fuel energizer, the hydrocarbon change their orientation and molecules of hydrocarbon change their configuration form para to ortho state. Hydrocarbon molecules treated with strong magnetic field tend to de-cluster, break the forming smaller associates with higher specific surface for the reaction with oxygen to create complete combustion. [2] The ionization fuel also helps to dissolve the carbon build-up in carburetor, jets, fuel injector and combustion chamber, thereby keeping the engines clear condition and hence also help in reducing thereby emission of unburned content.

2. LITERATUREREVIEW

HYDROCARBON FUEL

Rajan Garg, The hydrocarbon fuel is Simplest of hydrocarbons, methane, (CH4) is the major (90%) constituent of natural gas (fuel) and an important source of hydrogen. From the energy point of view, the greatest amount of releasable energy lies in the hydrogen atom.
Hydrogen, the lightest and most basic element known to man, is the major constituent of hydrocarbon fuels besides carbon and smaller amount of Sulphur and inert gases. It can be either diamagnetic or paramagnetic (weaker or stronger response to the magnetic flux) depending on the relative orientation of its nucleus spins. Even though it is the simplest of all elements, it occurs in two distinct isomeric varieties (forms) - Para and Ortho.[5]

Hasanain A. Abdul-Wahhab explains that

The Para & Ortho state of Hydrogen as follows:

- In the para H2 molecule, which occupies the even rotation levels (quantum number), the spin state of one atom relative to another is in the opposite direction ("counter clockwise", "anti-parallel", "one up & one down"), rendering it diamagnetic.[1]
- In the ortho molecule, which occupies the odd rotational levels, the spins are parallel ("clockwise", "coincident", "both up"), with the same orientation for the two atoms; therefore, is paramagnetic and a catalyst for many reactions. It has one positive charge (proton) and one negative charge (electron), i.e. it possesses a dipole moment. It can be either diamagnetic or paramagnetic (weaker or stronger response to the magnetic flux) depending on the relative orientation of its nucleus spins. The interesting fact is that the ortho-hydrogen is more reactive than its para-hydrogen counterpart[5]. As shown in fig 1. [1]

In literature review of Ali S. Faris, they have studied on the Type of magnet used:

Neodymium Magnets: Neodymium Magnets also known as Neo magnet which is most widely used type of rare earth magnet and in bright silver colour as shown in Fig.2. This is a permanent magnet which made from alloy of neodymium, iron and boron and this magnet considered to be the strongest magnet type among other permanent magnet.[3] Each device contains the number of permanent magnets arranged alternately in multiple stages. The magnetic intensities of those magnets are (2000, 4000, 6000, 9000) Gauss.[2]

**installation of fuel energizer**

Niraj N. Petkar, Magnetizer fuel energizer (eg: - Neodymium super conductor –NSCM) is installed on cars, trucks immediately before carburettor or injector on fuel line. On home cooking gas system it is installed just before burner[4]. As shown in fig.3

3. METHODOLOGY

When the hydrocarbon fuel(CH4) is combusted, due to the outer electron in valence shell of hydrogen first oxidised. Further carbon atoms are subsequently burned (CH4 + 2O2 = CO2+ 2H2O). In high speed internal combustion process, the hydrogen molecule takes less time to oxidized but in normal condition only some part of carbon atom is oxidised; this is responsible for incomplete combustion. Oxygen combines with hydrogen readily, however the reaction between hydrogen-oxygen is far less energetic. The optimum combustion efficiency is obtained by application of magnetizer on fuel and it is observed by percentage decrease in emission of toxic by-products which is validated by state emission control devices.

When fuel flows through magnetizer the hydrocarbon change their orientation from para to ortho state and molecules of hydrocarbon changes their configuration. This has the effect that fuel actively interlocked with oxygen molecules to produced nearly complete combustion in engine. The result is higher output efficiency, reduction in hydrocarbons, carbon monoxide and nitrogen oxide emitted through engine’s ionization fuel helps in dissolve carbon which in formed in
carburettor jets, fuel injectors and combustion chamber, hence thereby keeping engine in clear condition. Also it works on any vehicle or device cooking gas stove by using gas and liquid fuel.[4-5]

![Diagram of hydrogen molecule](image1.png)

Fig 4: a) Para Molecule In Normal Combustion

![Diagram of magnetized hydrogen molecule](image2.png)

Fig 4: b) Para Molecule After Magnetized Combustion

The above fig 4.a and fig 4.b shows the comparison of hydrogen molecule when magnetizer is not used and used respectively. Hence it shows that ortho molecule reduces the intermolecular force and increases space between molecules to interlock with oxygen molecule.

4. COMPARATIVESTUDY

The comparison between magnetizer and catalytic converter is as shown in above table no .1. One of the chief reasons for the Magnetizer to have possibility to lower the NOx level, as reported elsewhere, is due to the low reactivity of nitrogen gas. If we can bind up all the available oxygen with the hydrocarbon fuel, there simply will be no oxygen left over to form the unwanted nitrogen compounds[5].

i.

ii.

<table>
<thead>
<tr>
<th>Points</th>
<th>Magnetizer</th>
<th>Catalytic Converter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Warranty</td>
<td>Fig 4: a) Para Molecule After Normal Combustion</td>
<td>None Magnetized Combustion</td>
</tr>
<tr>
<td>Fig 4:b) Para Molecule After</td>
<td>5 minutes</td>
<td>45 minutes to 1.5 hours</td>
</tr>
<tr>
<td>Installation</td>
<td>Never wears out</td>
<td>20 to 50,00 miles depending on the vehicle it is fitted on</td>
</tr>
<tr>
<td>Product Life</td>
<td>Get Improvement</td>
<td>Less Power</td>
</tr>
<tr>
<td>Vehicle’s Power</td>
<td>Gets Improvement</td>
<td>Less economy</td>
</tr>
<tr>
<td>Vehicle’s Economy</td>
<td>love the benefits</td>
<td>Poor acceptance due to loss</td>
</tr>
<tr>
<td>Customer Opinion</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Air Pump Required</td>
<td>No</td>
<td>Yes</td>
</tr>
</tbody>
</table>

Table no 1: Comparative study

5. ADVANTAGES
More mileage (up to 28 increase) per litre due to 100% burning fuel.

No fuel wastage.

iii. Reduced smoke.

iv.duce Engine Noise.

v. 30% extra life for expensive catalytic converter.

6. APPLICATION
   i. It can be used for refrigerator.
   ii. It can be used in chemical industry.
   iii. It can be used vehicle such as cars, trucks.
   iv. It can be used agriculture field
   v. It can be used as pool and span conditioner.

7. CONCLUSION
   By establishing correct fuel burning parameters through proper magnetic means one can assume that an inside combustion engine is getting maximum energy per liter also as environment with lowest possible level toxic emission. Magnetic fuel energizer(MFE) increases the interior energy of a fuel to cause specific changes at a molecular level which obtained easier combustion. The resultant fuel burn more completely, producing higher engine output, better fuel economy, more power & most significantly reduces the quantity of HC, CO, NOx within the exhaust.& therefore control the emission at low cost. In short the summary of the conclusion includes: MFE increases 10-40% mileage of auto , Reduction in HC emission & other pollutants. Avoid clogging problems in diesel , Cost saving, Eco friendly, Provides 30% extra life for expensive converter , Reduce maintenance of engine most significantly doesn't require any design modification & finally cost saving. Since the Fuel Energizer saves fuel by increasing combustion efficiency, less CO is being emitted; thereby, less fuel is getting used.

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Rajashri G Chaudhari, the student of Pimpri Chinchwad College Of Engineering And Research, Pune, Maharashtra, India, 410401. Pursuing his bachelor’s degree in Mechanical Engineering from Pune University.
A Review on Phase Change Materials and Their Applications

Janhavi Satpute¹ Shashvita Muley² Haritha Magesh³ Shubham Bahir⁴ Prof. Vijay P Desai⁵

¹Dept. of Mechanical Engineering, Pimpri Chinchwad College Of Engineering and Research, Ravet, Pune, Maharashtra, India, 412101
²Dept. of Mechanical Engineering, Pimpri Chinchwad College Of Engineering and Research, Ravet, Pune, Maharashtra, India, 412101
³Dept. of Mechanical Engineering, Pimpri Chinchwad College Of Engineering and Research, Ravet, Pune, Maharashtra, India, 412101
⁴Dept. of Mechanical Engineering, Pimpri Chinchwad College Of Engineering and Research, Ravet, Pune, Maharashtra, India, 412101
⁵Dept. of Mechanical Engineering, Pimpri Chinchwad College Of Engineering and Research, Ravet, Pune, Maharashtra, India, 412101

ABSTRACT.
The choice of the phase change material (PCM) plays an important role, along with the heat transfer mechanism for the development of a latent heat storage unit (LHSU). The enviable thermo-physical, kinetic, and chemical properties of PCM with the economy is an essential criterion for efficient thermo-economical LHSU. The most important criteria that have limited widespread use of LHSU are the useful life of phase change materials. The PCM used in the system should be thermally stable and reliable for long term performance of LHS. After a repeated number of thermal cycles, it does not deteriorate its own properties, especially latent heat and melting point. Thus an exhaustive literature survey is carried out for different types of PCMs used. The primary objective of this chapter is to carry out a critical review of thermal stability of different groups of PCM for low and high temperature applications. This information is towards the selection of reliable PCM for latent heat storage unit.

INDEX TERMS - Phase change materials, latent heat storage, temperature, applications

1 INTRODUCTION
Energy plays a major role in the economic prosperity and the technological competitiveness of the nation. Rapid development has led to huge demand for energy. The resource augmentation and growth in energy supply have failed to meet the ever increasing demands exerted by the multiplying population, rapid urbanization and progressing economy. In order to conserve energy and reduce dependency on fossil fuels and also to reduce the greenhouse gas emission, it is essential to develop efficient and inexpensive energy storage systems. Energy storage systems eliminate shortage between supply and demand and also exhilarate energy system performance and reliability. The energy storage can substantially reduce the total energy consumption when integrated to sustainable energy sources such as solar energy, wind energy, waste heat recovery, biogas etc. And hence, conserve indigenous conventional energy sources. The thermal energy storage (TES) is also popular now and acts as a crucial aspect in engineering applications. TES may comprise sensible storage systems (energy storage by single phase heating and cooling), latent heat storage (energy storage by two phase melting and solidification) and thermo-chemical heat storage (energy storage by reversible chemical interactions between reactive components). The latent heat storage (LHS) systems stand out due to high storage density and nearly isothermal phase change.

The thermal energy storage materials used for LHS systems are also known as phase change materials (PCM). These phase change materials can be incorporated into thermal based machines and be best utilized for increased efficiency and utmost resource utilization.

FIGURE 1 Variation of temperature with energy provided to a PCM.[9]
A phase change material (PCM) is a substance which releases/absorbs sufficient energy at phase transition to provide useful heat/cooling. Generally the transition will be from one of the first two fundamental states of matter - solid and liquid - to the other. The energy released/absorbed by phase transition from solid to liquid, or vice-versa, the heat of fusion is generally much higher than the sensible heat. By melting and solidifying at the phase change temperature (PCT), a PCM is capable of storing and releasing large amounts of energy compared to sensible heat storage. Heat is absorbed or
released when the material changes from solid to liquid and vice versa, or when the internal structure of the material changes; PCMs are accordingly referred to as latent heat storage (LHS) materials. For many different commercial applications where energy storage and/or stable temperatures are required, including, among others, heating pads, cooling for telephone switching boxes etc, PCMs are used.

2. OBJECTIVE
The sole aim of the review paper is to identify various Phase change materials and to determine various thermal and mechanical properties of the same citing various engineering applications of the Phase change Material. This paper aims to focus on specific PCM’s which would function efficiently between 60 to 120 Celsius and provide workable thermal stability suiting its application.

3. CLASSIFICATION, PROPERTIES AND DEMERITS

A. PROPERTIES OF PHASE CHANGE MATERIALS
Successful utilization of the latent heat storage unit (LHSU) depends considerably on the selection of the PCM, which plays an important role in development of LHSU. The feasibility of using a particular PCM for an LHSU is based on some desirable thermo-physical, kinetic, and chemical properties of the PCM. These desirable thermal, physical, kinetic, chemical and economical properties of PCM are listed below in Table 1.[14][15]

As no single material can have all the required properties for an ideal thermal storage media, one has to use the available material and try to make up for the poor physical properties by an appropriate system design.

A. CLASSIFICATION OF PHASE CHANGE MATERIAL

<table>
<thead>
<tr>
<th>Properties of Phase Change Material</th>
<th>THERMAL PROPERTIES</th>
<th>PHYSICAL PROPERTIES</th>
<th>KINETIC PROPERTIES</th>
<th>CHEMICAL PROPERTIES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Suitable melting point for particular application</td>
<td>High density for smaller container volume</td>
<td>Little or no super cooling during freezing</td>
<td>No degradation after a number of freeze/melt cycle</td>
<td></td>
</tr>
<tr>
<td>High latent heat of fusion per unit volume</td>
<td>Small volume change during phase transition</td>
<td>High rates of nucleation and high rate of crystal growth</td>
<td>Non-corrosive ness to the construction material</td>
<td></td>
</tr>
<tr>
<td>High thermal conductivity of solid and liquid phases for better heat transfer</td>
<td>Low vapor pressure to reduce the containment problem</td>
<td>Effective heat transfer</td>
<td>No chemical decomposition</td>
<td></td>
</tr>
<tr>
<td>Higher specific heat for additional sensible heat storage</td>
<td>Reproducibility in the congruent during entire thermal cycle</td>
<td>Effective heat transfer</td>
<td>Non-poisonous, non-flammable, non-polluting and non-explosive</td>
<td></td>
</tr>
</tbody>
</table>

4. SELECTION CRITERIA
Materials to be used for phase change thermal energy storage must have a large latent heat and high thermal conductivity. They should have a melting temperature lying in the practical range of operation, melt congruently with minimum subcooling and be chemically stable, low in cost, nontoxic and non-corrosive. Materials that have been studied during the last 40 years are hydrated salts, paraffin waxes, fatty acids and eutectics of organic and non-organic compounds.[2] Depending on the applications, the PCMs should first be selected based on their melting temperature. Materials that melt below 15 C are used for storing coolness in air conditioning applications, while materials that melt above 90 C are used for absorption refrigeration. All other materials that melt between these two temperatures can be applied in solar heating and for heat load leveling applications. These materials represent the class of materials that has been studied most. [2] Various materials available for energy storage in a temperature range near 80–120 C have been identified for solar cooking.

The choice of the material is based on the melting temperature, the latent heat of fusion, density and other...
considerations such as toxicity, corrosiveness and cost. [1] The most important criteria that have limited widespread use of latent heat stores are the useful life of PCMs-container systems and the number of cycles they can withstand without any degradation in their properties. Insufficient long term stability of the storage materials is due to two factors: poor stability of the materials properties and/or corrosion between the PCM and the container. The development of PCM containers must be directed towards demonstration of physical and thermal stability, as the PCMs must be able to undergo repetitive cycles of heating and cooling. The purpose of these thermal cycling tests is to determine whether these thermal exposures will result in migration of the PCM or may affect the thermal properties of the PCM. [2]

The PCM cycles degrade over repetitive use for thermal functioning. A particular PCM may function for a definite cycle for said period based on its chemical composition and production techniques. Once the PCM functions for the defined cycles it loses its thermal properties. This property is termed as the thermal stability of the PCM. The selection of the PCM for a particular application may largely vary based on its thermal stability.

A. 4.1. IDENTIFICATION OF PCM FOR DESIRED TEMPERATURE RANGE

The PCMs mentioned below in table 2 have operating temperature ranges between 60 to 120 Celsius suiting the purpose

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>PCM</th>
<th>Melting point (°C)</th>
<th>Latent Heat (kJ/kg)</th>
<th>Densify (kg/m3)</th>
<th>Thermal cycle</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Paraffin</td>
<td>60</td>
<td>159</td>
<td>900</td>
<td>600</td>
</tr>
<tr>
<td>2</td>
<td>Stearic acid</td>
<td>64.5</td>
<td>161</td>
<td>940</td>
<td>450</td>
</tr>
<tr>
<td>3</td>
<td>Acetamide</td>
<td>79</td>
<td>263</td>
<td>1159</td>
<td>500</td>
</tr>
<tr>
<td>4</td>
<td>Magnesium nitrate hexahydrate</td>
<td>90</td>
<td>172</td>
<td>1464</td>
<td>500</td>
</tr>
<tr>
<td>5</td>
<td>Acetamide</td>
<td>118</td>
<td>222</td>
<td>1220</td>
<td>300</td>
</tr>
<tr>
<td>6</td>
<td>Erythritol</td>
<td>122</td>
<td>338.8</td>
<td>1450</td>
<td>1000</td>
</tr>
</tbody>
</table>

5. MAJOR APPLICATIONS OF PCM

The application of energy storage with phase change is not limited to solar energy heating and cooling but has also been considered in other applications as discussed in the following sections.

5.1. Air Conditioning

PCM Used- Magnesium Nitrate Hexahydrate

Until very recently, pcm were not reliable enough to be used in air condition. We have developed pcm with almost infinite life and good performance in the human comfort range of 18°C (64F) to 29°C (84F) and further for electronic comfort at higher temperature. [10]

FIGURE 2 Air cooling in ducts using PCM heat exchanger [16]

5.2 Telecom Shelters

PCM Used- N-eicosane : Telecom shelters are insulated, air-conditioned enclosures that house the heart of mobile communication, the Base Transceiver Station (BTS), BTS, and also the battery, is very temperature sensitive and its surroundings should always be maintained below 35 deg C. In under-developed countries, there are frequent power cuts and single phasing, forcing cellular service providers to install Diesel Generators to support the air-conditioner in case of power cuts or single phasing. Phase Change Material PCM installed in Telecom Shelter will absorb heat in case of unavailability of power, minimizing/eliminating use of DG Sets. PCM will get re-charged when power source is available. Thus, PCM stores energy using a cheap source of power and releases it when that cheap source of power is not available, thus saving on Diesel Cost. Telecom Shelters PCM

5.3 Transportation

Transportation of perishable foods, temperature sensitive
pharmaceuticals, sundry electronics (like ignition transformers) and chemicals (explosives) require refrigerated trucks. Such refrigerated trucks are prohibitively expensive to operate as they use Diesel as a source of energy. Cost of diesel-generated energy is 6 times higher as compared to conventional electricity cost. Thus, Phase Change Material stores energy using a cheap source of power and releases it when that cheap source of power is not available. Phase Change Material - General Products like Green House & Electronic cooling

5.4 Automobiles

PCM Used- alkyl hydrocarbons, exfoliated graphite

PCM is already used today in a latent heat battery offered by BMW as optional equipment in its 5 series. The principle is quite simple; the storage material is connected to the radiator and stores excess heat when the motor runs at operating temperature. This heat is then available at the next cold start to heat up the motor quickly (better gas mileage) and for the interior (driving comfort). Due to the latent heat battery’s excellent insulation, it can maintain the energy for 2 days at an outside temperature of – 20°C. As an extension to this application, PCM can also be used in tail-pipes (exhaust) of vehicles. This will maintain the catalytic converter at its design temperature, reducing excessive Hydro-carbon emissions during vehicle startup.

5.5 House heating, WarmWater

PCM Used- Erythritol, Adipic Acid, HDPE

Solar energy is not available at all times, and therefore solar installations require an intermediary storage of the energy for heating or warm water. PCM based systems will offer the following benefits over a conventional system: Low volume in comparison to water storage systems and a higher efficiency due to a lower temperature difference between loading and discharging of the energy. Latent heat storage can also be implemented in conventional heating systems. Phase Change Material based solar water heater will also give a better controlled water temperature. Natural Cooling Phase Change Material – PCM. [13]

5.6 Constructionmaterials

PCM Used- Paraffin Wax, Bee Wax.

5.7 Catering

The transportation of warm meals requires a heat source; otherwise it will not meet the quality standards set by the consumers. An electric heating source cannot always be implemented, in such cases Phase Change Material offers an ideal, self-regulating heating element. The melting point of the PCM depends upon the temperature at which the food should be kept. 60° – 70°C are optimal so that the food does not continue to cook but is hot enough to eat.

5.8 Electronics

PCM Used- N-eicosane

Electronic circuitry is extremely sensitive to overheating, negatively influencing both lifetime and reliability of the parts. To date, metal fins are used for heat sinking improving their cooling capacity with additional fans. The sinking of heat peaks using PCM is absolutely reliable since no motor or temperature measurements are required. The PCM regenerates itself between peaks by emitting the heat with cooling fins. The advantage is a smaller cooling system with a very high reliability.

5.9 GreenHouses

PCM Used- CaCL2.6H2O

It is important to maintain temperatures in a small range to enable plants cultivated in a greenhouse to flourish. However, due to large temperature swings in daytime and nighttime temperatures, most green houses need air-conditioning and/or heating. Phase Change Material installed in the floor of such green houses will eliminate or reduce the dependence on air-conditioning/heating.

5.10 Solar Water HeatingSystem

PCM Used- Stearic Acid
Solar water heaters are gaining tremendous popularity nowadays as they are relatively inexpensive and easy to maintain. A built-in storage-type water heater contains a layer of PCM filled at the bottom. During the sunshine hours, the water gets heated up which in turn transfers heat to the PCM below it. The PCM collects energy in the form of latent heat and melts. During off-sunshine hours, the hot water is withdrawn and is substituted by cold water, which gains energy from the PCM. The energy is released by the PCM as it changes its phases from liquid to solid.[9]

5.11 Solar Cookers

**PCM Used: - Acetamide, Erythritol**

One of the major domestic uses of solar energy is cooking using solar cookers. Due to the irregularity of solar radiation, the use of these solar cookers is limited. But if storage of solar energy is provided in a solar cooker, then the utility and reliability of these solar cookers would increase. A few studies have been conducted on latent heat storage materials in a box-type solar cooker to cook the food after sundown. Even though the solar cookers with solar cookers, they have good potential for mass rural and semi-rural applications. At present, further research is in progress on new PCMs which could be used effectively in solar cooking applications and make it more economical.[9]

5.12 Cooling Helmets

**PCM Used - Climsel C28**

The PCM helmet cooling system is simple and has the potential to be implemented as a practical solution to provide a comfortable experience to motorcycle riders and sportspersons. In 2006, Tan and Fok designed a helmet cooling system using PCM to absorb and store the users’ body heat to achieve comfort cooling. The PCM is packed into a pouch and placed such that it is in contact with the users. The heat from the users’ bodies is conducted to the PCM so that the PCM temperature is maintained just below that of the users’ body temperature. This keeps the user cool and alert. The cooling unit is able to provide comfort cooling up to 2 hours till the PCM is completely melted. The heat stored in the PCM pouch is discharged by immersing in water for about 15 minutes which solidifies the PCM before re-use.[9]

5.13 Temperature utilization in thermal equipments

In the mechanical industry, there are applications where refrigeration and heating are required in the same batch. In such cases, use of PCM will reduce utility costs, as PCM will store energy from the chemical reaction for use at a later stage in the same batch.

5.13.1 Indirect contact latent heat storage of solar energy

**PCM Used - Acetamide, Stearic Acid, Magnesium Nitrate Hexahydrate, Acetanilide, and Erythritol**

Extensive efforts have been made to apply the latent heat storage method to solar energy systems, where heat is required to be stored during the day for use at night. The studies varied from those related to the fundamental aspects of heat transfer to those in which the PCM is tested in full size heat storage units. Most PCMs have low thermal conductivity that limits heat transfer rates during their applications. Hence, the PCM must be encapsulated in such a way as to prevent the large drop in heat transfer rates during its melting and solidification. The PCM is usually contained in a number of thin flat containers, similar to plate type heat exchangers.[2]
containers for encapsulating the PCM [2]

![Image](image_url)

**FIGURE 5** Simplified sketch of a thermal storage unit employing two types of PCM [2]

5.13.2 Thermal storage with direct contact heat exchanger

**PCM Used-** Paraffin

The low thermal conductivity of most PCMs requires the use of large and expensive heat transfer surfaces, which is considered as the major drawback in applying them. Direct contact heat transfer arrangements eliminate the requirement of these expensive metallic surfaces. [2]

5.13.3 PCM major and common applications in optimizing heating and cooling load

**PCM Used-** Calcium chloride Hexahydrate

PCM applications in building are prevalingly divided into two large classes—passive and active systems. [9] Passive system achieves the functions of collecting, storing, and releasing heat by building structure itself. However, active system needs to rely on pumps or fans to convey heat transfer medium. Basically, three different ways to use PCMs for heating and cooling of building are as follows: A] PCMs in building walls. B] PCMs in building components other than walls, such as floor and ceiling. C]PCMs in heat and cold storage units located in building interior instead of envelope, such as storage heat/ice tank.[9]

6. CONCLUSION

In this review paper we have identified various phase change materials and summarized their physical, thermal and chemical properties based on their compositions and production methodologies. We have determined a criterion for the selection of PCM’s based on the mechanical and thermal requirement we have identified various applications of phase change materials which have assisted in bringing down the consumption of energy worldwide the energy storage systems like PCM exhilarate energy system performance and reliability.

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Design and Development of Coconut Tree Climbing and Harvesting Machine (May 2019)

A. Prof. R.S.Pimpalkar1, B. Mr. Rohit Sayaji2, C. Mr. Rajas Pawar3, D. Mr. Aniket Rupanwar4, E. Amol Satdive5

1Dept. of MECH Engineering, Pimpri Chinchwad College of Engineering, Pune, Maharashtra, India, 411044.
2Dept. of MECH Engineering, Pimpri Chinchwad College of Engineering, Pune, Maharashtra, India, 411044.
3Dept. of MECH Engineering, Pimpri Chinchwad College of Engineering, Pune, Maharashtra, India, 411044.
4Dept. of MECH Engineering, Pimpri Chinchwad College of Engineering, Pune, Maharashtra, India, 411044.
5Dept. of MECH Engineering, Pimpri Chinchwad College of Engineering, Pune, Maharashtra, India, 411044.

ABSTRACT

The main goal of this project is to minimize human efforts required for climbing the coconut tree and to provide safety to the climber. Nowadays in city areas climbers are not available because of that the wastage of coconut increasing day by day. Also these coconuts falls itself after a certain period of time if not harvested, which is a very unsafe scenario. If the climber climbs on tree and falls from the height of 90 feet then it is impossible for him to survive. During the survey a village man stated that if a person falls from height of 90 feet it’s unnecessary to see whether he is dead or alive, he is definitely dead. Also if the coconut rope climbing gears and spiked shoes are used, but are impractical and inefficient for use in large scale plantation harvesting. That’s why we are introducing a machine which can replace climber completely, so climber need not face any difficulties while coconut harvesting. The machine introduced is different than the existing machines because human can operate this machine from ground and need not to climb that much height for harvesting coconuts.

INDEX TERMS Coconut Harvesting, Tree climbing, robotic arm.

1. INTRODUCTION

Coconut is one of the cash crops in India. India is one among the top players of coconut producers in the world [5]. If we see as per statistical data India is second largest producer of coconut among 80 countries of world with 61 million tons per year. Coconuts harvested every year, plays a huge role in the economy of several states of country like Tamil Nadu, Kerala and Karnataka etc. But the coconut farmers and home-grown coconut tree growers face lot of difficulties in getting manual coconut tree climbers to harvest the coconut. Majority of coconut harvesting is done by climbing tree and cutting it by hands. This process is simple but it’s actually dangerous. There is acute shortage of human coconut tree climbers not only in India but all over the world. Traditionally this job is taken up by the socially and economically backward people in India. As the literacy rate increases and India is growing economically, there are several high paid jobs which people move to. It also a risky job in which an accident might be fatal in some cases. Without proper insurance coverage, this could be a blow to the entire family if the climber is the lone person to earn and take care of the family. Better solutions have to identify to harvest coconuts since the job is risky in nature. Almost in 78 cases out of 220 climbers fell down from coconut trees while doing their job. The conventional way of harvesting is by climbing the coconut tree and cutting it. Because of the difficulties in climbing and harvesting process different methods have been developed. In response, there is need to develop a device that could able to climb and harvesting coconut tree and ease of handling to farmer. Machines are used for many purposes and they are mainly used to replace human being while doing difficult and dangerous task.

2. PROBLEM DEFINITION

Design and development of a Coconut tree climbing and harvesting machine to reduce human efforts as well as to avoid accidents.

3. LITERATURE SURVEY

Mohammed Azarudeen[6] has the objective of project to make a cost-efficient coconut tree climber that will reduce
human labor and help farmers to get a better harvest. The majority of coconuts are harvested by climbing the trees and cutting the nuts down by hand. So the need is to design and develop an automated coconuttree climber which is economical and user friendly. Result of the final model is checked by the customer to validate the usability issues, safety measures and its function. The proposed concept is lighter than those existing by about 30% and is expected to be of lower cost on account of aluminum used in its construction.

Mr. Dhale (2017) [7] presents the need of coconut harvesting robot, with over five billion coconuts harvested every year, coconuts play a huge role in the economy of several regions and countries. In India prominent places of harvested are the states of Tamil Nadu, Kerala and Karnataka. The majority of coconuts are harvested by climbing the tree and cutting the nuts by hand. This process may seem simple; however, it is actually quite dangerous. In response, there is a genuine need to develop a device for coconut tree climbing and harvesting. There is large scope of development in this topic because of the cost and complexity of various devices available in the market.

Megalingam, [5] presents the Coconut palm growers are struggling with the acute shortage of human coconut tree climbers to climb and harvest the coconuts. Many are working towards possible alternatives to help them handle this situation. In this study paper author has analysed the problems associated with the shortage of human coconut tree climbers in depth. Author also present details of various existing mechanical models available in the market and have not yet solved this issue. Along with this, author has discussed how robotics and automation could be a possible solution for this entire problem.

B.Lalitha [8] has their project paper mainly based on the design and development of a coconut tree climbing robot and to empower mankind to hostile environment. Their robot is inspired by the inch worm mechanism for climbing the tree. It is a challenging task as the shape of tree is irregular and hence the robot uses a well-balanced mechanical design so that it can climb tree. The coconuts on the trees are cut down by the help of cutting arm, which is placed on the top gripper. The cutting arm is provided with 2 degree of freedom, which can be controlled flexibly by the user.

Mr.Rahul V, SebinBabu, Sameer Moideen [9] has aimed to design a mechanism which is simple and easy to operate. For this author first made a rough sketch considering average diameter of a coconut tree as 30 cm and designed it in Solid Works. Later a static analysis was done using ANSYS to ensure its stability. Then on to the fabrication of parts. The material used is GI steel. Three linear electrical actuators are used in this mechanism – two for gripping and one for the vertical up and down motions. Each actuator can carry up to 400kg.

Hariskrishna TV, Vineet Pandey and PDPR Harshavardhan [10] has find gripper assembly which uses a flexible casing, which grasps the tree trunk of almost all diameter within the predefined range, basically it uses passive compliance. This mechanism can be used for climbing trees which are almost straight like coconut trees and poles.

4. MECHANICAL DESIGN AND IMPLEMENTATION

A) Main components of machine

1. DC Wiper Motor
2. M.S frame
3. Taper Rollers
4. Roller Gripper
5. Wood Cutter
6. Helical Compression Springs
7. Connector
8. Cutter Arm
9. High speed DC motor
10. Servo Motor
11. Worm Gear DC motor

B) Working of Machine

The machine work in two mechanisms which are as follow:

(i) Climbing Mechanism

(ii) Harvesting Mechanism

For climbing purpose of machine on coconut tree, we activate the roller by using wiper motor. The power supply is provided from Battery which is placed on ground. When Wiper motor switch (Double Pole, Double Throw) is turn to its first position, the rollers starts rotating in opposite direction to each other. The tapered rollers are made in contact with tree surface (trunk) with compressive force from helical compression spring. The spring compresses roller towards the tree trunk which forms grip between roller and tree surface. As the roller rotates it takes machine
at the top of tree. When the switch is on second position, machine moves in downward direction. When the switch is on neutral position motor will stop and machine stop wherever it is on tree because of worm gear DC motor. Worm gear works as self-locking purpose to avoid backward motion of machine during harvesting.

After harvesting coconut, the coconut will directly fall on ground which can damage coconut and harmful for human being also. To avoid that we provide nylon net at ground in which coconuts are collect and get out from there easily. The power supply is given from ground with two batteries pack.

5. DESIGN CALCULATION

A. Spring calculation

CAD weight = 10 kg, Take FOS = 1.5,
Final weight (W) = 1.5*10 = 15 kg
W = 150 N,
Spring Material = Carbon Steel
Syt = 540 MPa, G = 79*cu(10) MPa,
\( \tau_{st} = 270 \text{ MPa} \quad E = 207*cu(10) \text{ MPa} \),
Assumption: - Spring Index (C) = 6,
Pitch of Coil = 10 mm.

Resultant Shear stress is given by,
\[ \tau = k \frac{8W'C}{\pi sq(d)} \]
where \( k \) = Wahl’s Correction Factor
\[ = \frac{(4C-1)}{(4C-4)} + 0.615/C \]
\[ = 1.2525 \]
From Eq. 1,
d = 4 mm, D = C*d = 6*4 = 24 mm.

Deflection of Spring per no. of turns is given by,
\[ \frac{\delta}{n} = \frac{8W'C}{Gd} \]
\[ = 0.82 \text{ mm} \]

1) For Large Spring

Given :- Free length (Lf) = 160 mm,
Pitch of coil = free length/n'-1
n' = 17,
Total deflections(δ)= 0.82*n’
= 0.82*17 = 13.94 mm

Solid Length (Lf) = n’*d
= 68 mm

Stiffness (K) = W/ δ = 150/13.946
= 10.76 N/mm

2. For Small Spring

Given:- Free length (Lf)= 120 mm,
Pitch of coil= free length/n’-1
n’= 13,
Total deflections(δ)= 0.82*n’
= 0.82*13 = 10.66 mm

Solid Length (Lf) = n’*d
= 52 mm

Stiffness (K) = W/ δ = 150/10.66
= 14.071 N/mm

B. Rotor calculation

Avg. diameter of wheel = 200 mm,
Radius of wheel =100 mm,
Length of rotor = 550 mm,Weight on one wheel = 75 N
Torque required on one wheel = Force * radius of wheel
T = 75*100 = 7500 N-mm

T = 7.5 Nm ≥ 10Nm

C. Shaft Design Procedure

The design of shaft on the basis of strength can be divided into two categories:

1. Design of Shaft by Theories of Failures
2. Design of Shaft by A.S.M.E Code

We design shaft on the basis of A.S.M.E Code. According to A.S.M.E code, the maximum shear stress induced in a solid shaft, subjected to the fatigue loading of combined torque and bending moment, is given by as follows:

\[ \tau = \frac{16Te}{\pi d^3} \]

Where,

Given:- Kb = Kt = 1, T = 10 Nm

1. Maximum Bending Moment

Cad weight of assembly= 10kg
Take FOS= 1.5,

Final weight=1.5*10=15kg
Load acting on one roller shaft = 75 N
In Vertical Plane and Horizontal plane, ΣF = 0
Ra +Rb =75 N
Hence, Ra = Rb = 37.5 N

Bending Moment:-

At Point A, ΣMa = 0 At Point B, ΣMb = 0
At Point C , ΣMc = 37.5 * 0.35 = 13.125 Nm

\[ T = 7500 \text{ N-mm} \]

\[ \tau = \frac{1600}{\pi (0.1)^3} \]

\[ \tau = 10 \text{ N/mm} \]

\[ M = 13.125 \text{ Nm} \]

\[ T = 10 \text{ Nm} \]

\[ \sum M_c = 13.125 \text{ Nm} \]
From Equivalent twisting formulae,

\[ T_e = 16.5 \, \text{Nm} \]

Also, \( \tau_{\text{max}} = 0.3 \times \text{Syt} \) or \( 0.18 \times \text{Sut} \) (Select whichever is min)

\[ \tau = 48.60 \, \text{MPa} \]

Putting all the values in shear stress Formula, we find the diameter of shaft,

\[ d = 12.03 \approx 15 \, \text{mm} \]

D. Bearing Selection

Depending on the shaft diameter we select the ball bearing from manufacturer’s catalogue.

Step 1 = Calculate the radial and axial forces acting on the bearing and diameter of shaft.

\[ P = X \times F_r + Y \times F_a \]

Given: \( F_r = 37.5 \, \text{N} \), \( F_a = 0 \), \( d = 15 \, \text{mm} \)

Step 2 = Select the type of bearing for given application

Selecting single-row deep groove ball bearing for low and medium radial loads.

Step 3 = Calculate the equivalent dynamic load from the equation

\[ P = F_r = 37.5 \, \text{N} \] since there is no axial load.

Step 4 = Assume expected bearing life and Express the life of bearing in million revolutions.

Assume, \( L_{10h} = 10,000 \) revolutions, \( N = 30 \, \text{rpm} \)

\[ L_{10} = \frac{60 \times N \times L_{10h}}{10^6} \]

Hence the expected life of bearing is 18 million revolutions.

Step 5 = Calculate the dynamic load capacity from the equation.

\[ C = P \times L_{10}^{1/3} \]

The value of dynamic load capacity is \( 98.18 \, \text{N} \)

Step 6 = Check whether the selected bearing of series 60 has required dynamic capacity. If not, select the bearing of next series and go back to step 3 and continue.

It is observed from the table that following bearings are available with 15 mm bore diameter [1]

<table>
<thead>
<tr>
<th></th>
<th>Bearing No.</th>
<th>C (N)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>61802</td>
<td>1560</td>
</tr>
<tr>
<td>2</td>
<td>6202</td>
<td>1560</td>
</tr>
<tr>
<td>3</td>
<td>6002</td>
<td>1560</td>
</tr>
<tr>
<td>4</td>
<td>6202</td>
<td>1560</td>
</tr>
</tbody>
</table>

Therefore bearing no 61802 is selected for above application.

6. RESULT AND ANALYSIS

A. Roller Analysis

**FIGURE 4 Import CAD model**

**FIGURE 5 Mesh Model**

1) Boundary Conditions

**FIGURE 6 Boundary condition**

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Notations</th>
<th>Boundary Conditions</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>A</td>
<td>Fixed Support</td>
<td>-</td>
</tr>
<tr>
<td>2</td>
<td>B</td>
<td>Force 3</td>
<td>800 N</td>
</tr>
</tbody>
</table>

2) Solution
B. Spring Analysis

1) Boundary conditions

<table>
<thead>
<tr>
<th>Sr. No</th>
<th>Notation</th>
<th>Boundary Conditions</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>A</td>
<td>Fixed Support</td>
<td>-</td>
</tr>
<tr>
<td>2</td>
<td>B</td>
<td>Force 1</td>
<td>100 N</td>
</tr>
</tbody>
</table>

2) Solution

7. ARDUINO CONTROL CIRCUIT

**A. Arduino uno**
The Arduino Uno is a microcontroller board based on the ATmega328. It contains everything needed to support the microcontroller. Simply connect it to
a computer with a USB cable or power it with an AC-to-DC adapter or battery.

**B. Motor Driver Module L293D** It is an H-bridge electronic circuit which enables DC electric motors to be run forwards or backwards. These circuits are often used in robotics. H-bridges are available as integrated circuits, or can be built from discrete components.

**C. Wiper motor** Two wiper motors are used, one for each upper rollers. They can provide high torque hence used to drive the rollers to climb up and down.

**D. Worm gear motor** This are low speed high torque motors. Worm gears are used in transmission to provide motion in only one direction. Used to rotate lower two rollers.

Figure 14 shows the control circuit of the machine. Transmitter receiver module is used to send signal to the Arduino. I/p 1-I/p4 are output of Receiver module which serves as input to the Arduino. Three L293D modules are used, two of them are for supplying high current and to control direction of wiper motor. Remaining one is for controlling the high speed motor. Two servos are used for manipulating the cutter arm and controlled by Arduino. DCM1 & DCM2 indicates the wiper motors. DCM2 & DCM4 indicates the worm gear motor. Whole circuit is powered by two 12V Batteries

8. **ADVANTAGES**

1. Cost effective as compare to any other semi-automatic Coconut cutting machine.

2. Reduces chances of accidents.

3. Cleaning and harvesting coconut tree branches.

4. Improve productivity.

5. Reduces the Labors cost and Time effective.

6. Compact and easy to handle

9. **FUTURE SCOPE**

The material for rollers can be replaced with wood or material which is stronger, easily available, less costly and lighter. Also similarly, The Frame material can be replaced with Aluminum, composites or Nano fibres which are stronger and lighter than mild steel. The cutter arm at the top can be made to rotate around the tree by using another servo motor, thus providing one more degree of freedom to the cutter. The battery can be alternatively charged using solar panels. Depending on the end effector attached to the robotic arm, the applications can be extended to cutting down branches, spraying pesticides etc.

10. **CONCLUSION**

The machine is simple in design and has greater stability than other existing mechanisms. The problem of holding machine in existing mechanism during cutting is solved by using worm drive motor so from this the stable and non-reversible mechanism is developed. The human efforts are reduced by design and development of such kind of machine. The results of component analysis and theoretical calculation come within limit and safe.

**ACKNOWLEDGEMENT**

We wish to express our deep sense of gratitude and honor towards our respected guide Prof. R.S.Pimpalkar for her inspiring guidance and constant encouragement. Her committed devotion, dedication and encouragement with full faith on us were like a lamp in our path which keeps us constant throughout project work.

We are thankful to all Teaching and Non-Teaching staff member of the institute and our classmate who had directly or indirectly made me enthusiastic for the project work.

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FIRST A. AUTHOR has pursued Bachelor of Engineering from Nagpur university, ME in design engineering from Sinhgad College, vadaonbudruk, Pune university with distinction in both and gold medalist in BE. She has worked in LG electronics pune for 2 years. Now working in Pimpri Chinchwad College of Engineering, Pune as Assistant Professor in Department of Mechanical Engineering. CAD/CAM, 3D printing, FEA are the area of interest of her.

SECOND B. AUTHOR, received the diploma in Mechanical Engineering from SMT.S.S. Patil Institute of Technology, Chopdaunder MSBTE in 2017. He is currently pursuing the B.E. degree in mechanical engineering from Pimpri Chinchwad College of Engineering Under Savitribai Phule Pune University. He has registered copyright on coconut tree climbing machine under B.E project in 2020.

From 2017 to 2019, he was working as steering system head in design and manufacturing of all terrain vehicles for National and International competitions. He was member of “Society of Automotive Engineers” (SAE INDIA) and “Indian Society of Heating, Refrigeration and Air Conditioning Engineers” (ISHRAE).
Investigative Study on Change in Behaviour of Composite Materials under Thermal Loading

Krishan Pandey¹, L V Awdhani², Hitesh Gadhawale³

¹Dept. of Mechanical Engineering, Pimpri Chinchwad College of Engineering, Pune, Maharashtra, India, 412101,
²Dept. of Mechanical Engineering, Pimpri Chinchwad College of Engineering, Pune, Maharashtra, India, 412101,
³Dept. of Mechanical Engineering, Pimpri Chinchwad College of Engineering, Pune, Maharashtra, India, 412101

ABSTRACT

Natural fibres are a type of renewable sources and a new generation of reinforcements and supplements for polymer based materials. The development of natural fibres composite materials or environmentally friendly composites has been a hot topic recently due to the increasing environmental awareness. Natural fibres are material which be used to replace synthetic materials and the product made by them to reduce the weight as well as conservation of environment. The application of natural fibres reinforced polymer composites and natural-based resins for replacing existing synthetic polymer or glass fibres reinforced materials in huge. Automotive and air crafts industries have been actively developing different kinds of natural fibres, mainly on hemp, flax and sisal and bio resins systems for their interior components. High specific properties with lower prices of natural fibres composites are making it attractive for various applications. The present study is based on understanding the effect of thermal loading on natural fibres reinforced composite. This paper is based on analyzing the behaviour of composite on various temperatures.

INDEX TERMS: Natural fibres, composites, thermal loading, tensile test, bending test

1. INTRODUCTION

Composite materials are getting attention because they have higher specific strength, stiffness and fatigue properties. Composite materials consists two or more constituents and they have two or more separable physical phase. Composite are made up of high load carrying capacity material known as reinforcement and relatively weaker material known as matrix. For structural load reinforcement provide desirable strength. The matrix or binder (organic or inorganic) keeps reinforcement to its position. Constituents have their individual properties but together they provide some better and enhanced characteristics.

Natural fiber composites are not new for us as it is found that Egyptians were using natural fibers in many applications. Wood cotton fiber composites were became hot topic in 20th century for electrical application due to their non-conductive nature. Now a days these are used in automotive and aviation applications where moisture is of second importance. For example, flax fiber reinforced polyolefin are extensively used today in the automotive industry, but it is only used as filler material have application in frames and other non-structural parts. Natural fibers can be used in structural applications but with certain environmental limitations. Natural fibers such as jute, sisal, pineapple, abaca and bamboo have been studied as a reinforcement and filler in composites. Bamboo stalk is hollow from inside and have circular cross section. Outer layer contain the pulp. The green layer has hardness equivalent to hardwood and give smooth finish as wax. Fibers can be extracted by Stem. It is strong, light in weight and is very flexible. It can bear earthquakes. Bamboo fibers can be used as reinforcement in polymer matrix because of its high aspect ratio and strong mechanical properties. Therefore bamboo fibers are getting famous. Application of natural fiber based composite are increasing day by day. In this study, jute fibers have also been used as reinforcement and were obtained from the local market. This paper primarily focuses on testing a hybrid composite under tensile condition and bending condition for various temperatures. Therefore the main objective of the present study is
a. To study the behavior of composite material under independent loading.

b. Study the behavior of composite material under thermal loading.

2. LITERATURE REVIEW

C M. Meenakshi [3] has fabricated three types of composite laminates with Glass, Kenaf and Aloe Vera fibers in Epoxy Resins and studied their mechanical and thermal properties. It is found that by adding natural fiber thermal stability increased.

Hua Hu [7] has studied moisture absorption and microstructure evolution of uncoated and coated short jute fibre reinforced He suggest that reliable measures of isolation from moisture must be taken when such composites are exposed in hygrothermal environment.

Paresh V [2] has investigated the mechanical properties of banana fibre epoxy composites in X and Y direction During hygrothermal aging the tensile strength of banana fibre epoxy composites subjected to reduce by average 13.3217%. The change was depending on how the environment was changing.

Yan Yu [13] focused mainly on has tested 11 bamboo fibre and two wood fibre for mechanical properties and he concluded that bamboo fibres shows excellent mechanical properties.

Deepa. A [3] observed that with increase in %weight gain, micro hardness of specimen decrease. %age area fraction decremented with time has also been studied.

Komorowski [5] concluded that environmental condition affects the noncritical design condition of no defect. Results of tests on samples exposed either on the ground or taken from structures that were in actual service for several years, show little degradation due to environmental exposure. However, most of these samples were only lightly loaded.

Manjunath Shettar [6] has talked about aging effect on GFRP. Thermal and moisture gradient have great influence in hygrothermal aging. It has been observed that aging for long duration has bad effect on strength as well as thermal stability.

Zulkafli [7] studied tensile, flexural and quasi-static indentations of hybrid banana / glass fibres in different stacking sequences were investigated. Based on the results, the hybrid banana / glass fibres showed better mechanical properties with the incorporation of glass fibres, especially in flexural properties.

Amir Hossein [9] concluded that natural fibres have outstanding mechanical and physical properties such as high strength-to-weight; high stiffness-to-weight, low density, good thermal insulation, and biodegradability. But composites have some limitations regarding mainly moisture absorption, variability, and dimensional stability.

Huang [1] successfully used resin transfer moulding to fabricate continuous unidirectional bamboo fibre reinforced epoxy composites. On the other hand, the tensile strength and modulus of bamboo fibres decrease after alkaline treatment. The mechanically extracted BF has the better strength compared to other methods.

From literature survey it was evident that natural fibres reinforced composites are very important in coming future. But main concern is their behaviour under various changing environmental conditions. Composite deteriorates under prolong exposure to humid condition their tensile strength and durability become main concern. Tensile properties of the developed composites improved because of integration of natural fibres. There is very less work has been carried out on studying the effect of thermal loading on hybrid composite.

3. MATERIALS AND SPECIMEN

The materials which have been selected are bamboo fibre and jute fibre reinforced epoxy hybrid composites Epoxy resin as binder and K-59 as hardener. Specimen has been prepared based on ASTM D3039 standard.

<table>
<thead>
<tr>
<th>S. No</th>
<th>Specification of the Specimen</th>
<th>For tensile testing (mm)</th>
<th>For bending Test (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
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</tbody>
</table>
4. EXPERIMENTAL SETUP AND METHODOLOGY

For different temperature condition oven system has been used. The used temperature and humidity for the test was 28°C and 65% respectively. Once chamber attained the required temperature 28°C and RH is 65% then the test specimens placed in the chamber. After the treatment test specimen is removed from the chamber and wiped to remove excess of moisture on its surface and weighed again by an electronic balance (corrected up to 2 decimal places) to calculate the amount of moisture absorbed [7]. Then Specimens were wrapped in aluminum foil to avoid moisture loss or moisture pickup. The % moisture uptake was given by the expression given below:

$$w_e (t) = 100 \times \frac{(w_t - w_o)}{w_o}$$

Where, \(w_e\) is water absorption percentage, \(w_t\) is weight after time \(t\), and \(w_o\) is the initial weight of the sample.

To get the result for large range of temperatures, finite element analysis has been performed on test specimen in ANSYS 19.

5. PREDICTION OF BEHAVIOUR UNDER THERMAL LOADING

Tensile test simulation has been performed on ANSYS 19. For ASTM D3039 the test speed can be chosen on the basis of material selected. A general test speed used for standard test specimens is 2 mm/min (0.05 in/min). To determine elongation an extensometer or strain gauge can be used. Determination of Young’s modulus is done by rules of mixture.

$$E_c = E_f V_f + E_m V_m$$

Where \(E_f\) is the Young's modulus of the fiber, \(E_c\) is the Young's modulus of the composite along the fiber direction, \(E_m\) is the Young's modulus of the matrix, \(V_m\) is matrix volume fraction and \(V_f\) is fiber volume fraction.
The above fig 3 shows the behaviour of composite under tensile loading at various temperatures.

\[ Q_f = \frac{3FL}{2bh^2} \]

Where,

- \( Q_f \) is the flexural stress, (M Pa);
- \( Q_t \) is the flexural stress, (M Pa);
- \( F \) is the load in newton’s (N);
- \( L \) is the span, in millimetres (mm);
- \( h \) is the thickness of the specimen, (mm);
- \( b \) is the width of the specimen, in millimeter (mm).

Figure 3 Tensile Test Performed

Figure 4 Schematic for Three Point Bend Test

Bend test is performed on a material to get the material’s ductility, bend strength, resistance to fracture. The above mentioned characteristics can be utilized to determine the behaviour of material under heavy load for the application in construction purpose. If material failed to perform under bending test it is assumed that this will catastrophically fail under similar condition in real life applications. Three points bending tests are performed to measure flexural strength. The flexural stress \( Q_f \) can be calculated by

\[ Q_f = \frac{3FL}{2bh^2} \]

Above figures are showing behaviour of composite under bending condition and also its deformation pattern has also been shown.

6. RESULTS

From the result it has been observed that by adding the natural fibre, tensile properties of neat epoxy-based composite have been improved.
The outcome of the flexural strength of the developed composites showed an increase in the flexural strength with increase in the temperature till 100°C and then decreases. The matrix material softens above this temperature and hence the tensile strength reduces above 100°C.

![Figure 7 Behavior of Hybrid Composite during Tensile Test](image)

The flexural strength of the developed composites also showing an increase in the flexural strength in Fig. 8 with increase in the temperature up to 100°C and then decreases further with increase in temperature.

The thermal performance of the hybrid composites is found to be better compared to the jute fibre composite seen in Fig.9. The flexural property of hybrid composite as compared to jute fibre reinforced composite.

![Figure 8 Behavior of Hybrid Composite](image)

![Figure 9 Comparison of Flexural Strength](image)

7. CONCLUSION

This study was conducted to predict the behaviour of natural fibre composites under combined thermal and tensile, bending loading. It is found that

The composite materials have great advantage over conventional materials varying largely from their higher specific strength, stiffness and fatigue characteristics, which increase application of natural fibres in structure uses.

Flexural property of the hybrid composites improved because of integration of natural fibres to the polymer and addition of properties of bamboo fibre. Best strength of composites is achieved at temperature of 100°C. Flexural strength drastically decreased after 100°C.

Hybrid composite is showing better flexural properties as compared to only jute fibre reinforced polymer composite.

The preferred spelling of the word “acknowledgment” in American English is without an “e” after the “g.” Use the singular heading even if you have many acknowledgments. Avoid expressions such as “One of us (S.B.A.) would like to thank ... .” Instead, write “F. A. Author thanks ... .” In most cases, sponsor and financial support acknowledgments are placed in the unnumbered footnote on the first page, not here.

REFERENCES


[8] Rui-Hua Hu a,b, Min-young Sun c, Jae-Kyoo Lim a,* Moisture absorption, tensile strength and microstructure evolution of short jute fibre/polyalactide composite in hygrothermal environment Materials and Design 31 (2010) 3167–3173 Elsevier Ltd. All rights reserved.


Books


Studied B.E. Mechanical from SPPU in 2016. Worked as Territory Manager in Force Motors Ltd. From 2016 to 2018. Pursuing M.E. from PCCoE in Mechanical Design. Active in academics as visiting faculty in various institutes. Research Interest: Vibration Analysis, Stress analysis, Composite Materials. Done project on “Discrete Model Analysis of Two Stage Engine Mountings to Reduce Vibrations”. Given seminars on “Composite Mono Leaf Spring” and “Behaviour of Hybrid Composite under Hygrothermal Loading”. Published a paper in national journal on “Detailed Studies On Stress Concentration By Classical And Finite Element Analysis”

Born in Gulbarga, Karnataka India and studied BE Mechanical from Walchand Institute of Technology, Solapur in 1996, MTech Design from COEP in 2006. Worked as Assistant Professor, Mechanical Engineering at DYPCPE from 1996 to 2010. Working as Associate Professor at PCCoE, Nigdi since 2010. Research interests: Mechanics of composites, Machine Design, Mechanisms. Pursuing PhD from SPPU with ZCOER Narhe as Research Centre. Completed Funded projects from AICTE, SPPU and Industries. Conducting training programmes for the Industries since 2019. Published 10 papers in the International journals, 5 text books for UG courses and filed 1 Patent. Guided 30 PG Dissertations. Member of Mechanisms and Machines, ISTE.

Born in Amravati, Maharashtra India in 1998. He is currently pursuing B.E. in the Fourth year of mechanical engineering department of Pimpri Chinchwad College Of Engineering Nigdi, Pune, Maharashtra, India. From 2017 to 2018 he worked in design and manufacturing of an electric solar vehicle for an ISIE event (ESVC 2018) as a member of ‘Team Solarium’ in ‘Steering’ system. Award include “best design award adventure class ESVC 2017-2018” as a member of Team Solarium.
A Review on Methanol as a Fuel for I.C. Engine

Nikhil Pawar¹, Shubham Rathi², Deep Pimple³, Atul Pawar⁴, Tejal Patil⁵

¹Dept. of Mechanical Engineering, Pimpri Chinchwad College Of Engineering and Research, Ravet, Pune, Maharashtra, India, 412101
²Dept. of Mechanical Engineering, Pimpri Chinchwad College Of Engineering and Research, Ravet, Pune, Maharashtra, India, 412101
³Dept. of Mechanical Engineering, Pimpri Chinchwad College Of Engineering and Research, Ravet, Pune, Maharashtra, India, 412101
⁴Dept. of Mechanical Engineering, Pimpri Chinchwad College Of Engineering and Research, Ravet, Pune, Maharashtra, India, 412101
⁵Dept. of Mechanical Engineering, Pimpri Chinchwad College Of Engineering and Research, Ravet, Pune, Maharashtra, India, 412101

ABSTRACT

Petrol engines are widely used for Automobiles due to compactness, simplicity, low cost of maintenance and low cost of production. These engines have low compression ratio (CR), they run at rich mixtures. Their power is low and emissions are high. Alternative solution to increase the efficiency and decrease in CO and HC emissions, methanol can be solution. As well as methanol can be produced at cheap price. Objective of this Paper to overview the drawbacks of petrol engines and the effect of methanol based fuels in IC engines.

INDEX TERMS Efficiency, Emission, Engine, Methanol

1. INTRODUCTION

In the present scenario petrol engines and diesel engines are used for various applications. These engines have some drawbacks such as while burning petroleum, greenhouse gases are generated and cause environmental pollution. Also the resources of petroleum are limited. Due to continuously increase in demand of energy, cost fossil fuels are also increasing. Methanol (CH₃OH) has been proposed as fuel for IC engines. There are various methods for production of methanol-

a) Methanol produced from coal.
b) Methanol produced from natural gas.
c) Methanol produced from coke-ovengas.
d) Methanol produced from hydrogen.
e) Methanol produced from biomass.
f) Methanol produced from a wide variety of renewables.

Methanol is clean burning fuel and is consider as a green fuel because of low CO₂ and soot emission. It is considered as lean energy resource. Methanol exhaust contains lower concentration of particulate matter and nitrogen oxides than petrol exhaust. The alternative fuels like Methanol gives lots of benefits which can mitigate national security and economic concerns over other fuel supplies.

Methanol behaves like petroleum so it can transported and stored in same manner. It has relatively good lean combustion characteristics as compared to hydrocarbon fuels. It wider inflammability limits and higher flame speed showed higher thermal efficiency and less exhaust emissions compared with petrol engines.

2. LITERATURE REVIEW

A. Performance of Methanol as Fuel in IC Engine-

1) Mr. Avhale Swapnil, et.all [4] used methanol as an alternative fuel for IC engine. Either they have used methanol blend fuels or used directly. Tests was conducted on Single Cylinder Four stroke S.I. Engine (Hero Honda 100CC) Compression ratio of 8.8:1. They worked on the parameters like Brake Power, Indicated Power, associated Mean effective pressure, Fuel consumption, Brake thermal efficiency, mechanical efficiency and emission of methanol and comparison with Petrol as fuel.

Experiment tests were at 2000 rpm and at variable load conditions, using various blends of methanol with gasoline. Result obtained was that the methanol based fuels leads to a reduction of CO and HC by about 25% and 10% respectively. After the modification in the IC engine such as increasing compression ratio advancing ignition timing the engine performance increases almost 12.5%.

2) Louis Sileghem and Maarten Van De Ginste [3] used 1.8ltr Volvo 4-cylinder petrol engine for tri-fuel operations and 1-cylinder Audi-NSU test engine with a cooled EGR system. They found that Efficiency gain are most distinct at low loads, where this strategy yields up to 30% relative increase of BTE compared to gasoline operation. The efficiency of engine increased by 5-10% compared with petrol engine.
It was observed that methanol has higher efficiency (5-10% relative compared to gasoline) and Efficiency up to 42% are found during experiment.

3) A.N. Basavaraju, et al [2] worked on performance study of methanol blended petrol in SI engine. Engine used was 350cc four strokesinglecylinderpetrolbulletenginetoechievebetterpowerandefficiency. Theyhaveusedhydraulicdynamometerto load and measure the brake power of engine at different loads. Mileage tank is used to measure fuel consumption. The emission characteristics of the engine were studied by gas analyser. The performance tests are carried out at constant speed and variable conditions over the range of 1330rpm, using various blends of methanol and gasoline fuel. The test have been conducted at no load and at different load maintaining speed of hydraulic dynamometer at constant value of 240-260 rpm throughout test. They found that engine produced a maximum power of 7.65kW at 1330rpm. The efficiency of about 27.5% obtained at 15% blending. They finally concluded that there is slight improvement when engine is working with methanol blended petrol.

B. Effect of Methanol on Emission

1) Mr. Avhale Swapnil, et al [4] found that using methanol blends of M20 the exhaust emission of SI engine leads to reduction in CO and HC by about 25% and 10% respectively. They concluded the blend including M20 is most suitable for SI engine from the engine exhaust emission point of view.

2) Louis Sileghem, et al [3] conducted tests on 1-cylinder Audi-NSU test engine with a cooled EGR system. The results on the engine indicate that methanol is more EGR tolerant than gasoline, due to its higher flame speed. The efficiencies of the methanol-fueled engine obtained with EGR are higher to those obtained with throttled stoichiometric operation. The advantages of EGR are zero pumping losses and lower heat losses. When EGR is used the result shows the huge decrease in NOx emission. COx emissions also decreases as methanol/gasoline ratio increases.

3) A.N. Basavaraju, et al [2] have used Gas Analyzer to detect emissions. The Gas Analyzer provides the HC, CO and other emission characteristics of the engine. They have found that as fraction of methanol in the blend increases, specific fuel consumption increases and CO, HC emission decreases. They also found that as ratio of methanol to gasoline increases there is reduction in COx emissions.

18. CONCLUSION

This paper systematically reviews the methanol as an alternative fuel for IC Engine. It is clear that methanol has lot of potential as an alternative fuel. There is reduction in exhaust emission and increase in performance of IC Engine when Methanol (methanol blends) are used than that of convention Petrol and Diesel fuels.

ACKNOWLEDGMENT

We with great pleasure take this opportunity to express our deep sense of gratitude towards Pimpri Chinchwad College of Engineering and Research, Ravet affiliated to Savitribai Phule Pune University for allowing us to do the
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REFERENCES

DESIGN AND MANUFACTURING OF CONVEYING SYSTEM FOR ONION HARVESTER

Siddhant Nalawade¹, Rohan Pathak², and Prof. Pradeep Gaikwad³
¹Dept. of Mechanical Engineering, Pimpri Chinchwad College Of Engineering and Research, Ravet, Pune, Maharashtra, India, 412101
²Dept. of Mechanical Engineering, Pimpri Chinchwad College Of Engineering and Research, Ravet, Pune, Maharashtra, India, 412101
³Dept. of Mechanical Engineering, Pimpri Chinchwad College Of Engineering and Research, Ravet, Pune, Maharashtra, India, 412101

ABSTRACT

The present research work has been carried out to bring out solution in the harvesting process of onion. Harvesting of onion crop is a labour intensive operation. Onion harvesting requires huge amount of labor and time. The product yield is not satisfactory as there are many harvesting losses. This trial is made to implement on lower power capacity tractors to improve productivity. Onion Harvester machine provides operator comfort and saves time. Unlike the traditional practices it does not damage the onion crops. This research consists of design of conveying system for an onion harvester. It transfers dig out onions to a separating system. Major factors considered are onion bulb size, soil properties, operating conditions, weight on the system.

INDEX TERMS

Agriculture, Conveying System, Onion Harvester

1. INTRODUCTION

Onion is one of the most important commercial vegetable crops grown in India over a large area. Cool weather is needed for the growth of onion bulbs. Factors like soil, climate, soil moisture, cultural practices play an essential role in successful cultivation of onion crop. Harvesting at proper maturity stage is needed to decide storage life. Harvesting should be completed within specified tie limits. The conveying unit conveys onions from one place to another in less time and cost. Conveyors are of various depending upon the requirements. It should withstand the load of onion and soil to function properly. It improves productivity in less time and cost providing operator comfort.

2. MATERIAL SELECTION

Material Selection is an important factor in designing any system. To satisfy requirements market survey of materials is essential. Proper materials provide strength, withstand loads without failure. High factor of safety is needed to avoid any damage to unit. Material selection depends on:

- Availability of Material
- Cost
- Operating Conditions
- Physical and Chemical Properties

3. CONVEYING SYSTEM

The conveying mechanism transfers onions from one place to another. It transfers loads in less time and in less cost providing operator comfort. It conveys onions to the end of the system to the separating system. Conveying unit includes shafts, chain, sprockets, side casing, round bars, angled bars and bearings. Each component has a design procedure. Material of components is selected to satisfy the requirements. Compact design with reduced weight is an ideal for an onion harvester.

A. DESIGN OF CHAIN AND SPROCKET

The chain is selected and designed so that it can withstand the loads of onions and other soil particles. It carries the onions to the other end. Chain selected should attach connect with sprockets to ensure transmission of power. Pitch, Centre distance and teeth on sprockets are important factors in designing chains.

For Front Shaft:

Pitch = 19.05 mm
Centre distance = 609.6 mm
Tooth on sprocket = z₂ = z₁ = 17

Calculation:

Pitch angle \( \alpha \) = \( \frac{360}{\pi} \)
Pitch circle diameter of sprocket, \( D = 103.67 \) mm
Tip diameter = \( D + 0.6 * P = 115.03 \) mm
Roller diameter = 11.91 mm
Roller width = 12.57 mm
Centre distance = 32 * P = 609.6 mm
ap = 609.6
ap = 609.619.05 = 32
Link of chain (lp) = 2 * ap + \( \frac{Z₁ - Z₂}{2} \) * \( \frac{\pi}{P} \)
= 82 links
Length of chain = \( lp * P = 82 * 19.05 = 1562.1 mm \)
Thickness of Sprocket Tooth = 0.95 * b₁ = 11.9415 mm
Tooth Side Relief = 0.1249 * p = 2.38 mm

Maximum Pitch Circle Diameter:
Da max = D + 1.25*p - d1 = 115.66 mm

Minimum Pitch Circle Diameter:
Da min = D + p*(1 - 1.6) - d1 = 109.017 mm

Roller Seating Radius:
i max = 0.505*d1 + 0.0693*3√d = 6.172 mm
i min = 0.505*d = 6.0145 mm

Tooth Flank Radius:
re max = 0.008*d*(z2 + 180) = 44.686 mm
re min = 0.12*d*(z + 2) = 27.1548 mm

Root Diameter:
Df = D - 2*ri
Df max = 91.64 mm
Df min = 91.326 mm

Roller Seating Angle:
α max = (140 – 90/z) = 134.70
α min = (120 – 90/z) = 114.70

Total Height above Pitch Polygon:
ha max = 0.625*p - 0.5*d + 0.8*p/z = 6.84 mm
ha min = 0.5*(p-d) = 3.57 mm

Teeth on Input Sprocket, Z1 = 17
Teeth on Output Sprocket, Z2 = 26

Calculations:-
Diameter of Sprocket, D = Psin (180/z)
Diameter of Input Sprocket, D1 = 86.3947 mm
Diameter of Output Sprocket, D2 = 131.7026 mm

B. DESIGN OF SHAFT
Shafts are an important component of the conveying system.
It provides support to the sprockets and chain.
Let,
T = Torque or twisting moment acting on shaft, N-mm.
M = Maximum bending moment acting on shaft, N-mm.
D = Diameter of shaft, mm.
Sy = Yield strength of shaft material in tension, N/mm².
Su = Ultimate strength of shaft material in tension, N/mm².
τper = Permissible shear strength, N/mm².

Material selected is 30Cr8 as per requirements.
Sy and Su is selected as per the selected material. Forces are calculated in horizontal and vertical plane. Torque is calculated from power and speed obtained. Diameter is calculated with the help of bending moment diagram.
From calculations, Diameter of shaft, d = 30 mm

C. DESIGN OF ROUND AND ANGLED BRACKET
Round bracket conveys the onions and other particles to the other side. It should sustain the loads in the operating
conditions. Alternatively angled brackets are used to reduce weight of the system.

Material selected for round and angled bar is mild steel. Dimensions of brackets are calculated on the basis of weight on brackets and the working width.

Weight on full rod = 20 kg = 20*9.81 = 196.2 N
Working Width = 780 mm
The load is converted into point load. Bending Moment Diagram is calculated. Using flexural formula the dimensions are obtained.

Area moment of inertia:
\[ I_{xx} = \pi \frac{64*(d_1^4 - d_2^4)}{6} \]
Taking ratio of inner diameter & outer diameter
\[ d_2/d_1 = 7/11 = 0.6363 \]
\[ I_{xx} = 0.04908*d_1^4*[1-(d_2^4/d_1^4)] = 0.04908*d_1^4*[1-(0.6363)^4] = 0.04103*d_1^4 \]

Now, by using flexure formula
\[ \sigma = \frac{M \cdot Y}{I} \]
\[ 250*106 = 38.259 \cdot \frac{Y}{d_1^2} \cdot 0.04103 \cdot (d_1)^4 \]
From calculations, \( d_1 = 12.30 \) mm
\[ d_2 = 7.82 \text{ mm} \]
For angled bar the material used is mild steel.
Weight on full rod = 50 kg = 50*9.81 = 490.5 N
The load is converted into point load. Bending Moment Diagram is calculated. Using flexural formula the dimensions of angled bar is obtained.

\[ \sigma = \frac{M \cdot Y}{I} \]
Assume dimension 6t*6t*t
\[ Y = 1.8636t \]
\[ I_{xx1} = 1/12*(6t)^3*t + 6t^2*(1.8636t - 0.5t)^2 = 25.748t^4 \text{ mm} \]
\[ I_{xx2} = 1/12*(t)^3*5t + 5t^2*(1.8636t - 0.5t)^2 = -7.2346t^4 \text{ mm} \]
\[ I_{xx} = I_{xx1} + I_{xx2} = 25.748t^4 + 7.2346t^4 = 32.98264t^4 \text{ mm}^2 \]
\[ \sigma = \frac{M \cdot Y}{I} \]
\[ 250*10^6 = 110.36 \cdot 1.8636/32.98264t^3 \]
\[ t = 2.9217*10^{-3} \text{ mm} \]
\[ t = 2.9217 \text{ mm} = 3 \text{ mm} \]

From calculations, Thickness = 3 mm

**D. DESIGN OF BOLT**

Maximum Conveyor Weight = 100 kg
Maximum Weight of Soil = 60 kg
Shear Stress = 120 MPa
Draft Force = 2701 N

Conveyor Bolt Design:
Shear Stress = \( F/A \)
120 = (100+10+60)*9.81+2701/(\pi*dc*dc4)/2
\[ dc = 9.6284 \text{ mm (Core Diameter)} \]
\[ d = dc/0.84 = 11.4624 \text{ mm} \]

**E. DESIGN OF BEARINGS**

Bearings are used as a supporting component to the conveying unit. Suitable selection of bearing is essential to assure a high factor of safety. There are various types of bearings. Type is selected in order to satisfy therequirements. Here flange bearings were selected. The material of bearings is mild steel.

Shaft Diameter, \( d = 30 \) mm
Axial Force, \( F_a = 0 \)
Life in hours, \( L_{10h} = 10000 \) hrs.
Speed of Shaft, \( N = 244.335 \) rpm
For bearings, Equivalent Load Carrying Capacity, \( P = F_r + Y_1F_a \)
Life in million revolutions, \( L_{10} = L_{10h} \cdot N \cdot 60 \cdot 10^6 \)
Based on the life in million revolutions and resultant forces the load carrying capacity of a bearing is calculated. The bearing is selected from the catalogue. If the calculated load carrying capacity is less as compared to catalogue value the bearing is safe. Bore diameter, outer diameter, width of bearing should also be considered to satisfy the requirements.

Selecting lowest series first and then calculating. The catalogue value of load carrying capacity is 15600 N. The calculated value was greater. Thus it is not safe. From iterations we get large series of flange ball bearings to be safe.

**F. MATERIALS SELECTED**

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Component</th>
<th>Material</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Shaft</td>
<td>30C8</td>
</tr>
<tr>
<td>2</td>
<td>Round, Angled Brackets</td>
<td>Mild Steel</td>
</tr>
<tr>
<td>3</td>
<td>Side Casing</td>
<td>IS 2062</td>
</tr>
<tr>
<td>4</td>
<td>Sprockets</td>
<td>EN 8</td>
</tr>
<tr>
<td>5</td>
<td>Bearings</td>
<td>Stainless Steel</td>
</tr>
</tbody>
</table>

**G. SPECIFICATIONS OF CONVEYOR**

| TABLE II |
|------------------|----------------------|
| **Sr. No.** | **Component** | **Material** |
| 1           | Shaft      | 30C8        |
| 2           | Round, Angled Brackets | Mild Steel     |
| 3           | Side Casing | IS 2062     |
| 4           | Sprockets   | EN 8        |
| 5           | Bearings    | Stainless Steel |

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Crack this lockdown with your skills

VOLUME 01, EDITION 01, 2020

Pimpri Chinchwad College Of Engineering and Research, Ravet  Page 178
### SPECIFICATIONS

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Component</th>
<th>Material</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Length of Conveyor</td>
<td>960 mm</td>
</tr>
<tr>
<td>2</td>
<td>Width of Conveyor</td>
<td>830 mm</td>
</tr>
<tr>
<td>3</td>
<td>Velocity</td>
<td>2-3 m/s</td>
</tr>
<tr>
<td>4</td>
<td>Angle of Conveyor</td>
<td>25°</td>
</tr>
<tr>
<td>5</td>
<td>Material Handling Capacity</td>
<td>36 kg/s</td>
</tr>
<tr>
<td>6</td>
<td>Pitch of Chain</td>
<td>19.05 mm</td>
</tr>
</tbody>
</table>

#### 4. PERFORMANCE INDICES

**A. DAMAGE TO CROP %**

It will determine the damage caused to the crop during the harvesting by onion harvester.

$$\text{damage} = \frac{\text{Total no of damaged onion}}{\text{Total no of digged onion}}$$

**B. CROP PICKING EFFICIENCY**

It is calculated for a conveying unit to find out the efficiency of conveyor system.

$$\text{pick} = \frac{\text{Total no of onion picked up}}{\text{Total no of onion dig out}}$$

**C. HARVESTER PRODUCTIVITY**

In this measure the productivity of the onion harvester system can be estimated.

$$\text{Productivity} = \frac{\text{Total Harvested Area Covered}}{\text{Time Required}}$$

### 5. CONCLUSION

The problems faced by Indian agriculture such as increasing input costs, time consuming operations and labour intensive operations. These problems can be eliminated by mechanization of this sector. Onion harvester machine reduces the harvesting losses. It completes the harvesting in given stipulated time. It increases the productivity of the farmers. Proper design, fabrication and operation of conveying unit increases productivity. Design of all the components follow the specified standards.

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ROHAN. R. PATHAK, Pursuing final year in Bachelor of Mechanical Engineering degree from Pimpri Chinchwad College of Engineering and Research, Pune, Maharashtra, India.

Prof. PRADEEP. R. GAIKWAD working as an assistant professor in Pimpri Chinchwad College of Engineering and Research, Pune, Maharashtra, India.
DESIGN & MANUFACTURING OF MOTORIZED PAINT ROLLER

Parth Sahastrabuddhe¹, Pravin Pradhan², Amit Prajapati³, Sumit Garade⁴

¹Dept. of Mechanical Engineering, Pimpri Chinchwad College Of Engineering and Research, Ravet, Pune, Maharashtra, India, 412101
²Dept. of Mechanical Engineering, Pimpri Chinchwad College Of Engineering and Research, Ravet, Pune, Maharashtra, India, 412101
³Dept. of Mechanical Engineering, Pimpri Chinchwad College Of Engineering and Research, Ravet, Pune, Maharashtra, India, 412101
⁴Dept. of Mechanical Engineering, Pimpri Chinchwad College Of Engineering and Research, Ravet, Pune, Maharashtra, India, 412101

ABSTRACT

Painting flat surfaces with paint rollers consumes a lot of time and movements. The painter needs to dip the roller sponge into the paint and roll it on the wall surface until the job is finished. This means that the painter needs to do a lot of bending and stretching. This causes strain in the worker’s shoulder and in turn increases the time cost of the job. The proposed innovation, Motorized Paint roller, focuses on introducing an innovative paint roller mechanism that does not involve dipping of the roller cover in paint. Rather the paint being directly applied on the outer surface of the roller cover. This reduces movement of the worker also saves overall time consumed and the cost for the job.

INDEX TERMS
Paint system, Paint Roller, Dipping, Sponge, Painting

INTRODUCTION

Painting is one of the construction works. The painting activity comes near the end of any construction project. Painting process starts after wall plastering and tiling. Painting can significantly enhance a wide range of building functional characteristics. It prevents fungus and erosion from damaging the surface due to weather and climate changes. It also improves aesthetic values of the building and regulates the room temperature. Light colour paints keep the room cool as they do not absorb heat as opposed to dark colour paints.

Normally, a painter uses a brush or a paint roller as a tool to paint surfaces of houses, buildings or other structures. The process involves dipping a brush or a paint roller into the paint and applying it to the building surfaces. These also involve climbing, bending and stretching in the painting process. This process usually takes a lot of movements which result in strain in the hand and shoulders of the worker. It also consumes a lot of time which increases the overall cost of the job.

A. PAINTING TOOLS

Most popular house painting tools are paint brushes and paint rollers. The choice of the tools whether to use a paint brush or paint roller depends on the painter. The painter will choose according to the type of surface that is needed to be painted
- Brush
- Paint Roller

B. PAINT TYPES

There are different types of paints used for interior wall painting. But mainly they are categorized into two types:

1. Water Based
   Water based paints are most commonly used for walls and ceiling, because of their advantages over oil based paints like less in price, washable, harmless substance and odourless. Water based emulsion paints are most popular in Indian market, below are the few popular categories of water based emulsion.
   - Distemper
   - Tractor emulsion
   - Premium emulsion
   - Royal emulsion

2. Oil Based
   These paints are popular for glossy wood paint (Doors), window frame, window grills, balcony grills and furniture. Oil based paints are available in different finish, such as
   - Glossy
   - Semi-Glossy
   - Matt
   - Eggshell

1. PAINT ROLLER

Paint roller is a paint application tool for rapid and effective application of paint on large flat surfaces. It consists of two parts: Roller frame and Roller cover. The roller cover is dipped into the paint and ten is applied to the surface to be painted whereas the roller frame is attached to the roller cover. A roller is as good as the frame it sits on. While painting the painter holds the roller handle on the frame. It is possible to clean and reuse a roller cover, but it is typically disposed of after use.

The size of the roller depends on the paint roller width; it ranges from 4 to 18 inches. The roller with 7 inches and 9 inches width are the two most popular sizes of the roller.

There are different types of paint rollers:
A. MANUAL ROLLER
Manual rollers are generally used for painting walls and ceiling surfaces. These rollers have features for handle extension and if the handle is long enough workers can paint the ceiling without the use of ladder. They are the most common types of rollers. One drawback is that they tend to produce paint drops even if little extra paint is applied.

B. PAD ROLLER
Pad rollers are an effective tool for painting trims or edging. They use a highly absorbent flat pad to apply paint in straight and even strokes. As they have highly absorbent pads they eliminate splattering and dripping of paint unlike other rollers. Since they have a flat surface they tend to hold more paint and are used specially when painting a single surface more than on colour.

C. TEXTURED ROLLER
Textured rollers are specifically designed to paint a texture on the wall surface. They have special foam covers that have certain patterns on them so as apply paint in a certain way. They have patterns like wood grain, brick, stone, tile etc.

D. SPECIALTY ROLLER
Textured paints, like suede, stone, and light plasters, usually have a specialty roller. They typically don’t produce as much paint splatter. These rollers are quite absorbent as the texture paints have heavy consistency.

E. MINI HOT DOG ROLLER
Mini hot dog rollers, as the name suggests, are shaped in the form of mini hot dogs. They are the perfect tools to paint difficult places like behind the sink or toilet. They are also very useful when it comes to painting cupboards, shelves, and rolling doors. They are also good for applying paint to trim and edging.

2. RELATED WORK

A. AUTOMATIC FEED PAINT AND TEXTURE APPLICATOR
In this invention, the author has used a casing With a hinged plate for forming a compressible compartment that can hold liquid paint, and the author mounted a roller adjacent to a discharge opening or nozzle in the compartment. So that pressure applied to the plate will swing it and force paint from the compartment and onto the paint applicator roller. The nozzle includes a hinged member that extends across the width of the casing and adjustable spring which means to urge the member into yielding contact with the periphery of the roller. It is by this mechanism that the amount of paint delivered to the roller can be controlled when the hinged plate is depressed.

The compartment can be replenished with paint by opening the hinged member and using the nozzle as the point of entrance.

The length of the paint-applying roller is at least, equal to the width of the casing. This permits the tool to apply paint in the corners. If less than the length of the roller is needed for paint-applying purposes, a slide is provided that can be manually adjusted for closing off any desired portion of the nozzle.

B. POWER DRIVEN PAINTING DEVICE
This invention consists of a paint applicator roller combination comprising an extendable handle, a rotating perforated cylinder and an absorbent cover. This invention also has end means for closing each end of said cylinder, detachable means to mount said rotating cylinder on an extendable handle. The motor is mounted on an extendable handle adjacent to the rotating cylinder and transmission is connected to the motor and rotating cylinder whereby the rotating cylinder rotates at a speed of from 75 to 100 rpm. The paint roller with the combination of this invention facilitates painting and saves on labour in applying paint to a surface. The paint is supplied to the rotating cylinder which is of inexpensive construction and can readily be replaced or refilled. This makes painting an easier and cleaner job as the paint is not applied on the outer surface, thus avoiding splashing or dripping. The paint filled cylinders can easily be exchanged when a cylinder is...
C. PAINT ROLLER CONSTRUCTION

A paint roller construction comprises a roller which is supported on a support which has a handle. The support carries an electric drive motor for the pump to supply paint to the roller through a connection in the support. The pressure inside the roller is kept at a predetermined value so that the paint can be delivered in radially outward direction through the perforations on the roller applicator surface at a controlled rate for the application of paint on the surface.

The device also advantageously includes a drive motor which can be operated at a selected speed in order to rotate the roller at an amount which is comparable to the pressure of the paint supply so as to apply the paint at a predetermined application rate and thickness.

D. ROTARY BRUSH INCLUDING STATIONARY GUIDE MEANS WITH SLIDABLE BEARING MEANS

This invention consists of a hollow body, elongated and rotatable about its axis, which is rotatably mounted in an elongated housing. On the external surface of the body there are several brush units formed by soft hairs supported in elongated base members which have open channels or grooves in their bottom or inner sides in order to allow the paint to flow from the interior of the hollow body to the interstices between the hairs. The body thus forms a rotor driven by means of a driving unit. The driving unit is capable of slowly rotating the hollow body and brush units. This driving unit can be an appropriate electric motor, preferably associated with a speed reducer. The hollow body rotates about a coaxial shaft which is also hollow and, on one of its ends, is coupled to a duct supplying pressurized paint, while the other end is closed. The paint passes from the hollow shaft to the interior of the hollow body through holes distributed over the entire length of the hollow shaft.

The assembly formed by the hollow body, inner shaft, brushes and driving unit is mounted in a motor casing, said the driving unit being located outside the housing. Housing having a large opening in the longitudinal sleeve wall thereof, through which the brush units appear when the hollow body rotates. Assembly is supported by a tubular handle by means of which the operator holds the assembly.

E. PAINT ROLLER ASSEMBLY WITH A POWER ACTUATED ROLLER SUPPORT

This invention provides a roller assembly for uniformly applying liquid onto a roller Surface. The roller assembly includes a handle having a hand grip portion and a roller attachment portion. A substantially cylindrical roller Support, having each of a predetermined diameter and predetermined length, is disposed of adjacent to the roller attachment portion. A drive member is engageable with the roller attachment portion of the handle and with the roller support and is operable for rotating the roller Support in one direction. A switch is coupled to a power source and to the drive member for controlling operation thereof.

To uniformly apply liquid which is generally disposed in a container onto the roller surface, the roller assembly is positioned to place a portion of the roller surface at a predetermined depth below the surface of the liquid. The drive member is then activated by the switch to rotate the roller which uniformly applies such liquid onto the roller surface. When the liquid is applied onto the roller surface, the drive member is deactivated by the switch. Refer fig. 5.
In this paper, the conceptual design of an autonomous wall painting robot is described consisting of an arm that scans the walls vertically and is fitted on a mobile robot base to give the lateral feed motion to cover the painting area. Ultrasonic sensors are fitted on the arm and the mobile base to adjust the motion limits and maneuver in the room area. A control system is designed to guide the arm motion and plan the mobile base motion. Refer fig. 6.

G. SMART ROLLER

The two main parts of the smart roller are the paint tank and the innovative paint roller. The paint tank consists of aluminium casing which will be filled with paint to be applied. The aluminium casing is placed with a battery and a water pump (which is also suitable for paints). The battery is required for powering the pump. When operated, the pump will supply paint to the paint roller continuously.

The innovative paint roller consists of a clear hose, roller sponge, controller and handle. Then the paint will flow continuously through the clear hose to the sponge. The controller will control the flow of the paint to the sponge. The sponge is applied on the surface to be painted. Refer fig. 7.

H. AUTOMATIC GUIDED WALL PAINTING SYSTEM

This paper presents the development of a prototype Automatic Wall Painting Machine guided by a wall dimensions and color being sent from the user through a camera embedded in an arduino board. The arduino board used for this system is Raspberry Pi. The Raspberry Pi Module captures the wall image and calculates the dimensions using Image Processing tools and remotely forwards the dimensions to the base painter system using bluetooth transmission.
The Mechanical structure consists of a 2-D plotter with the painting joint attached to a DC operated Directional Control Valve spray paint that moves from a point to another point by line. The plotter runs with two Nema 17 stepper motors and contains a STM32 as the slave controller, receiving the dimensions via a bluetooth module connected to it. The overall system is run by a dual shaft Nema 23 Stepper motor. Refer fig. 8.

3. PROPOSED INVENTION

In all the previous inventions the paint was delivered to the roller from inside the cover. An innovation was needed for the application of paint directly on the outer surface of the cover which results in less usage of paint.

In the proposed innovation, the paint is applied directly on the surface of the roller cover by a mechanism similar to that of a ballpoint pen. A mounting is added on the roller handle consisting of roller bearing in a compartment. The roller bearing is in contact with the outer surface of a roller cover which can be seen in figure 10. The paint is supplied to the compartment from one side with the help of a pump attached to the traditional paint bucket. The flow pressure of the paint is controlled so the overflow of the paint does not occur from the mounting compartment.

The paint is pumped from the bucket by the pump to the mounting in a clear hose. This supplied paint fills the mounting and when we start to roll the roller the bearing applies paint on the roller cover as the roller rotates. In this way only the outer layer of roller cover is used. Refer fig. 10 and fig. 11.

4. CONCLUSION

The continuous movement like climbing, dipping and stretching can cause muscle strain in the worker. In the long term this can cause injuries to the worker. Introducing a motorized paint roller can not only decrease strain but also the time required and the total cost of the job. According to [7], the time to paint a standard area was reduced by almost 45% by introducing a smart roller. It also stated that the movements like bending for dipping were eliminated. The motorized paint Roller uses far less amount of paint compared with a standard paint roller. By
using the motorized paint Roller in the construction, it is for sure will save a lot amount of money in buying paint, paying painters salary and also reimbursing painters medical expenses caused by injuries. Motorized paint roller is the future of painting in the construction business.

I feel great pleasure to present the Project Stage-I entitled “Design & Manufacturing of Motorised Paint Roller”. But it would be unfair on our part if we do not acknowledge efforts of some of the people without the support of whom, this seminar would not have been a success. First and foremost I am very much thankful to my respected Guide Prof. Aniket Deshmukh for his leading guidance in this Project topic. I thankful to our Head of Department Prof. Dr. Sham Mankar, also he has been persistent source of inspiration to us. I would like to express my sincere thanks and appreciation to Principal Prof. Dr. Harish Tiwari and Project coordinators Prof. Ganesh Fodse for their valuable support. Most importantly I would like to express our sincere gratitude towards my Friends & Family for always being there when I needed them most.

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ACKNOWLEDGMENT

PARTH SAHASTRABUDDHE is pursuing his Bachelor of Engineering in Mechanical from Pimpri Chinchwad College of Engineering and Research. His interest lies in the field of Electric Vehicle. He looks ahead to explore more in the field.

PRAVIN PRADHAN is pursuing his Bachelor of Engineering in Mechanical from Pimpri Chinchwad College of Engineering and Research. His interest lies in the field of automation. He looks ahead to explore more in the field.
AMIT PRAJAPATI is pursuing his Bachelor of Engineering in Mechanical from Pimpri Chinchwad College of Engineering and Research. His interest lies in the field of Automotive design and industrial design. He looks ahead to explore more in the field.

SUMIT GARADE is pursuing his Bachelor of Engineering in Mechanical from Pimpri Chinchwad College of Engineering and Research. His interest lies in the field of design. He looks ahead to explore more in the field.
Development of Test Rig for Behaviour Study of Metal to Composite Bolted Joint under Combined Bending and Vibration Loading

Aditya S. Choudhari¹, Bhavesh S. Baviskar², Chetan B. Dhanuka³, Shreyash H. Khedekar⁴, L. V. Awadhani⁵

¹Associate Professor, Dept. of Mechanical Engineering, Pimpri Chinchwad College of Engineering, Savitribai Phule Pune University, Pune, India
²³⁴Dept. of Mechanical Engineering, Pimpri Chinchwad College of Engineering, Savitribai Phule Pune University, Pune, India

ABSTRACT - Testing is very crucial to ensure the effectiveness of any component. The current scenario only focuses on the cases of uniaxial loading while in real life situations, the components are subjected to multiple loads simultaneously. In such cases conventional testing doesn’t help to predict the exact behaviour of particular component in real life applications. To study correct behaviour, it is important to adopt the approach of testing under combined loading. Use of composite materials in various industrial sectors is increasing day by day due its desirable properties. Due to the extensive use of composites, it is necessary to study behaviour of composites under combined loading. This paper primarily focuses on development of a test rig for the study of behaviour of composites subjected to combined loading. The combined loading constitutes primary load vibration and the secondary load consists of bending. Also, the paper focuses on identifying the effect of various parameters like load, frequency, and amplitude on the behaviour of composite material.

INDEX TERMS – behaviour study, bending, Carbon fibre, combined loading, vibration.

1. INTRODUCTION

A composite is a structural material that consists of two or more combined constituents that are combined at a macroscopic level and are not soluble in each other. One constituent is called the reinforcing phase and the one in which it is embedded is called the matrix. The reinforcing phase material may be in the form of fibres, particles, or flakes. The matrix phase materials are generally continuous. Examples of composite systems include concrete reinforced with steel and epoxy reinforced with graphite fibres, etc.[1]

Monolithic metal and their alloys do not always fulfil the demand in some special applications such as Space shuttles, Aeroplane, marine vehicles, etc. Composites can be designed in such a way that it will complete the requirement of a particular application specifically.

From Figure 1 it can be concluded that the composite materials offer higher strength to weight ratio than metals. Composites offer several other advantages over conventional materials. These may include improved strength, stiffness, fatigue and impact resistance, thermal conductivity, corrosion resistance, etc. Due to these desirable properties, composite materials are becoming popular these days in industries like automation, aviation, robotics, automobile, etc.

Figure 1 Relationship between Specific strength and Specific Modulus for different material [2]

In the current scenario, only the unidirectional testing approach is considered for the composite but the conditions have arrived which requires a combined loading approach in such cases conventional testing may not fulfil the required results. In real-life applications, various combination of loads acts on components simultaneously. For example, Thermal and Bending load, Vibration and bending load, etc. In this paper, a setup is developed in order to simulate loading condition of an automotive rear car spoiler. A car rear spoiler is subjected to two primary loads, one is bending due to the drag force developed because of air and other is vibration due to excitation from road surface irregularities.
This paper primarily focuses on development of test rig to simulate real life loading case and studying the effect of the combined loading on the behaviour of composite material. Therefore, the objectives of this research paper are to design and develop a test set up for behaviour study of metal to composite bolted joint under combined bending and vibrations. To simulate load case as that of automotive rear spoiler and to test the metal to composite bolted joint specimen based on DOE and to determine the influence of parameters namely load, frequency and amplitude on behaviour of metal to composite bolted joint.

2. LITERATURE REVIEW

In the current scenario, only the unidirectional testing approach is considered for the composite testing, but conditions have arrived which requires a combined loading approach in such cases conventional testing may not fulfil the required results.

Following is the work done by scholars:

Fatih Kagnici have investigated Vibration Induced Fatigue Assessment in Vehicle Development Process. In this study a new methodology was developed in order to predict the fatigue damage of vehicle and compared with the conventional method which is used frequently in automotive sector.[3]

Rym Taktak, Noamen Guermazil and Tasnim Kossentini Kallel have carried out experimentation whose main goals was to investigate comparison of the mechanical behaviour of resins reinforced with different woven fabrics (bidirectional and quadriaxial rovings), manufactured with the classical hand lay-up process. The quadriaxial composites (QA/VE and QA/UP) with stacking sequences of $[0^\circ, +45^\circ, 90^\circ, -45^\circ]$ can bear the stress of about 75 MPa steadily, when subjected to tensile loading, and show balanced performance.[4]

Kakur Naresh, Shankar Krishnapillai and Velmurugan Ramachandran have studied the tensile and impact properties by performing a series of tests on neat epoxy and different stacking sequences of UD CFRP composites.[5]

Zhengwei Fan, Yu Jiang, Shufeng Zhang and Xun Chen have carried out vibration testing on a Carbon fibre composite in order to study the effect of holes and notches on fatigue life using electrodynamic shaker.[6]

N. V. Lakshmi Kumaria, Dr. Afroz Meharb, Mohammed Abdulrahmanc, Sheetal Tatinenid, Ellendula Venkateshwar Shashanke and Jonathan Ted Muthyalaf concluded that the material used for the composite laminate is Carbon Epoxy, The orientation of the 10 ply composite is $[90^\circ, 0^\circ, -45^\circ, 45^\circ]$s. The result obtained after calculating using MATLAB and comparing with the already obtained values are found to be within the limit.[7]

3. TEST SETUP

The test setup consists of two parts as follows:

A. Electrodynamic Shaker

For application of vibration load to the specimen a “Electrodynamic Shaker” is used. The electrodynamic shaker functions to deliver a force proportional to the current applied to its voice coil. These devices are used in such diverse activities as product evaluation, stress screening, squeak-and-rattle testing and modal analysis. These shakers may be driven by sinusoidal, random or transient signals based upon the application. They are invariably driven by an audio frequency power amplifier and may be used “open loop” (as in most modal testing) or under closed-loop control where the input to the driving amplifier is servo-controlled to achieve a desired motion level in the article under test. The heart of the shaker is a single-layer coil of wire, suspended in a radial magnetic field. When a current is passed through this coil, a longitudinal force is produced in proportion to the current and this is transmitted to a table structure to which the test article may be fixed.

Specifications of the shaker used are as follows:

**Model:** SEV 125 – DSA 1K

Dimensions: 540 x 375 x 495 (mm)

Peak Displacement: 20 mm

The types of tests available on the electrodynamic shaker are as follows:

i. Swept Sine Test

ii. Random Test

iii. Shock Test
For this experimentation Swept Sine Test is to be used. In practice the frequency is swept back and forth between a lower limit and an upper limit at a pre-determined rate; the rate may be specified as linear, logarithmic, or stepped.

**B. Bending Load Attachment**

For application of bending load, a separate attachment is manufactured. The components of the bending attachment are as follows:

1) **FRAME:** Frame is designed considering space requirement and then it is validated using ANSYS. For the fabrication of the frame, square and rectangular tubes are used in order to reduce overall weight of the attachment. To increase the strength of beams in the frame, two rectangular tubes are welded together and then used as a single entity.

Rubber pads are introduced in between main frame and sub frame’s bolting section so that the vibration in the frame gets damped reducing error in experimentation.

The frame is subjected to a load of 1000 N for Finite Element Analysis, the results can be summarized as follows:

The total deflection observed is 0.57 mm and maximum deflection at free end is 0.3 mm. Maximum stress induced is 139.18 MPa. Overall Factor of safety achieved is 1.8. This confirms safety of frame.

2) **LOADING ARRANGEMENT:** The loading arrangement consists of a square threaded screw and nut, actuator assembly. The arrangement is as shown in Figure 7. The material requirement of the actuator assembly is as shown in Table 1.
Material requirement of actuator assembly

<table>
<thead>
<tr>
<th>Name</th>
<th>Material</th>
<th>Size</th>
<th>Length</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Spring</td>
<td>C65</td>
<td>= 45 mm</td>
<td>150 mm</td>
</tr>
<tr>
<td>2</td>
<td>Nut</td>
<td>CuSn10Zn2</td>
<td>M16</td>
<td>22 mm</td>
</tr>
<tr>
<td>3</td>
<td>Screw</td>
<td>C50</td>
<td>M16</td>
<td>450 mm</td>
</tr>
</tbody>
</table>

Horizontal supports have been added for the actuator so that it prevents the wobble of loading arrangement.

In the loading arrangement as shown in Figure 6, the load applicator is directly bolted to the specimen in order to avoid slipping while simultaneous application of vibration and bending load.

![Figure 6 Loading arrangement](image)

C. Specimen

1) SPECIMEN SIZE: Standard test methods mentioned in D790 cover the determination of flexural properties of unreinforced and reinforced plastics, including high-modulus composites and electrical insulating materials in the form of rectangular bars moulded directly or cut from sheets, plates, or moulded shapes. These test methods are generally applicable to both rigid and semirigid materials.

For high-strength Reinforced Composites, the span-to-depth ratio shall be chosen such that failure occurs in the outer fibres of the specimens and is due only to the bending moment. A span-to-depth ratio larger than 16:1 may be necessary (32:1 or 40:1 is recommended). For some highly anisotropic composites, shear deformation can significantly influence modulus measurements, even at span-to-depth ratios as high as 40:1. Hence, for these materials, an increase in the span-to-depth ratio to 60:1 is recommended.

According to these standards selecting specimen size as 300 mm * 75 mm * 3 mm.

![Figure 7 Exploded view of actuator assembly](image)

2) SPECIMEN MATERIAL: Carbon fibres have remarkable properties such as tensile strength, stiffness, low density, electrical conductivity, and chemical inertness. Carbon fibres have been used to manufacture sportscars as well as sport equipment. Currently, a great deal of attention is being paid to reduce the weight of passenger vehicles to increase vehicle fuel economy and lower the greenhouse gas emissions. Thus, carbon fibres are now used in aircraft and industrial applications such as pressure vessels, windmills, civil engineering/construction-related uses, and cars and yachts.[3]

Carbon fibre composites are ideally suited to applications in which strength, stiffness, low weight, and outstanding fatigue characteristics are critical requirements.[3]
Taking into consideration the needs of modern industrialization ‘Carbon fibre Composite’ is selected as a specimen material.

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Specifications</th>
<th>Tolerances</th>
</tr>
</thead>
<tbody>
<tr>
<td>Area Weight (g/m²)</td>
<td>400</td>
<td>± 3%</td>
</tr>
<tr>
<td>Width (mm)</td>
<td>500</td>
<td>-0/+10 mm</td>
</tr>
<tr>
<td>Dry Fabric Thickness (mm)</td>
<td>0.43</td>
<td>± 0.03 mm</td>
</tr>
</tbody>
</table>

Table II
Carbon Fibre Specifications

Table III
Fibre Properties

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Density (g/cm³)</td>
<td>1.8</td>
</tr>
<tr>
<td>Filament Diameter (µm)</td>
<td>7</td>
</tr>
<tr>
<td>Tensile Strength (MPa)</td>
<td>4000</td>
</tr>
<tr>
<td>Tensile Modulus (GPa)</td>
<td>240</td>
</tr>
<tr>
<td>Elongation (%)</td>
<td>1.7</td>
</tr>
</tbody>
</table>

Sizing Epoxy Compatible

3) SELECTION OF LAMINATE ORIENTATION:
Laminated composite materials consist of layers of at least two different materials that are bonded together. Lamination is used to combine the best properties of its constituent layers and bonding material in order to achieve a more useful material. One of the fundamental advantages of laminates is their ability to adapt and control the orientation of fibres to best resist loadings. Plies contribute to the laminate resistance by orienting with respect to the loading direction. Fibres oriented at 45° can support the tension and −45° can support compression. [7]

The composites with stacking sequences of [0°, +45°, −45°, 90°] can bear the maximum load with minimum deflection hence this laminate orientation is popular among automotive manufacturers. [4]

Taking into account the advantages and popularity, selecting orientation as symmetric [0°, +45°, −45°, 90°].
1 Ply = 0.127 mm
1 Laminate = 8*0.127 = 1.016 mm
Total Specimen thickness = 3*1.016 = 3.048 mm

Therefore, Area of specimen = 300 * 75
= 22500 mm²
= 0.0225 m²

Figure 8 shows actual manufactured test setup with specimen attached.

4. TESTING PARAMETERS

Following are the various parameters to be considered for the experimentation,

- Load Variation (3 Variations)
• Frequency Variation (2 Variations)
• Amplitude Variation (3 Variations)

A. Load Variation

The tensile strength of the carbon fibre composite with given compositions is 307 MPa. [5]

For selecting the reference loads let us consider three load steps till the carbon fibre composite specimen reaches its ultimate strength. For the selected dimension of specimen, the stress calculations are as follows:

\[ \sigma_b = \frac{M}{Z} \]

\[ M = \text{Load} \times \text{Distance} = 180 \times P \]

For a rectangular section,

\[ Z = \frac{b \times d^2}{6} = \frac{75 \times 32}{6} = 112.5 \text{ mm}^3 \]

\[ \sigma_b = \frac{180 \times P}{112.5} \]

\[ \sigma_b = 1.6 \times P \]

Therefore, \[ P = \frac{\sigma_b}{1.6} \]

So, for calculating the reference load values, we have to select 3 values of Bending stress till it reaches ultimate strength of the carbon fibre composite. To calculate the intermediate stress value using geometric progression,

\[ \sigma_1 = 50 \text{ Mpa} \quad \sigma_3 = 307 \text{ Mpa} \]

Geometric Progression Ratio \( \Phi = \frac{307}{50}^{0.5} = 2.4779 \)

\[ \sigma_2 = \Phi \times \sigma_1 = 2.4779 \times 50 = 123.895 \text{ MPa} \]

Therefore, the reference loads are selected as follows:

\[ P_1 = \frac{50}{1.6} = 31.25 \text{ N} \]

\[ P_2 = 123.895/1.6 = 77.43 \text{ N} \]

\[ P_3 = 307/1.6 = 191.875 \text{ N} \]

B. Frequency Variation

In order to evaluate the natural frequency of specimen for deciding frequency parameter for testing, modal analysis of specimen is carried out using ANSYS Hence the frequency variations are finalized as:

F1 = 40 Hz
F2 = 60 Hz

C. Amplitude Variation

The electrodynamic shaker has the facility to decide the amplitude of induced vibrations through shaker table. So, taking into consideration some real-life applications of composites, following are the amplitude variations decided:

A1 = 2 mm (Vehicle on plane road)
A2 = 5 mm (Vehicle on Off-road conditions)
A3 = 10 mm (All-terrain vehicle)

5. TESTING AND RESULTS

Sample experimentations are carried out using Glass Fibre composite and Carbon Fibre composite. This experimentation is carried out by subjecting the specimen to combined loading.

As shown in Figure 12 there is no sign of resonant frequency. This is due to the wrong position of accelerometer (i.e. At the end of specimen). To rectify this issue the most For analysis purpose the material of specimen selected in ANSYS is “Epoxy Carbon Woven 230GPa Wet”.

From the results it is clear that the natural frequency of the specimen is 54.12 Hz.

In order to check the behaviour of carbon fibre composite specimen at resonant frequency selecting one of the frequency variations for testing as 60 Hz.

The frequency variation is taken as a bandwidth to carry out the swept sine test. E.g. 3 Hz to 60 Hz. This is done in order to identify the change in natural frequency of the specimen in various loading combinations as discussed before.

The frequency variation bandwidth is started from 3 Hz instead of 1 Hz that is to eliminate testing errors.

From the observation of pilot experimentation, the specimen under combined loading started vibrating abruptly around 40 Hz. To verify this another frequency variation is decided to be 40 Hz.

Feasible solution is found out to be shifting the position of accelerometer to the centre of specimen along the length.

Result from experimentation on Glass fibre composite is as shown in Figure 13. From the graph it is observed that the peakdisplacement is at 6 Hz which indicates resonant frequency of Glass fibre specimen. Similarly, in case of Carbon fibre specimen peak displacement will indicate resonant frequency.
6. CONCLUDING REMARK

From the literature studied and sample experimentation following are the concluding remarks:

The sample test was carried out successfully, which indicates that the test rig developed for applying vibration and bending load simultaneously is working properly. Vibrations from the specimen are not transferred to frame due to presence of rubber pads in between main frame and sub frame. In order to ensure the proper working of electrodynamic shaker it is necessary to select the starting frequency as 3 Hz. This limits time required to initiate the test and reduces testing errors. After carrying out the complete test, none of the components of test rig have failed. This verifies that the design of the test rig is safe.

As the testing is continued for prolonged period of time it is observed that the composite specimen undergoes microscopic cracks and delamination. As a result, the natural frequency of specimen decreases as damage to the specimen increases. A cross ply specimen initially experiences tangential cracks along the surface then eventually leads to delamination damage. The microscopic crack propagation is initiated from small holes created due to manufacturing defect present on specimen surface. The peak frequency decreases to a certain degree initially then remains constant till delamination phenomenon. The first decrease in frequency is considered to be the life of specimen.

With some modification in the frame, it can be used to apply bending load at various sections of specimen. Also, by carrying out experimentation using electrodynamic shaker, change in natural frequency of test specimen with and without bending load can be computed.

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ADITYA S. CHOUDHARI was born in Khamgaon, Buldhana, Maharashtra, India in 1998. He has received his Diploma in Mechanical Engineering from Maharashtra State Board of Technical Education (MSBTE) in 2017, and B.E degree in Mechanical Engineering from Savitribai Phule Pune University, Pune, Maharashtra in 2020. He has worked with TIFAC on project name ‘Neck-Aid’. His research interests include composites, tribology, and design of reliable prosthetics for differently abled patients. He was a member of Product Innovation lab at PCCOE, Pune from 2018 to 2019. From 2019 to 2020 he was member of “Indian society of heating, refrigeration and air conditioning engineers” (ISHRAE).

BHAVEESH S. BAVISKAR was born in Chopda, Jalgaon, Maharashtra, India in 1998. He received the Diploma in Mechanical Engineering from Maharashtra State Board of Technical Education (MSBTE), India, in 2017 and B.E. degree in mechanical engineering from the Savitribai Phule Pune University (SPPU), Pune, in 2020. From 2017 to 2018, he worked as Transmission system head in design and manufacturing of All terrain vehicle for National and International inter-college competitions under SAE BAJA. He was member of “society of automotive engineers” (SAE INDIA and from 2019 to 2020 he was member of “Indian society of heating, refrigeration and air conditioning engineers” (ISHRAE).

CHETAN B DHANUKA was born in Shegaon, Buldhana, Maharashtra, India in 1998. He has received his Diploma in Mechanical Engineering from Maharashtra State Board of Technical Education (MSBTE) in 2017, and B.E degree in Mechanical Engineering, from Savitribai Phule Pune University, Pune, Maharashtra in 2020. From 2019 to 2020 he was member of “Indian society of heating, refrigeration and air conditioning engineers” (ISHRAE).

L. V. AWADHANI was born in Gulbarga, Karnataka India and studied BE Mechanical from Walchand Institute of Technology, Solapur in 1996, MTech Design from COEP in 2006. Worked as Assistant Professor, Mechanical Engineering at DYPCE from 1996 to 2010. Working as Associate Professor at PCCoE, Nigdi since 2010. Research interests: Mechanics of composites, Machine Design, Mechanisms. Pursuing PhD from SPPU with ZCOER Narhe as Research Centre. Completed Funded projects from AICTE, SPPU and Industries. Conducting training programmes for the Industries since 2019. Published 10 papers in the International journals, 5 text books for UG courses and filed 1 Patent. Guided 30 PG Dissertations. Member of Mechanisms and Machines, ISTE.
Development of Attachment for Experimental Behaviour Analysis of CFRP Specimen Subjected to Combined Bending and Thermal Loading

Aneesh Anthony#1, Simlan Awachat#2, Kaustubh Battul#3, Jatin Dhanwani#4, and L.V. Awadhani*

#UG students, Dept. of Mechanical Engineering, Pimpri Chinchwad College Of Engineering, Nigdi, Pune, Maharashtra, India, 411044
*Associate Professor, Dept. of Mechanical Engineering, Pimpri Chinchwad College Of Engineering, Nigdi, Pune, Maharashtra, India, 411044

ABSTRACT

Composite materials have become an inseparable part of our life and are being used in a majority of applications like automobiles, sports equipment and aeronautical structures. Many practical applications involve a combination of loads acting on a member simultaneously. This paper explains the process of designing and manufacturing a standard attachment for the testing of composite specimen under combined loading. The load combination is thermal and bending. The material for the sample tests is selected as CFRP, owing to its widespread use in the industry. The ply orientation of the composite laminate is taken as [0/90/(±45)2]s. 3-point bending test is performed on the specimen after preheating them to a certain temperature. For this, a fixture and thermal insulation box is designed and manufactured based on the specimen dimensions and for facilitating a smooth test experience. Some pilot tests were taken to validate the proper working of the attachment by comparing with the previous research done on it.

INDEX TERMS
CFRP specimen, Combined loading, Fixture, 3-point bending test, Thermal and bending load, Thermal insulating box

1.INTRODUCTION

Composites are popularly used in the industry today and are prominent in automotive, construction, aerospace and defense applications among others. As a cost-effective replacement to traditional materials like metal and engineered thermoplastics, thermoset composites are common materials in the appliances, construction, electrical and transportation industries. The reason of composites gaining such popularity may be attributed to their properties such as low weight, high strength-to-weight ratio, corrosion resistance, high impact strength, design flexibility, low thermal conductivity and dimensional stability.

Unlike conventional materials, composites are anisotropic in nature. The relationships between forces and deformations is complicated for such materials and the results can be unexpected. Normal stresses may induce both normal and shear stresses and vice versa. Temperature changes in an anisotropic material may cause non-uniform expansion/contraction and distortion [1]. Theories that try to explain the behaviour of composite materials exhibiting such properties are not available till date. Thus, it is important to perform experimental behavioural analysis of composites to determine the relationships between applied loads and mechanical properties of the laminate.

In real life, structural as well as machine components are subjected to a combination of loads at any particular time. A part may face a combination of two or more load conditions based on the application. For example, a turbine propeller shaft is subjected to combined bending, torsion and axial thrust. This paper considers the two-load combination of thermal and bending loads for the testing of composite specimen.

2.PROBLEM DESCRIPTION

The paper focusses on the design and development of an attachment conforming to standard dimensions (as applicable) and that which facilitates testing for CFRP composite laminates under combined thermal and bending load applied by means of preheating and 3-point bending respectively. The attachment in its entirety must be able to be mounted on a Universal Testing Machine for the 3-point bending test.

3.LITERATURE REVIEW

A brief review of the findings from relevant research papers is presented below:

A. Literature pertaining to Laminate Design
1. M.A. Caminero et al. [2], suggested the procedure mentioned in ASTM D7264 which will be used to decide specimen dimensions and test parameters. [45]12 and [90]12 type of orientation showed lowest impact energy and flexural strength due to brittle behaviour whereas [0]12 orientation showed best performance in both bending and impact. Also explained [±45]3s, has high impact energy but low flexural strength. Along with this, [0/90/(±45)]3s showed 86% and 65% of impact and flexural strength of [0]12 type of orientation respectively.

2. Ernie I. Basri et al. compared the result for different orientation of ply combination which contribute to the high performance of composite. In his observation, ply orientation [0/ (0/45/90) /0] showed the significant structural performance as the lowest displacement and stress as compared with other sequence.

3. N.B.V. Lakshmi Kumari et al. performed the analysis on CFRP laminate with in-plane loading condition of tensile and shear failure. In this research, the mathematical calculation of determining the failure criteria of the laminate with ply orientation of [90/0/0/-45/+45]s is done by writing stress program on MATLAB and further analysis is performed using ANSYS. The paper used 10 ply stacks and mid plane symmetry i.e. stacking of the plies on both sides starting from the mid-plane which is identical for the ply orientation of [90/0/0/-45/+45], in order to limit interlaminar stresses. After obtaining both the results the design is validated.

4. Walid Roundi et al. [3], established fatigue behaviour of glass/epoxy composite materials under different stress ratios and for various plies orientation angles. Experimental and numerical analysis (Finite Element Method) were performed on various specimens subjected to cyclic tensile tests in order to outline the influences of stress ratios and the stacking sequence ([0°/90°]; [90°/0°]; [0°/90°]; [90°/0°]) on glass/epoxy fatigue properties. His findings showed that for structures under higher applied stress, it’s more adequate to use the [0°/90°] fibre orientations to achieve the maximum fatigue life. The glass/epoxy composite [0°/90°], exhibits a higher tensile strength (610 MPa). However, composite [90°/0°], presents the lowest static properties (tensile strength about 205 MPa) among the four stacking sequences. Also, the results of monotonic tests clearly confirm that the most resistant laminate is the one with more plies (6 plies) in the loading direction i.e. the [0°/90°].

B. Literature pertaining to Thermal Behaviour of FRP

1. Milad Bazli et al. [4], suggested that the glass fibres are the most common and widely used in constructing FRP composites due to their relatively low cost (particularly compared to CFRP and AFRP) and high strength. The first stage of resin degradation occurs when the resin glass transition temperature (T_g) is reached. More severe degradation occurs when the temperature reaches the resins decomposition temperature (T_d). The conditioned specimens were subjected to temperatures of 60, 120, 200, and 300°C for two different periods: 20 and 120 min. The specimens were left to cool for 24h and then tested. At 300°C temperature, which is close to the resin Td, all GFRP laminates lost almost all their bending strength and impact energy absorption capacity.

2. Phi Long Nguyen et al. focused on the thermo-mechanical performance of the CFRP which was fabricated on site with the hand lay-up methods. The material was tested at different temperature levels varying from 20-600°C and simultaneous at different stress ratio from 10% to 75% of materials ultimate tensile stress. The results of the experiments showed that the mechanical performance of the material decreased as the temperature increased, the ultimate strength decreased by 50% at 400°C and the Young’s modulus varies little in temperature, ranging from 20°C to 400°C. As the temperature rises to 600°C, the reduction in ultimate strength is more gradual while the Young’s modulus decreases to 30% which confirmed a correlation between thermal and mechanical loads.

3. Rami A. Hawileh et al. [5], examined all specimens which were subjected to the specified temperature (25-300 °Celsius) level for 45 min and left to cool down for 24 h prior to testing and then tested on UTM for tension at strain rate of 2 mm/min. Stress–strain relationships were plotted, and the different observed failure modes were discussed. Based on the test results, the decrease in the mechanical properties of the composite C and G sheets was more severe than those of the composite hybrid CG sheets. In particular, the elastic modulus of the C, G and CG at 250 °C was reduced by about 28%, 26% and 9%, respectively and their tensile strength at the same temperature was reduced by about 42%, 31% and 35%, respectively, all as compared to room temperature values. Elastic modulus goes on decreasing as temperature.
increases. Percent reduction in strength is more in CFRP as compared to GFRP and hybrid laminate was analysed.

C. Literature pertaining to Flexural Behaviour

1. Elanchezhian et al.[6], suggested CFRP and GFRP were treated at 35 °Celsius for flexural test at different strain rates. The flexural test was performed on the same universal testing machine, using the 3-point bending fixture according to the ASTM D790 with the crosshead speed of 2mm/min. Load vs displacement curve was plotted for CFRP and GFRP. The maximum flexural strength is observed in CFRP. The flexural stress and breaking load are more for CFRP as compared to GFRP. For CFRP flexural stress is 31.58 N/mm²and that for GFRP is 8 N/mm². Breaking load for CFRP is 1785 N, and that for GFRP is 475N. Impact strength of CFRP composite is 11J which is quite high when compared with the GFRP composite whose impact values are 6J and 4J respectively.

2. Dongdong Chen et al. [7], investigated the flexural performance of carbon fibre reinforced polymer along with GFRP, basalt and hybrid FRP using experimental, numerical and analytical approach. The mechanical properties of CFRP were better than any other material. The flexural strength and flexural modulus of CFRP were 1080 MPa and 990 MPa respectively, which were the maximum values compared to others. The strain rate was less compared to most materials. The flexural performance of the hybrid FRP decreased with the increase in hybrid ratio. However, the cost efficiency of CFRP was less than hybrid FRP and GFRP.

19. TEST SPECIMEN DIMENSIONS

The specimen dimensions are referred from ASTM D790 [8]. For 3-point bending test the specimen cross-section is taken as rectangular. ‘Procedure A’ was followed which is designed principally for composite materials that break at comparatively small deflections.

The thickness is taken as 3 mm. For high strength reinforced composite materials, the span: depth ratio is taken as 32:1 as referred from [8]. For 3-point bending test, there can be two orientations of the specimen while performing the test, namely flatwise and edgewise. The former will be used for this test for which the depth is same as the thickness.

**Span length**

\[
\text{Span length, } L = 32 \times \text{depth} = 32 \times 3 = 96 \text{ mm}
\]

Overhang should be provided by at least 10% on either side of the support.

\[
\text{Overhang} = 0.1 \times 96 = 9.6 \text{ mm}
\]

Hence, Total specimen length = 115.2 mm

The width of specimen as per [8] depends on the depth of the specimen. As the depth of the specimen is less than 3.2 mm, the standard width is taken as 12.7 mm.

![Specimen Dimensions](image)

20. DESIGN OF ATTACHMENT

The design procedure for each component of the attachment is described below:

A. Design of Fixture

In order to accommodate a specimen with the maximum specimen length, the length of the fixture base is taken to be 220 mm. The values of width and depth are 50 mm each.

The specimen will be placed on two supports at the span length as calculated above. The supports would be placed on the fixture base and can be adjusted for the required specimen length. This functionality can be
achieved by engaging the supports and base with the help of a T-bolt which can slide in a T slot present in the base. Based on standard available T slot and T bolt dimensions the slot is designed with a base width of 20 mm. The overall dimensions of the base are shown in Fig. 2.

The L shaped supports would be manufactured using mild steel flats of thickness 10 mm and width 50 mm. The characteristic dimension of the support is its radius at the contact surface with the specimen, which has to be 5 mm according to [8]. Other dimensions of the supports are shown in Fig. 3.

The indenter is shown in Fig. 4. The characteristic dimension of the indenter is its radius at the contact surface with the specimen, which must be 5 mm according to [8].

### B. Check for failure of fixture

The load acting on the specimen will be transferred to the fixture base through the supports. Compressive stress will be developed at the contact between the base and supports. Neglecting the force due to pre-tension of T bolt nuts, the load is taken to be 2.5 KN as referred from Fig. 11 of [2], which is the maximum load experienced during the test. This force will be equally distributed in the two supports and hence the load acting at the interface of the base and support is 2500/2 i.e. 1250 N.
The compressive strength of MS ranges from 140 to 160 N/mm\(^2\).

The area of support through which force would be transmitted to the base is 50 mm x 10 mm. The part of the area supported by the base is 40 mm x 10 mm since there is a slot of width 10 mm.

Therefore, Compressive strength,
\[ c = \frac{F}{A} \]
\[ c = \frac{1250}{(40 \times 10)} \]
\[ c = 3.125 \text{ N/mm}^2 < 140 \text{N/mm}^2 \]

From the above result, we can conclude that the fixture does not fail in compression.

C. Need of Insulation Box

The specimen to undergo bending test is also subjected to thermal loading. From [9], the Specific Heat Capacity of CFRP,
\[ C_p = 577.4 + (6.85165T) - (0.018078T^2) \]

Check for applicability of Lumped System Analysis:

Biot Number, \( Bi = \frac{h \times Lc}{k} \)
where, \( h = \) convective heat transfer coefficient = 25 W/m\(^2\)K
\( Lc = \) characteristic length = Volume/Surface area = 0.001188 m

\[ k = \text{Thermal conductivity} = 5 \text{ Wm}^{-1}\text{K}^{-1} \]

Therefore, \( Bi = 0.00594 \) which is very small as compared to 0.1.

Hence, the system can be modelled as a Lumped System.

1. For 50°C:
\[ C_p = 874.7875 \text{ Jkg}^{-1}\text{K}^{-1} \]
\[ b = (\frac{hAs}{\rho V C_p}) \]
where \( \rho = \) density of CFRP = 1770 kg/m\(^3\)
Therefore \( b = 0.019 \)

After a time period of ‘t’ minutes, the temperature reached is given by:
\[ \frac{(T - T_f)}{(T_i - T_f)} = e^{bt} \]
Where, \( T_f = \) surrounding temperature = 25°C
Therefore, taking \( t = 7 \) min, we get
\[ T = 25.008°C \]

2. For 250°C:
\[ C_p = 1160.4375 \text{ Jkg}^{-1}\text{K}^{-1} \]
\[ b = 0.0144 \]

Following the same procedure, we get,
\[ T = 25.531°C \]

In the above graph, the red coloured curve represents the temperature variation with time for an initial value of 50°C and the blue coloured curve represents the temperature variation with time for an initial value of 250°C. It is evident that the temperature drops rapidly and
thus an insulating box is required to ensure that the specimen temperature remains stable throughout the test duration.

21. MANUFACTURING OVERVIEW

All the components of the attachment were manufactured using AISI 1080 steel. The brief description of the process is as follows

A. Fixture and Indenter Manufacturing

- The dimensions of the base were fixed based on the maximum length of the specimen. Thus, the required dimensions are 220mm x 50mm x 50mm.
- T-slot machining was done so as to fix and slide the supports as required.
- The supports were manufactured by drilling steel plates and welding them at right angles by MIG welding. Rod of 10 mm diameter were welded at the edge of the plates to form the contact surface with the specimen.
- A steel bar and plates were welded to make the indenter which can be attached to the UTM. Nuts and bolts were used to fix the supports with fixture base.

The final assembly of the fixture is shown in Fig. 6 below.

B. Insulation Box Manufacturing

Wooden ply is used for making the structure of the insulation box. Its dimensions were determined based on the space available for the experiment. They are as follows:

- Length: 350mm
- Width: 270mm
- Height: 200mm

Rockwool is used as the material for insulation because of its sustainability at the required temperatures and its inherent advantages over other materials, which are as follows-

- Retains heat well and traps air, which slows the transfer of heat
- Non-combustible and fire resistant to about 1,400 °C
- Highly water repellent

The thickness of the rockwool sheets is 50mm.
Fig. 7. Wooden insulating box

The box is inlaid with two sheets of rockwool on each face of the box to provide optimum insulation and achieve appreciable accuracy.

22. EXPERIMENTAL PROCEDURE

The composite specimen would be heated to the required temperature in a muffle furnace, except for the first set of specimens, which are to be tested at room temperature. The temperature will be increased gradually to further decrease the chances of warping due to sudden heating of the specimen. Each specimen is to be maintained in the furnace at the required temperature for 15 minutes to ensure uniform heating.

Clamp the supports of the test fixture at the required span length using T bolts and nuts. Place the fixture inside the insulating box. Clamp the indenter in the chuck of the UTM and adjust the height such that the head of the indenter is inside the chamber.

The further procedure is as follows-

1. Place the specimen on the supports at the correct span length and close the box
2. Apply load on the indenter at the specified strain rate
3. On failure of the specimen, remove it from the chamber and visually observe delamination or other failure phenomena if any.

4. Save the Load-deflection curve for further analysis
5. Repeat the above procedure for each specimen of each set and for all the temperature sets.

23. TEST PERFORMANCE AND RESULTS

Flexural test at room temperature was performed on three of the previously described CFRP specimens to validate the results and to verify the effectiveness of the attachment. The graphs depicting Load vs. Cross Head Travel, of this test are as follows-

Fig. 8. Graph showing 1st specimen at room temperature
From the results, it is observed that maximum peak load obtained is 360 N.

Maximum elongation at peak is 16.08 mm. The following table consolidates the results obtained from the experiment for all the three specimens.

<table>
<thead>
<tr>
<th>Sample No.</th>
<th>Thickness (mm)</th>
<th>Strain Rate (mm/min)</th>
<th>Peak Load (N)</th>
<th>Displacement (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>3</td>
<td>2.3</td>
<td>340</td>
<td>13.02</td>
</tr>
<tr>
<td>2</td>
<td>3</td>
<td>2.1</td>
<td>340</td>
<td>13.51</td>
</tr>
<tr>
<td>3</td>
<td>3</td>
<td>2.4</td>
<td>360</td>
<td>16.08</td>
</tr>
</tbody>
</table>

The flexural test results published in [6] are as follows:

<table>
<thead>
<tr>
<th>Sample No.</th>
<th>Thickness (mm)</th>
<th>Strain Rate (mm/min)</th>
<th>Ultimate Stress (N/mm²)</th>
<th>Displacement (mm)</th>
<th>Breaking Load (N)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>4.5</td>
<td>2.5</td>
<td>31.578</td>
<td>6.1</td>
<td>1785</td>
</tr>
<tr>
<td>2</td>
<td>4.5</td>
<td>1.5</td>
<td>29</td>
<td>6.3</td>
<td>1520</td>
</tr>
<tr>
<td>3</td>
<td>3.5</td>
<td>2.5</td>
<td>26</td>
<td>5.5</td>
<td>1135</td>
</tr>
<tr>
<td>4</td>
<td>3.5</td>
<td>1.5</td>
<td>25</td>
<td>6.7</td>
<td>1085</td>
</tr>
</tbody>
</table>
The test was performed at 35°C on CFRP composite specimen with dimensions pertaining to ASTM D790.

24. CONCLUSION

The flexural test conducted on the specimens at room temperature displayed a similar trend as that of the results referred from [8]. The value of peak load, at which the specimens showed sign of failure, is comparatively lower due to the lower thickness of the specimens. The average peak load for the specimens is 346.67 N and the average deflection is 14.20 mm. Thus, performance of flexural test with the developed attachment produces the expected results without the presence of any unexplained behaviour or discrepancies. Thus, the attachment developed can be utilized for the behaviour analysis of CFRP specimen under combined loading, with valid outcomes.

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A Review on Enhancement of Flame Retardancy of Natural Based Fibres and their Testing

Vaishnavi Pandey1, Nirmala H. Bhingare2, Pratiksha Bhor3, Satyam Todkar4, Suraj Choudary5

1Student of Mechanical Engineering Department, D. Y. Patil College of Engineering, Akurdi, Pune, India
2Student of Mechanical Engineering Department, D. Y. Patil College of Engineering, Akurdi, Pune, India
3Student of Mechanical Engineering Department, D. Y. Patil College of Engineering, Akurdi, Pune, India
4Student of Mechanical Engineering Department, D. Y. Patil College of Engineering, Akurdi, Pune, India
5Student of Mechanical Engineering Department, D. Y. Patil College of Engineering, Akurdi, Pune, India

ABSTRACT

Drastic increase in noise pollution due to sedentary lifestyle has paved a pressing need to use acoustically excellent sound absorbers. Now, with the rise in use of synthetic materials for sound absorption, environmental pollution has tremendously escalated. Therefore, in order to reduce the harmful effect, natural fibres come into picture. Fibres like jute, sugarcane fibres, kenaf, coconut coir, arengapinnata have extremely good sound absorption coefficient. But their application is difficult to commercialize because of the lack of fire retardant properties. Hence, this review highlights the flame resistant properties of the natural fibres and further enhances their performance. Also, there is an emphasis on current tests to measure relative flammability. An extensive study of different fire retardants has also been analysed along with their optimum composition in the composite material. The effect of using fire retardants on the fibres acoustic properties has also been discussed.

Keywords: Natural Fibres, acoustic absorber, fire retardant absorbers, coconut coir, and flammability.

INTRODUCTION

Sound pollution is increasing at phenomenal level and has negatively impacted the mankind. The negative impacts range from hearing loss, fatigue, reduction in productivity, stress, communication difficulties at workplace to serious ailments like cardiovascular diseases, cognitive impairment and chronic hearing issues. Due to lack of urban planning and rampant industrialization, the effect has accelerated. Large noise generating machines like vacuum pump, air compressors, exhausts, generators increment in the noise pollution. Prolonged exposure to 70 dB-90 dB of sound level such frequently poses serious issues to the environment and human health.[1-3] The existing solutions for curbing the noise pollution are synthetic sound absorbers. Absorbers like, acoustic foam, mineral wool, fibre glass, cotton batts, synthetic hanging baffles have real good efficiency in sound absorption, sufficient structural strength, durability and are widely available and accepted across the world [4-5]. But the synthetic sound absorbers are quite expensive and pose great threat to environment. Synthetic sound absorbers are mainly composed of isocyanates which are highly reactive chemicals. Their long term to exposure to humans may cause skin, eye and lung irritation, asthma [6-7].

India being an agro based country produces 400 million tons of agro waste annually. These waste primarily contain Coconut fibre, rice husk, jute, stalk etc. 19th century did open a wide market of polymers. However, the environmental loss suffered by society due to pollution and their health hazards again draws back to going natural. The natural fibres fulfill all the requirements of a good sound absorber. They are found to be efficient over a wide range of frequencies [8-9]. Generally, the acoustic applications in our industries deal with high temperatures like compressor, pump, etc where there is a high possibility of flame propagation. This review paper focuses on the fire retardant property of the natural fibres and further enhancing it.

Urea Mohd Faizal Mat Tahir et.al making use of urea as fire retardant on coir fibre was evaluated. The results revealed the effectiveness of using urea as fire retardant for Malaysian coir fibre. Flammability and thermogravimetric analysis (TGA) tests were performed to evaluate the fire retardancy. For the results of flammability and TGA weight loss and percentage of mass residue were used. It is sufficient to just dip application for the fire retardant of
DAP reaction system to other biopolymers like lignin, positive effect on fire protection. It was concluded that solubility, reaction time, the well soluble additives have flame retardant are depend on the amount of phosphate, pyrolysis combustion flow calorimeter, the efficiency of thermogravimetric analysis, and cone calorimeter, also the characterized with small burner and smoldering tests, the flame retardants (FR) properties are extensively fungilded [16]. Stefan Gebke et al. have study that temperature of 160 and 190°C protects it from fire and thermal condensate of glucose diammonium phosphate at a George Chen et al. analysed that when the wood contains other systems. The oxidative pyrolysis and fire behaviour of the composites produced were studied using thermogravimetric and cone calorimeter tests that demonstrated improvement of their thermal stability and fire performance[12]. Mona A. Nassar et al concluded making use of saw dust a cheaper and better quality fire resistant particle board was made[13]. Pere Ferrerborrell et al. a polymer was created using a (PLA) polyactic acid and(PCL)polycaprolactone when mixed in different ratios. The PCL present played the role of increasing the biodegradability of PLA. A protective layer was created on polymers surface using DAP which acts as flame retardant [14]. A. Richard Horrocks et al. came across conclusion that amoung the antimony—halogen or in some cases, tin—halogen formulations only one single flame retardant system, tris(tribomoneopentyl) phosphate, is presently effective in polypropylene when required for fibre[15].

II. DIFFERENT FIRE RETARDANTS

1. DAP (Diammonium Phosphate)

George Chen et al. analysed that when the wood contains thermal condensate of glucose diammonium phosphate at a temperature of 160 and 190°C protects it from fire and fungledegradation [16]. Stefan Gebke et al. have study that the flame retardants (FR) properties are extensively characterized with small burner and smoldering tests, thermogravimetric analysis, and cone calorimeter, also the pyrolysis combustion flow calorimeter. The efficiency of flame retardant are depend on the amount of phosphate, solubility, reaction time, the well soluble additives have positive effect on fire protection. It was concluded that DAP reaction system to other biopolymers like lignin, hemicelluloses and proteins would show a better flame retardancy effects. Research prove that starch-based flame retardants are suitable, showing alternative to genral flame retardants in the wood fibre industry[17]. S.Kamalakannan et al. has researched that the synthetic fibre used in current market Results in the problem related to depletion of environment. To overcome this issue engineer has turned on to natural fibre. The natural fibre obtain from agriculture waste has to deal with the fire was a major problem. to overcome this fire retarding chemicals like urea and DAP were used. experiment like Vertical burning was performed based on standard of ASTM E69—02 (Standard Test Method for Combustible Properties of Treated Wood) using of Fire-tube Apparatus was done prior to chemical Treatment. The results obtain shows that DAP have great ability to reduce fire in coir fibre over other additives [18].

2. Chaboric acid and Borax

Qingwen Wang et al. has discussed the fire retardant mechanism of boric acid on wood. Different experimental results like use of thermal analysis, cone calorimetry (CONE), and gas chromatography—Fourier transform infrared spectroscopy (GC—FTIR) analysis were done treating the boric acid, guanylurea phosphate (GUP), and GUP—boric acid with Basswood was done. This treated wood was then analysed by thermogravimetry (TG/DTG), differential thermal analysis (DTA), CONE, and GC—FTIR. When the boric acid treated with Basswood, according to thermogravimetry the weight loss of basswood was about three times that of untreated or GUP—treated wood at 165°C, at which GUP is stable. According to output of CONE the boric acid and GUP has a considerable effect on fire retardant effect on wood [19]. Zafer Demirci et al. results shows Boric acid (BA) decreases the glowing time, while borax (BX) extends it[20]. N.Parkunam et al. studied about the mechanical and thermal properties of the particle and fibre reinforced polymer composites incorporated with fire retardants. They augmented natural fibres with base matrixes. They also correlated different types of fire retardants for the best one and also the optimum composition for the fire retardants in the composite material. They found that epoxy composite has great mechanical property and thermal stability. They combined fire retardants with composite to improve the thermal stability. Their study shows that boron compound has superior thermal stability and valuable smoke suspension [21]. N.S.Suharty et al successfully prepared bio-composites base on waste polypropylene (rPP) and kenaf fibre (KF) using coupling agent acrylic acid (AA), and crosslinkerdivinylbenzene (DVB) containing nano CaCO3 (nCC) with and without DAP as a mixture fire retardant (FR). According to ASTM D635, they performed horizontal burning test of bio-composite to check its flammability. They examined the nature of its biodegradability & they buried the bio-composites in a technical manner in garbage dump land. They measured tensile strength properties of bio-composites according to ASTM D638 type V. they concluded that effect of 20% total weight flame retardant [nCC+DAP] ratio 7:13 can
effectively reduce the burning rate (BR) up to 54% compared to bio-composites without any fire retardant. Also, biodegradability of bio-composite rPP/DVB/AA/KF/[nCC+DAP] was studied by burying the bio-composite specimens in the garbage soil during four months. The biodegradability of bio-composite was measured by them by losing weight (LW) of bio-composite specimens. After burying in the soil for four months, it was found up to 11.82%. The results showed that [nCC+DAP] in the bio—composites marginally decreases the tensile strength (TS), compared to that of without FR [22]. K. K. Saju et al. reviewed growing awareness and concern over the environment has promoted researchers over the world to focus their attention on studies related to natural fibre reinforced polymer composites along with their relative advantages. Coir fibre a biodegradable natural fibre extracted from the husk of the coconut (Cocos nucifera L.), traditionally used for making ropes, carpets or mattresses is now being used in various Fibre Reinforced Polymer composites. Coir fibre based composite boards as substitute to plywood is a relatively new application and their flammability characteristics are under investigation. Use of coir composite boards for potential applications makes it necessary to add knowledge on the flammability characteristics to widen the range of their application. This paper reviews the potential of coir composites and types of composite boards currently available. It also covers the different types of flame retardants (FRs) that can be used and their mechanisms for inhibiting fire, and discusses the various methods of fire retardant treatment[23]. Stanley Okiy et al. evaluated the effectiveness of borax and boric acid as fire retardant chemicals in timber. They selected three species of timbers namely; Iroko, Mahogany, and Arborea to study this. They concluded that; i.Timber treated with fire retardant chemicals can prevent flame spread and avert the danger of fire disaster. ii. Borax and boric acid are effective for treating wood against fire outbreak with borax and boric acid indicating a greater proficiency. iii. Arborea could compete favourably as treated fire retardant material with other conventional tree species such as Iroko, and mahogany commonly used as roofing timbers. iv. The ignition time of the treated timbers increased in the order of Arborea, Iroko to Mahogany, while the flame propagation rate and afterglow time generally decreased as compared with the control sample, and the char formation increase only in borax and boric acid treated Arborea but less in Iroko and Mahogany. Timbers treated with retardant chemicals have higher fire resistance to burning than untreated timbers [24].

M. Sain et al. they studied flammability of polypropylene, sawdust/rice husk filled polypropylene composites and flame retarding effect of magnesium hydroxide for these composites by horizontal burning rate and oxygen index tests. They also studied effect of flame-retardants such as boric acid or zinc borate in combination with magnesium hydroxide. They found that magnesium hydroxide can effectively reduce the flammability (almost 50%) of natural fibre filled polypropylene composites. Also they observed no synergetic effect when magnesium hydroxide was used in combination with boric acid and zinc borate [25]. Chen et.al found that thermal condensation of glucosediazonium phosphate in wood at 160 and 190°C protects wood against fire and decay in one treatment using an aqueous system. Also for fire protection, treatments at 160 or 190°C led to low flammability as evidenced by fire-tube tests. For nonleached wood, weight losses were 1.9, 2.0, and 2.0% with chemical retentions of 56.7, 44.7, and 64.7%, respectively, for 2-, 4-, and 6-h heating; and for leached wood, weight losses of 5.1, 3.8, and 1.5% with chemical retentions of 24.5, 24.1, and 45.6%, respectively, for 2-, 4-, and 6-h heating compared with 18.8% weight loss for diammonium phosphate-treated wood with chemical retention of 19.4%. For decay protection, they performed heat treatment at 190°C for 30 min after 2-wk water leaching also prevents degradation by brown and white rot fungi[26]. Sabyasachi Gaan et.al studied the effect of six organophosphorus compounds, including Pyrovatex CP (PCP), dianmonium phosphate (DAP), phosphoric acid (PA), tributyl phosphate (TBP), triallyl phosphate (TAP) and triallyl phosphoric triamide (TPT) on the flame retardancy of cotton cellulose was studied. Their experimental outcomes showed that PCP, PA and DAP are more efficient compared with the other three compounds in improving the limiting oxygen index (LOI) of cotton. They probed the effectiveness of these compounds by using scanning electron microscope (SEM) images of char formed after LOI tests, char content, activation energy of decomposition and heat of combustion data. Their results obtained showed that DAP, PCP and PA chars maintain the surface morphology during the burning process, which might be due to the formation of a protective layer or crosslinking effect. They concluded that PA, PCP, and DAP treated fabrics have a higher activation energy of decomposition, higher char content and lower heat of combustion [27]. Hemmati et.al combined the flame retardant with natural fibre composite which decomposed at high temperature resulted in NFC with significant decrease in burning rate (up to 98%) compared to the composite without flame retardant. Their results indicated that darker color pigment improved color stability and caused much lower fading for UV-stabilized NFC in comparison to the nonstabilized unpigmented composite[28]. C. Reti et.al evaluated the efficiency of different intumescent formulations to flameretardpoly(lactic acid) (PLA)[29].

### III. FLAMMABILITY PROOF TESTS

Each test has its own unique setup which helps to determine the above mentioned parameters. The standard tests used in the following project carried out are - limited oxygen index test, UL-94 HB test, UL-94 V test.
Flammability test as per ASTM D3014 Flammability test is carried out by placing a natural fibre specimen vertically on vertical stand inside a closed glass chimney. Bunsen burner with flame of >35mm is to be placed under the specimen with a gap in between the tips of the flame to the bottom surface of the sample. The ignition time is recorded mostly in seconds sec and after the recording procedure, burner is to switched off. There are various parameters like the flame height, time of burning and weight percent retained are to be calculated for each sample [30].

UL - 94 is the standard used for evaluating the flammability values of plastics conventionally, but also the tests have been used to analyse the coconut coir. The horizontal and vertical tests are the two orientations measuring different factors such as time for the flame front to move from one point to another [31].

Various flammability tests are carried out on natural fibres to check the following parameters.

<table>
<thead>
<tr>
<th>Parameters for flame proof evaluation</th>
<th>Measurement of a products ability to resist catching on fire</th>
<th>Literature support</th>
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<tbody>
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<td>Resistance to fire</td>
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<td>Ignition rate and/or flame spread</td>
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<td>Reaction to fire</td>
<td>measurement of a products response when exposed to fire</td>
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<td>Smoke density</td>
<td>measurement of smoke generated in the presence of flame</td>
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<td>Decomposition</td>
<td>measurement of a products degradation when exposed to fire</td>
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<td>After flame</td>
<td>measurement of length of time for flaming to cease</td>
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<td>Afterglow</td>
<td>Measurement of length of time for flaming and glowing to cease.</td>
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Table 1. Parameters for flame proof evaluation.

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IV. RESULTS AND DISCUSSION

Coconut fibres are tested as per ASTM D3014 and UL 94 Horizontal and Vertical conditions. Flame testing results shows the linear pattern in flame burning rate (mm/min) and weight loss rate (gm/mm). Chemically treatment on fibres has shown increased flame burning rate compared to non-chemically treated fibres. The chemicals used are mostly borax, urea and DAP. The mass loss rates were found to decrease as the density of fraction of fibres increased. The increase in flame resistance was observed with the decrease in weight % of fibres.

From the flammability test results, it is evident that chemically coconut fibres alone has good fire retardant property and bare coconut fibres is vulnerable to flame and heat due to presence of voids and air pockets in its structure. The treated fibres are thermally stable and are efficiently fire retardant.

V. CONCLUSION

From the tests above it is evident that the treated fibres have high fire retardant property. They are naturally good sound absorbers when even untreated. Upon treatment they become flame proof as well as fairly good sound absorbers.
These properties combined pose a great promising future in the acoustic industry. Their eco-friendly behaviour also adds to the same. Natural fibre is relates as a key role player in the green tech industry because of its great properties such as outstanding low density and low cost have attracted fair attentions to various industries. It would be commercially viable to conduct further studies about the great potential of natural fibre like coconut as an alternative resource and raising awareness of the importance of natural fibre to consumers and the environment thereby aiming to reduce carbon emissions and lessening the waste materials.

References


Semi-Automatic Multifunctional Farm Machine (JUNE 2020)

OMKAR G. GHULE1, RAJ D. GAIKAWAD2, SHARDUL G. JAGADALE3 AND SNEHAL S. DHOKANE4

1Dept. of Mechanical Engineering, Sinhgad College Of Engineering and Research, Pune, Maharashtra, India, 411041
2Dept. of Mechanical Engineering, Sinhgad College Of Engineering and Research, Pune, Maharashtra, India, 411041
3Dept. of Mechanical Engineering, Sinhgad College Of Engineering and Research, Pune, Maharashtra, India, 411041
4Dept. of Mechanical Engineering, Sinhgad College Of Engineering and Research, Pune, Maharashtra, India, 411041

ABSTRACT

In India, there is lack of research and technologies available in the agricultural field. The productivity and quality of various crops will get increase if the proper plantation method with accuracy and precision is used. As well as the labour cost in India is getting increased day by day. So it is inevitable to introduce new technologies with automation. Considering all this aspects designing and fabricating a machine is done which can be used to plant as many as possible various plants. After surveying problems of farmers and technologies available it is found that, there is no machine to plant tomatoes plants. Reasonable price of the machine 10-15 thousands have been fixed. So that even small farmers also can afford. After analyzing various mechanisms which can be used, a final mechanism which is crank and slotted quick return mechanism is fixed. Considering price of machine sowing mechanism is added as supplementary, so that it can be used for multi-purpose farming. By considering all required mechanism and techniques design manufacturing and fabrication will be done. Then the schedule for testing of the machine in actual conditions is planned. In such a way this machine performs automatic planting, sowing operations. The machine will definitely make a big change in Indian farming.

INDEX TERMS Agritech, Automatic, Farming, High-Yield, Invention, Machine, Multifunctional, Non-Tractor, Planting, Profit, Regularity, Sowing, Spraying.

1. INTRODUCTION

Agriculture is the bread and butter for all kind of people. And generally in our India traditional methods are used for farming. Even though agriculture is the most important enterprise in the world. Over the years, agricultural practices have been carried out by small-holders, by using human labour. Modern agricultural techniques and equipments are not used by small land holders because these equipments are too expensive and difficult to acquire. By implementing such scientific mechanisms and techniques the multifunctional farm machine can work efficiently and effectively.

Technology has played a big role in developing the agricultural industry. Farming with technology can help to increase various factors like economy. By using machines instead of manual work is beneficial for farmers because it save time and human effort. This multifunctional machine also help to do all required farming operations by using same machine. To perform planting operation crank and slotted quick return mechanism is used.

For better performance, another mechanism are also added like sowing mechanism. Also search for new trends available related to our design and construction. Then by referring various books the basic calculations to obtained required power has been done. Motor and power train are decided.

LITERATURE REVIEW

S.D. Shelare, P.S. Thakare, Dr. C.C. Handa dated 5 June 2012 titled as Computer Aided Modelling And Position Analysis of Crank And Slotted Lever Mechanism [1] more particularly, The paper is discussed about crank and slotted mechanism that converts rotary motion into reciprocating motion at different rate for its two strokes i.e. working stroke and return stroke. Time ratio has been calculated for constant length of stroke with specified dimensions. A CAD model has been prepared to simulate the mechanism and to specify the accurate path of the mechanism. Also the analytical method which can be used to define the various position of crank and respective position of slider in quick return mechanism is discussed.

CRANK AND SLOTTED LEVER QUICK RETURN MECHANISM
This mechanism is mostly used in shaping machines, slotting machines and in rotary internal combustion engines. In this mechanism, the link AC (i.e. link 3) forming the turning pair is fixed, as shown in Fig. The link 3 corresponds to the connecting rod of a reciprocating steam engine. The driving crank CB revolves with uniform angular speed about the fixed centre C. A sliding block is attached to the crank pin at B slides along the slotted bar AP and thus causes AP to oscillate about the pivoted point A. A short link PR transmits the motion from AP to the ram which carries the tool and reciprocates along the line of stroke R1R2. The line of stroke of the ram (i.e. R1R2) is perpendicular to AC produced. In the extreme positions, AP1 and AP2 are tangential to the circle and the cutting tool is at the end of the stroke. The forward or cutting stroke occurs when the crank rotates from the position CB1 to CB2 (or through an angle θ in the clockwise direction). The return stroke occurs when the crank rotates from the clockwise direction.

FIG. 2 CRANK AND SLOTTED LEVER QUICK RETURN MOTION MECHANISM

Conclusion of this invention is from the given dimensions of links of the quick return mechanism, time ratio has been calculated which is equal to 1.71 for constant stroke length of 520 mm. This approach will help designer to synthesize the quick return mechanism for desired stroke length.

Prof. Gaffar G. Momin Dept. of Mechanical Engineering, Pimpri Chinchwad College of Engineering, Pune, India dated April 2017 titled as, Design, Analysis and Fabrication of a Roll cage for an All-Terrain Vehicle [2] The study aims to design, develop and fabricate a roll cage for an All-Terrain Vehicle (ATV) in accordance with the rulebook of BAJA 2017 given by Society of Automotive Engineers (SAE). Baja SAE is an intercollegiate design competition run by the Society of Automotive Engineers (SAE).

eams of students from universities all over the world design and build small offroad cars i.e. ATV. A roll cage is a skeleton of an ATV. The roll cage not only forms the structural base but also a 3-D shell surrounding the occupant which protects the occupant in case of impact and roll over incidents. The roll cage also adds to the aesthetics of a vehicle. The design and development comprises of material selection, chassis and frame design, cross section determination, determining strength requirements of roll cage, stress analysis and Simulations to test the ATV against failure. Finally the roll cage is fabricated as per the tools and techniques available in the workshop.

All-Terrain Vehicle is a package of different systems, which are designed to enrich the performance and to provide comfort to the driver. Many different systems include chassis, steering system, suspension system, braking system, drive train, ergonomics and aesthetics. All these mentioned systems are inter-dependent. Failure of a single system or apart may lead to loss of the operator or driver. ATVs are also popular for their good aesthetics and their sporty look. The roll cage is designed for the following objectives:

1. The roll cage must comply with the Baja SAE International rulebook 2017.
2. Ease and accuracy of manufacturing.
3. Provide full safety to the driver, by obtaining required strength and torsional rigidity, while reducing weight through diligent tubing sections.
4. Maintain serviceability by ensuring that roll cage members do not interfere with sub systems.
5. Light in weight.

Conclusion of the paper is that design output is for no plastic deformations. The vehicle should remain in the elastic region. The Safety of the driver in case of crash is taken care of by safety equipment, which includes special helmets, foam padding on bars and seat belts. Further, software analysis shows us that the vehicle can take frontal impacts of up to approx. 11,000 Newton and side impacts of up to approx. 6,000 Newton. This clearly reaffirms the vehicle’s ability to withstand extreme conditions.

Hitesh Rakholiya1, Nirbhaysinh Raulji2, Montu Patel3, Rushabh Rana4, Krunal Shah5 Department of Electrical Engineering Shroff S R Rotary Institute of Chemical Technology, India dated February 2017 titled as Design and Simulation of Speed Control of DC Motor using Chopper [3]. This projects deals with the speed control of separately excited DC motor with a high performance manner. There are four different quadrants operation of DC motor implement. In this project using chopper as a converter, the speed of a DC motor is to be controlled. We simulate the operation of DC motor in open loop as well as closed loop. As speed control is desired in order to get accurate performance of
DC motor, the simulation of model will be done and analysed in MATLAB under varying condition. A closed loop system brings the motor to the speed set by the user irrespective of load.

A chopper is a power electronic device which is also called as dc-dc converter and it is a static device which converting fixed input dc voltage to variable output dc voltage. Earlier days the choppers were used for converting fixed dc variable dc but due to involvement of multistep conversion it was bulky and insufficient. So the dc choppers are only single step static devices and more efficient and also less bulky than the earlier choppers, and are also available in a lower price so it can be used for a speed control.

CONTROL STRATEGIES

A. Time ratio control

In this method of control strategies time ratio or duty ratio is varied. And this is done by two different ways called

a) Constant frequency system
b) Variable frequency system.

We explain in details as follows:
1. Constant frequency system: In this scheme of control, on time Ton is varied but the chopping frequency id kept constant. So this scheme is called PWM scheme.
2. Variable frequency system: In this scheme of control, chopping frequency f is varied according to the input value and Ton is kept constant or T off is also kept constant, in this method it is called FMscheme.

B. Current Limit Control

In this control strategies, the ON and OFF time of the chopper is determined by the value of the output load current. The maximum and the minimum output load current is dependent on the ON and OFF time of the chopper. In this strategy the chopper is turned on when the output current equals to a present value. The chopper is kept on till output current equals to another present value. The chopping frequency and pulse. Conclusion of the project is that the speed of a separately excited DC motor can be controlled using two types of loop configuration such as open loop speed control and closed loop speed control technique. Here the speed of DC motor can is control in the forward motoring first quadrant open loop operation using ideal switch. The simulation results under varying the load armature current and voltage are also studied and analysed.

3. METHODOLOGY

Stage 1:

By considering interested fields of all members and on the basis of what's today's requirement and need, the topic is finalized. In India agriculture is the main field which helps to developed country. So for growing economy and good quality product invention of modern technology in farming is necessary. For that after discussing problems, solutions were found out.

Stage 2:

Following are the problems that can be solved by machines

1. During planting farmer as to give a lot of efforts like bending repeatedly for plant crops, for giving fertilizer they has to use heavy pump
2. There will be less accuracy during planting manually.
3. It is possibility that drip cannot provide water to plants at accurate position properly.
4. In traditional agriculture farmer has to give efforts during sowing.
5. For different operation, farmer has to use different machines.

Following are the solutions of problems that mentioned above

1. The crank and slotted lever mechanism is used as primary mechanism for planting.
2. Due to machine planting has been done in appropriate manner, at uniform distance with ease.
3. A proximity capacitive sensor is used to detect drip.
4. Sowing mechanism also installed along with fertilizer.

5. This machine is prepared for doing various operations at a time i.e. planting, sowing, giving fertilizer etc. that's why it is called as multifunctional farm machine.

Stage 3:

A. Planting mechanism:

The best stroke and QRR for the application is decided by doing iterations. By using trial and error method the geometry of 200mm stroke and 1.855 QRR is done. As in nonworking conditions ground clearance plays an important role so it was most important for deciding geometry. Return stroke is at high speed than forward stroke because it is non-working stroke. As shown in fig.3
C. Rollcage

The roll cage of machine has priorities of protection of all the plants and seeds. The material of tubes of the roll cage is chosen by the weighted point method. It is made as light as possible to maintain the efficiency of motor as well as the strength and torsional rigidity of roll cage is also maintain. During the assembly of whole machine the interference of roll cage members is also considered. As shown in Fig 5.

B. Sowing mechanism

Iterations are done for best flow rate and depth of sowing. Iterations are done for part drawing and assembly. After doing correct calculations, the design finalized and analysed. Sowing mechanism is the supplementary mechanism. But it is as efficient as primary mechanism. The flow rate of grains is adjusted by making slots in solid circular disc. During sowing of grains the uniformity is most important as the growth of plant is mainly dependent on spacing between the two seeds. The sowing mechanism is done by taking iteration of geometry. Sowing mechanism as shown in Fig 4.

The DC motor used for the project. The power requirement is of 250W. The torque and speed are choose according to the requirements needed for machine considering planting mechanism as a priority.

Specifications of geared motor:
- Power = 250W
- Voltage = 24V
- Peak torque = 22.3 N-m@300RPM

E. Packaging

While packaging of whole machine, the ergonomics and aesthetics of the farmer is at most important. As size of the machine is small the lot of mechanisms and components are fitted in small place so that the track and wheel base of machine is small. So that the turning radius gets small. The simple mechanisms are used because if there is some failure the farmer must be able to resolve the problems and hence the expert is not required.
4. PROPOSED OUTCOME
1. Multi functions: planting, sowing, spreading fertilizer can be done in samemachine
2. Easy to operate and maintenancefree.
3. Mechanisms are very simple so that farmers can resolve withoutexpert.
4. Time saving andefficient.
5. Planting in regularfashion.
6. Reduce the human effort with greaterextent.
7. Machine can also operate for long range so that big farmers attract towardsit.
8. Reasonable cost hence small farmers can afford.

5. RESULT

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Values</th>
</tr>
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<tbody>
<tr>
<td>Angle of forward stroke</td>
<td>127.498°</td>
</tr>
<tr>
<td>Length of crank</td>
<td>60.744mm</td>
</tr>
<tr>
<td>Length of fixed link</td>
<td>137.336mm</td>
</tr>
<tr>
<td>Length of slotter</td>
<td>226.09mm</td>
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<td>Quick return ratio</td>
<td>1.823</td>
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</table>

Drive System

<table>
<thead>
<tr>
<th>Drive system</th>
<th>Measurements</th>
</tr>
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<tbody>
<tr>
<td>Working Speed</td>
<td>0.3048 m/sec</td>
</tr>
<tr>
<td>Non-Working Speed</td>
<td>0.7778 m/sec</td>
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<tr>
<td>Total Reduction Ratio</td>
<td>56.79</td>
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</table>

Capacity of Machine

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Measurements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capacity of one longitudinal belt</td>
<td>40 plants</td>
</tr>
<tr>
<td>Capacity of one lateral belt</td>
<td>5 plants</td>
</tr>
<tr>
<td>Total storage capacity of machine</td>
<td>205 plants</td>
</tr>
<tr>
<td>Planting Capacity of Machine</td>
<td>1 acre per hour</td>
</tr>
</tbody>
</table>

6. CONCLUSION
The multifunction farm machine has considerable potential to greatly increase productivity. This machine can perform many operation like planting, sowing and spreading fertilizer. Based on the overall performance of the machine we can definitely say that the project will satisfy the need of small scale farmer as well as big scale farmer. The machine required less man power and less time as compared to traditional methods. This machine can be readily made from local components in workshop. By using this machine we can maintain distance, depth accuracy for different type of plantation and solve the labour problem that is need of today's farming in India.

7. FUTURESCOPE
1. Sensors can be interface with this machine so that it can monitor different properties of soli like PH, Humidity, etc.
2. Wireless technology can be installed to controlmachine.
3. Solar power or any other nonconventional technologies can be installed to charge batteries
4. Attachment to the machine can be given so that it can be attach withtractor.
5. Artificial intelligence can be use so that machine will
get fully automatic.

6. In future using different mechanisms more functions can be done with this machine only.

7. Harvesting mechanisms can be attached easily so that, this machine can be used for harvesting.

8. ACKNOWLEDGMENT

It is my great pleasure to acknowledge sense of gratitude to all, who have made it possible for us to complete this project with success. It gives me great pleasure to express my deep gratitude to our project guide Prof. A. P. Kaldate for his support and help from time to time during project work. It is my pleasure to acknowledge sense of gratitude to Prof. V. N. Kapatkar our Head of Department and Principal Dr. S. D. Lokhande for their great support and encouragement in project work. Finally yet importantly I would like to thank all Staff Members and all our colleagues for their valuable suggestions and support.

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OMKAR G. GHULE pursuing the B.E. degree in mechanical engineering from Sinhgad College of Engineering, Pune, Maharashtra, India and will earn degree in 2020

RAJ D. GAIAWAD pursuing the B.E. degree in Mechanical Engineering from Sinhgad College of Engineering, Pune, Maharashtra, India and will earn degree in 2020

SHARDUL G. JAGADALE pursuing the B.E. degree in Mechanical Engineering from Sinhgad College of Engineering, Pune, Maharashtra, India and will earn degree in 2020

SNEHAL S. DHOKANE pursuing the B.E. degree in Mechanical Engineering from Sinhgad College of Engineering, Pune, Maharashtra, India and will earn degree in 2020
Magnetic Levitation Wind Turbine

Sanket N. Bhadane, Bhushan R. Patel, Manthan S. Nikam, Rohan S. Tapkir

ABSTRACT

This project dwells on the implementation of an alternate configuration of a wind turbine for power generation purposes. Using the effects of magnetic repulsion, spiral shaped wind turbine blades will be fitted on a rod for stability during rotation and suspended on magnets as a replacement for ball bearings which are normally used on conventional wind turbines. Power will then be generated with an axial flux generator, which incorporates the use of permanent magnets and a set of coils. The selection of magnet materials in the design of wind turbine system will be discussed. A model of wind turbine is built to perform several tests such as starting wind speed, rotational speed at constant wind speed, and time taken to stop rotation completely. The results obtained will be compared with the model of conventional wind turbine. Power will then be generated with an axial flux generator, which incorporates the use of permanent magnets and a set of coils.

INTRODUCTION

Renewable energy is generally electricity supplied from sources, such as wind power, solar power, geothermal energy, hydropower and various forms of biomass. These sources have been coined renewable due to their continuous replenishment and availability for use over and over again. The popularity of renewable energy has experienced a significant upsurge in recent times due to the exhaustion of conventional power generation methods and increasing realization of its adverse effects on the environment. This popularity has been bolstered by cutting edge research and groundbreaking technology that has been introduced so far to aid in the effective tapping of these natural resources and it is estimated that renewable sources might contribute about 20% – 50% to energy consumption in the latter part of the 21st century. Facts from the World Wind Energy Association estimates that by 2010, 160GW of wind power capacity is expected to be installed worldwide which implies an anticipated net growth rate of more than 21% per year.

This project focuses on the utilization of wind energy as a renewable source. In the United States alone, wind capacity has grown about 45% to 16.7GW and it continues to grow with the facilitation of new wind projects. The aim of this major qualifying project is to design and implement a magnetically levitated vertical axis wind turbine system that has the ability to operate in both high and low wind speed conditions. Our choice for this model is to showcase its efficiency in varying wind conditions as compared to the traditional horizontal axis wind turbine and contribute to its steady growing popularity for the purpose of mass utilization in the near future as a reliable source of power generation.

Unlike the traditional horizontal axis wind turbine, this design is levitated via maglev (magnetic levitation) vertically on a rotor shaft. This maglev technology, which will be looked at in great detail, serves as an efficient replacement for ball bearings used on the conventional wind turbine and is usually implemented with permanent magnets. This levitation will be used between the rotating shaft of the turbine blades and the base of the whole wind turbine system. The conceptual design also entails the usage of spiral shaped blades and with continuing effective research into the functioning of sails in varying wind speeds and other factors, an efficient shape and size will be determined for a suitable turbine blade for the project. With the appropriate mechanisms in place, we expect to harness enough wind for power generation by way of an axial flux generator built from permanent magnets and copper coils. The arrangement of the magnets will cultivate an effective magnetic field and the copper coils will facilitate voltage capture due to the changing magnetic field. The varying output voltage obtained at this juncture will then be passed through a DC-DC converter to achieve a steady output DC voltage.

OBJECTIVE:

- To create new opportunities in low-speed areas, with starting speed as low as 1.5 m/s. By use of Magnetic levitation to reduces the friction & eliminates need of bearings in wind mill.
- To convert wind energy into electrical energy

Pimpri Chinchwad College Of Engineering and Research, Ravet
remarkably cheap with low operating cost.

- By use of Magnetic levitation due to absence of friction to convert energy with very less noise production compare to existing conventional wind mills.
- In design and fabrication of magnetic lift wind mill with the dimensions 600mm*600mm to balance the rotor under the repulsive force of (Nd Fe B magnet) magnetic field.

**WORKING PRINCIPLE:**

The basic working principle of a wind turbine is when air moves quickly, in the form of wind, the kinetic energy is captured by the turbine blades. The blades start to rotate and spin a shaft that leads from the hub of the rotor to a generator and produce electricity. The high speed shaft drives the generator to produce electricity. The low speed shaft of wind turbine is connected to shaft of high speed drives through gears to increase their rotational speed during operation. Using the effects of magnetic repulsion, spiral shaped wind turbine blades will be fitted on a rod for stability during rotation and suspended on magnets as a replacement for ball bearings which are normally used on conventional wind turbines. The energy that can be extracted from the wind is directly proportional to the cube of the wind speed. We can then calculate the power converted from the wind into rotational energy in the turbine using equation.

**IMPLEMENTATION:**

In this project Magnetic levitation weight reduction structure for a vertical wind turbine generator included. The fixed permanent magnet fixed to the frame has a first repulsive surface. The axle is connected to the frame. The revolving permanent magnet fixed to the axle has a second repulsive surface in relation to the first repulsive surface of the fixed permanent magnet. Both the first and the second repulsive surfaces repel with each other. The blade hub and the generator are connected to the axle. When the revolving permanent magnet is rotated, the axle functions as a balance centre. An out structure supports the stator and the rotor is placed over turbine head. The main components of the system are the maglev zone, blade hub and Auxiliary Current (AC) generator. It will convert the kinetic energy from the wind to the electricity for usage. A modified roof ventilator is used as wind turbine. The main function of the free spinning roof ventilator is to provide fresh air in roof space and living area all year round 24 hours a day free of charge. The new idea of the magnetic levitation helps to improve the turbine speed and electrical production. This modification has benefits of the better air ventilation, but also has extra electricity supply for load appliances.

**SCHEMATIC DIAGRAM**

Above figure gives an idea of maglev wind turbine. This phenomenon operates on the repulsion characteristics of permanent magnet. This technology has been predominantly utilized in the rail industry in the far east to provide very fast and reliable transportation on maglev trains and with ongoing research its popularity is increasingly attaining new heights . using a pair of permanent magnets like neodymium magnets and substantial support magnetic levitation can easily be experienced. By placing these two magnets on top of each other, the magnetic repulsion will be strong enough to keep magnet at a distance away from each other. The force created as a result of this repulsion can be used for suspension purposes and is strong enough to balance the weight of an object depending on threshold of magnets.

**COMPONENT DESCRIPTION**

1. **NEODYMIUM MAGNETS**
The Neodymium metal element is initially separated from refined Rare Earth oxides in an electrolytic furnace. The "Rare Earth" elements are lanthanides (also called lanthanides) and the term arises from the uncommon oxide minerals used to isolate the elements. Although the term "Rare Earth" is used, it does not mean that the chemical elements are scarce. The Rare Earth elements are abundant e.g. Neodymium element is more common than gold. The Neodymium, Iron and Boron are measured out and put in a vacuum induction furnace to form an alloy. Other elements are also added, as required for specific grades e.g. Cobalt, Copper, Gadolinium and Dysprosium (e.g. to assist with corrosion resistance). The mixture is melted due to the high frequency heating and melting the mixture.

**RESULT ANALYSIS AND DISCUSSION**

**Experimental Analysis**

To analyze the magnetic lift wind mill an experimental analysis was conducted.

<table>
<thead>
<tr>
<th>Sr.no</th>
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<th>Voltage (V)</th>
<th>Current (A)</th>
<th>Power (W)</th>
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<td>2</td>
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<td>3</td>
<td>4.2</td>
<td>0.472</td>
<td>0.04</td>
<td>0.168</td>
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</tbody>
</table>

**CONCLUSION**

Over all, the magnetically levitated vertical axis wind turbine was a success. The rotors that were designed harnessed enough air to rotate the stator at low and high wind speeds while keeping the centre of mass...
closer to the base yielding stability. The wind turbine rotors and stator levitated properly using permanent magnets which allowed for a smooth rotation with negligible friction. The Vertical Axis Wind Turbine (VAWT) with magnetic levitation performed better than the conventional wind turbine. Tests results VAWT model has lower starting wind speed compare to conventional one. The rotational speed of maglev VAWT is higher. The time taken for the maglev wind turbine to stop rotating is longer than that of conventional. Therefore, the Maglev wind turbine is more suitable for power generation application. The home for the magnetically levitated vertical axis wind turbine would be in residential areas. Here it can be mounted to a roof and be very efficient and able to extract free clean energy thus experiencing a reduction in their utility cost and also contribute to the “Green Energy” awareness that is increasingly gaining popularity.

FUTURE SCOPE OF THE PROJECT

The home for the magnetically levitated vertical axis wind turbine would be in residential areas. Here it can be mounted to a roof and be very efficient and practical. A home owner would be able to extract free clean energy thus experiencing a reduction in their utility cost and also contribute to the “Green Energy” awareness that is increasingly gaining popularity. The maglev windmill can be designed for using in a moderate scale power generation ranging from 400 Watts to 1 KW. Also it is suitable for integrating with the hybrid power generation units consisting of solar and other natural resources.

- The technology is expected to create new opportunities in low-speed areas, with starting speed as low as 1.5m/s & cut in speed of 3m/s.
- It is configured to capture wind from any direction and convert wind to energy at very high efficiency.
- Magnetic levitation reduces the friction & eliminates need of bearings.
- Today wind turbines are considered to be the most developed form of renewable energy technology.
- Able to deliver clean green-power for less than one cent per kilowatt hour.
- This new technology is remarkably cheap with low operating cost. Less noise compared to existing conventional wind turbines.

REFERENCES


Optimization of Sheet Metal Bracket using 3D Printing Technology

Nikhil B. Dharmadhikari¹, Mandar O. Shete², Manthan S. Degaonkar³, Ganesh Dawkar⁴

¹Dept. of Mech Engineering, Sinhgad College of Engineering, Vadgaon BK, Pune, Maharashtra, India, 411041
²Dept. of Mech Engineering, Sinhgad College of Engineering, Vadgaon BK, Pune, Maharashtra, India, 411041
³Dept. of Mech Engineering, Sinhgad College of Engineering, Vadgaon BK, Pune, Maharashtra, India, 411041
⁴Dept. of Mech Engineering, Sinhgad College of Engineering, Vadgaon BK, Pune, Maharashtra, India, 411041

ABSTRACT

The proliferation of 3D printing technology has created a substantial demand for engineering services that create and deliver its benefits. At the forefront of these services is design optimization for 3D printing. The 3D printing industry has long recognized that engineering design for 3D printing is a critical competency to unleash the benefits of the technology. In automobile industry lot of automobile part (bracket, supports, clips etc.) will be optimize using 3D printing technology. In this project we are considering Sheet Metal Bracket for optimization purpose. In optimization exiting automobile Sheet Metal Bracket material will be replace by thermoplastics materials. The main focus of this project is to convert the sheet metal brackets to plastic brackets which will ultimately reduce weight and production cost associated with automobile. Automobile sheet metal brackets which we selected for optimization will be design using CATIA V5. Nonlinear analysis of automobile part will be done using ANSYS 19 software. Comparative results between sheet metal and polypropylene will be studied.

Keywords: Optimization, 3D printing, Static Analysis, Modal Analysis, Topology, Battery Bracket.

INTRODUCTION

Recently in automobile industry reduction of weight is one of many concerns. Such reduction of weight is achieved with the help of replacing different metal components with thermoplastic materials. The fuel efficiency of the vehicle can be increase by reducing the overall weight of vehicle by replacing metal components with thermoplastic component.

Additive manufacturing has emerged as an effective method of manufacturing. Different components can be easily manufactured only with the help of a CAD model and a manufacturing machine setup. Fused Deposition Modelling (FDM). FDM has become the most popular and widely used AM technique with half of the machines on the market being of this kind. The layer wise printing process allows for the manufacture of functional and intricate parts at a relatively low cost.

In this paper, battery supporting bracket is selected for the replacement. Sheet metal battery supporting bracket is replaced with polypropylene thermoplastic material which is proved to be effective than other thermoplastic material. Static analysis and modal analysis is done on sheet metal and polypropylene battery supporting bracket and comparison is done. The compatibility of replaced polypropylene battery supporting bracket is checked. Topology optimization is also done to check the required thickness of the battery supporting battery bracket.

LITERATURE REVIEW

Merulla et.al [1] We observed that the increasing importance of additive manufacturing is explained. It is also explained that the for the justified use of any additive manufactured material topology optimization is important. With the help of additive manufacturing technology it is possible to obtain parts with complex geometries and features, impossible to be produced by other processes. Additive manufacturing employs the layer-by-layer material deposition process. In building the new parameterized CAD model, the designer usually includes manufacturing considerations and constraints, which hamper the full exploitation of the optimization and can potentially lead to compromise solutions. In the case of AM, the great design freedom allows to remove extra-mass and to achieve the best benefits from the optimization process. This freedom is very advantageous from manufacturing point of view, as it will reduce the design time and it will thereby reduce the manufacturing cost.

Melissa et.al [2] The topology optimization exercise removes material from all locations where it is not necessary to support the specific loads or satisfy specific boundary conditions, resulting components often contain structures that are not constant in cross section and
resemble tree branches or bones, and hence, are termed ‘bionic’ or ‘organic’. Topology optimization is a “mathematical approach that, within a given design space, and a set of loads and boundary conditions, provides a solution that respects certain constraints and either minimizes or maximizes the objective variable. The fabrication of hollow structures, structures with internal cooling channels, organic, bionic shaped structures, and structures filled with lattice elements can now be made via Additive Manufacturing. Additive manufacturing employs the layer-by-layer material deposition process. Due to this layered approach, the engineering parts can be designed with great complexity. An important aspect of the topologically optimized design for Additive Manufacturing is to create self-supporting components, or when not possible, components with the minimal number of support structures. This will increase the stability and significantly reduce the overall weight.

F.Brites et.al [3] Among natural fillers, cork has been acknowledged as a suitable alternative of other cellular materials that are widely employed in engineering applications due to their low conductivity to heat, noise and vibration, high abrasion resistance and flexibility, high compressibility ratio, among other characteristics. The eco-friendly features of natural fillers-based composites make them a very promising and sustainable solution to large markets mainly if additive manufacturing technologies, such as 3D printing, are used. Through 3D printers, engineers, designers and architects can create design and decor products with a free complexity of geometry. In this research work, plastic matrices of HDPE – obtained from conventional suppliers – were reinforced with different ratios of cork waste and natural cork powders – obtained from cork transformation industries – to find the optimum mixture for 3D printing. The effects of cork powders content in the plastic on the morphological, physical and mechanical properties of the composites were investigated through the density, optical microscopy, wettability, thermal analysis and tensile testing. Cork-based composites were processed by an extrusion system, and the mixture of polymer, adhesive and fillers is discussed. The results show that the addition of pure cork and cork waste can be processed with polymers such as HDPE, having adequate physical and mechanical properties.

Karjol et.al [4] In this paper the replacement of the existing sheet metal electronic unit bracket is replaced with the help of polypropylene material. Modal analysis is done to achieve the required natural frequency targets so as to avoid resonance and the part is also checked for the load cases to check its structural integrity. Topology optimization is done to find out the required thickness of the replaced bracket so as to match the required frequency ranges. Maximum thickness is selected so as to give the required stiffness. Ribs addition is also done according to experience based on previous designs. The main motive is to reduce the weight of the vehicle so as to increase the fuel economy.

Yongsheng Ma et.al [5] In this paper has we observed that the interpolation of nodal or point wise densities with material properties is an effective approach compared to direct density optimization. It has contributed to achieving the manufacturing-oriented topology design. Manufacturing rule violations are very common in topology optimization based conceptual design solutions, which negatively impact the manufacturability and even make them non-manufacturable. With the help of additive manufacturing those metal components which previously were non manufacturable can be easily manufactured.

Aubrey L. Woern et.al [6] In order to assist researchers explore the full potential of distributed recycling of post-consumer polymer waste, this article describes a recyclebot, which is a waste plastic extruder capable of making commercial quality 3-D printing filament. The device design takes advantage of both the open source hardware methodology and the paradigm developed by the open source self-replicating rapid prototype (RepRap) 3-D printer community. Specifically, this paper describes the design, fabrication and operation of a RepRapableRecyclebot, which refers to the Recyclebot’s ability to provide the filament needed to largely replicate the parts for the Recyclebot on any type of RepRap 3-D printer. The device costs less than $700 in mate rials and can be fabricated in about 24 h. Filament is produced at 0.4 kg/h using 0.24 kWh/kg with a diameter ±4.6%. Thus, filament can be manufactured from commercial pellets for printing.

Tianyun Yao et.al [7] 3D Printing is widely used in scientific researches and engineering applications, ranging from aerospace to biomedicine. However, little is known about the mechanical properties of 3D printing materials. In order to promote the mechanical analysis and design of 3D printing structures, the ultimate tensile strength of FDM PLA materials with different printing angles were studied theoretically and experimentally. A theoretical model was firstly established to predict the ultimate tensile strength of FDM PLA materials based on transverse isotropic hypothesis, classical lamination theory and Hill-Tsai anisotropic yield criterion, and then verified by tensile experiments. Compared with previous models, this model provided two kinds of in-plane shear modulus calculation methods, so the calculation results were more reliable. The specimens, designed according to the current plastic-multipurpose test specimens standard ISO 527-2-2012.
were printed in seven different angles (0°, 15°, 30°, 45°, 60°, 75°, 90°) with three layer thicknesses (0.1 mm, 0.2 mm, 0.3 mm) for each angle. The relative residual sum of squares between theoretical data and experimental data were all close to zero, so the results that the theoretical model can accurately predict the ultimate tensile strength of FDM materials for all angles and thicknesses were confirmed. It was also found that the ultimate tensile strength decreased as the printing angle becomes smaller or the layer becomes thicker. This theoretical model and experimental method can also be applied to other 3D printing materials fabricated by FDM or SLA techniques.

**Bhansali S. et.al [10]** this breakthrough development involves material conversion from aluminium die cast to polypropylene long fibre thermoplastic (40% long glass filled) for two-wheeler bracket of a leading automotive OEM. The plastic bracket was developed working with molder, glass supplier, technology collaborator and OEM. The new part needed to be designed lighter in weight, easier to process and suitable for painting, outdoor exposure and stringent dynamic conditions. The scope of this study includes evaluation of the new material from different point of view and comparison of the same with existing material. The submission goes through the intricate analysis carried out in the development process and highlight the key advantages over aluminium. Studies includes static and dynamic analysis, fibre orientation studies, gate location studies etc.

The methodology we used is as follows:

**3D Model**

The design of sheet metal battery supporting bracket is taken and its CAD model is generated in CATIA V5 R20.

Similar CAD model is generated for polypropylene battery supporting bracket. Thickness of sheet metal bracket is 2 mm. An increased thickness of 3 mm is considered taking into account the stiffness of replaced material based on previous experiences.

**Specifications**

- Bracket base dimensions: 240 mm × 175 mm
- Height of bracket: 5 mm
- Thickness of sheet: 2 mm
- Battery dimension: 220 mm × 158 mm × 173 mm
- Weight of battery: 10 kg
- Weight of bracket: 0.714 kg
- Material: Steel (sheet metal)
Static Analysis

In this FEA of battery mounting sheet metal bracket we are taking 100 N remote forces (C.G of Battery + Battery weight). The weight of the battery is taken 10 kg.

Static analysis is done on both sheet metal and polypropylene battery supporting bracket and stresses are shown in Fig. 3 and Fig. 4. Analysis is done by using ANSYS 18.1.
Maximum deformation obtained in sheet metal battery supporting bracket is 0.034714 mm and maximum deformation obtained in polypropylene battery supporting bracket is 1.7407 mm.

25. Modal Analysis

Static analysis tells us whether the material will fail or not in static scenarios. Modal analysis is necessary to know the natural frequencies and vibration characteristics of the sheet metal as well as polypropylene material. Modal analysis is done to achieve the required natural frequency targets so as to avoid resonance.
As shown in the Fig. 13 the maximum amplitude if acceleration for sheet metal battery supporting bracket is 57.742 m/s² and from Fig. 14 the maximum acceleration for polypropylene battery supporting bracket is 33.385 m/s².

26. TOPOLOGY Optimization

Topology optimization is a “mathematical approach that, within a given design space, and a set of loads and boundary conditions, provides a solution that respects certain constraints and either minimizes or maximizes the objective variable.

The topology optimization exercise removes material from all locations where it is not necessary to support the specific loads or satisfy specific boundary conditions, resulting components often contain structures that are not constant in cross section.

Topology optimization is done to determine the thickness of material at different locations under the given load conditions. It gives the optimum design of particular component under given loadcases so as to save material and cost.

The conventional method used by industry while converging the sheet metal bracket to plastic bracket is based on experience of design engineer. Recently in industry topology optimization is used. Topology optimization is a mathematical method that optimizes material layout within a design space, for a given set of loads, boundary conditions and constraints with the goal maximizing the performance of the system.

Topology Optimization is different from space optimization in the sense that the design can attain any shape within the design space, instead of dealing with predefined configurations. Nowadays in some cases results from topology optimization can be directly manufactured using additive manufacturing; Topology Optimization is thus a key part of design for additive manufacturing.
Fig. 9 shows the required thickness at particular locations. If density values vary between 0.0 to 0.4 the material at that particular location can be neglected. Topology optimization is done in ANSYS 18.1.

After applying boundary condition and loading condition it gives the required density at different locations of the component. As given above if the density at particular location varies from 0-0.4 the it is shown with help of red colour i.e. material at that particular location is not adding to the strength and it can be removed. If density varies from 0.4-0.6, it is marginal density and thickness at that particular location can be reduced without altering its strength. Topology optimization gives the unused material location and amount which is helpful to further reduce the weight of component.

27. Results

a. Mass

<table>
<thead>
<tr>
<th>Mode</th>
<th>Frequency for sheet metal battery bracket (Hz)</th>
<th>Frequency for polypropylene battery bracket (Hz)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>426.04</td>
<td>189.3</td>
</tr>
<tr>
<td>2</td>
<td>703.95</td>
<td>313.23</td>
</tr>
<tr>
<td>3</td>
<td>997.25</td>
<td>444.73</td>
</tr>
<tr>
<td>4</td>
<td>1167.6</td>
<td>519.13</td>
</tr>
<tr>
<td>5</td>
<td>1273.6</td>
<td>563.49</td>
</tr>
<tr>
<td>6</td>
<td>1721.9</td>
<td>760.21</td>
</tr>
</tbody>
</table>
28. CONCLUSION

The optimization of selected component i.e. battery bracket is done by replacing existing sheet metal battery bracket by 3D printed polypropylene battery bracket. The weight of the existing sheet metal battery bracket is reduced which will in turn increase the fuel economy of the vehicle. The static loading characteristics of 3D printed battery bracket is better than existing sheet metal battery bracket which will subsequently increase the life of battery bracket. Topology optimization is also done to find out the excessive material so as to further reduce the weight of the optimized battery bracket. It can be concluded that the 3D printed battery bracket have less weight, better load bearing capacity and longer life than the existing sheet metal battery bracket. The selected component is one of the components which is replaced by thermoplastic material with the help of 3D printing. Similarly different components of automobile like engine bracket, seats, BIW can also be replaced with 3D printed components without altering the characteristics.

ACKNOWLEDGMENT

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N.B. Dharmadhikari was born in Pune on 14 December 1997. He is pursuing his bachelor’s degree in mechanical engineering from Sinhgad College of Engineering, Pune affiliated by Savitribai Phule Pune University, Pune.

Mandar O. Shete was born in Umbraj Village, Maharashtra, India in 1998. He is pursuing his bachelor’s degree in mechanical engineering from Sinhgad College of Engineering, Pune affiliated by Savitribai Phule Pune University, Pune.

M.S. Degaonkar was born in Kolhapur, Maharashtra, India in 1998. He is pursuing his bachelor’s degree in mechanical Engineering from Sinhgad College of Engineering, Pune affiliated by Savitribai Phule Pune University, Pune.

G.M. Dawkar was born in Beed, Maharashtra, India on 1999. He is pursuing his bachelor’s degree in mechanical engineering from Sinhgad College of Engineering.
Analysis of COVID-19 in five zones of India


1Dept. of Mechanical Engineering, GES’s R. H. Sapat College of Engineering, Management and Research Studies, Nashik, Maharashtra, India, 422005
2 Dept. of Mechanical Engineering, GES’s R. H. Sapat College of Engineering, Management and Research Studies, Nashik, Maharashtra, India, 422005
3 Dept. of Mechanical Engineering, GES’s R. H. Sapat College of Engineering, Management and Research Studies, Nashik, Maharashtra, India, 422005
4 Dept. of Mechanical Engineering, GES’s R. H. Sapat College of Engineering, Management and Research Studies, Nashik, Maharashtra, India, 422005
5 Dept. of Mechanical Engineering, GES’s R. H. Sapat College of Engineering, Management and Research Studies, Nashik, Maharashtra, India, 422005

ABSTRACT

At present the world is facing major crisis due to the pandemic spread all around the globe. COVID-19/Corona virus first found in the city of Wuhan, China took very less time to expand its outreach and the world observed an exponential growth in the number of cases and deaths. Almost many of the countries were not prepared to face such a huge pandemic, worsening the situation. The world observed some of the jaw dropping positive environmental changes amid the lockdown but it cost human lives. Some of the scientists were busy in finding its cause while others were trying hard to find a permanent solution. Temporary but effective medical aids such as hydroxychloroquine helped curing many patients also social distancing, use of PPE kits, sanitizers have played vital role in preventing the spread of the virus. Economies are jolted and increasing lockdown will even worsen the situation. According to the report post COVID-19 the Indian economy will take us 30 years back. WHO has asked people to accept the fact that the virus has no end in the near future and they will have to start their activities in the presence of the virus. As rightly said lockdown is acting just as a pause button. Particularly in India, population, lack of discipline, unawareness among the people is the real hurdles in front of the government. Hitherto many patients have been cured, the virus was still found in some of them after recovery which is making it inevitable. The world is in need of protective/preventive measures/devices till we get the permanent solution.

INDEX TERMS

Analysis of COVID-19, Central zone, COVID-19, Corona virus, East zone, Five zones, North zone, North-East zone, Pandemic, Potential Solutions, South zone, Study of situation in India.

INTRODUCTION

A survey was carried out across the states of India to analyze the situation amid COVID crisis. The nation was divided into 5 zones namely central, eastern, western, northern, north-eastern and southern for the study purpose. The data covers all the parameters such as: State population, Cases found, Cases cured, Number of deaths, Preventive measures adopted, Main reason of spread, Date of first patient found, Literacy rate, Lockdown imposed after how many days, Number of days took to add 1000 cases.

NORTH ZONE

1. Jammu and Kashmir
   A. State Population – 1.50 Crores
   B. Cases Found
      Confirmed – 1300+
      Cured – 647
      No of deaths – 17

2. Ladakh
   A. State Population – 3 lakhs
   B. Cases Found
      Confirmed - 43
      Cured – 43
      No of deaths – 0

3. Himachal Pradesh
   A. State Population – 75.03 lakhs
   B. Cases Found
      Confirmed - 92
      Cured – 47
      No of deaths – 4

4. Punjab
   A. State Population – 3.05 crore
   B. Cases Found
      Confirmed – 2000+
      Cured – 1642
      No of deaths – 38

5. Chandigarh
   A. State Population – 11.5 lakhs
   B. Cases Found
      Confirmed - 199
      Cured – 57
      No of deaths – 3

6. Haryana
   A. State Population – 2.89 crores
B. Cases Found
   Confirmed – 964+
   Cured – 627
   No of deaths – 14

7. Uttarakhand
   A. State Population – 1.17 crore
   B. Cases Found
      Confirmed – 111+
      Cured – 52
      No of deaths – 1

From the data collected it can be inferred that, Delhi has been most affected by this crisis of Covid-19 followed by Punjab in the North zone of India as per the number of cases and deaths overall.

The main reasons of this are due to people not following the preventive measures which were asked by the Delhi government to follow. Social distancing was not maintained between people in Delhi which made this virus spread much faster and the due to one person the entire locality was affected.

Secondly, some doctors were also affected by this virus which led to many patients to come in contact with them and this spread grew throughout the state rapidly. The protests happening in Delhi lead to crowds which could not be controlled by the police and hence the number of infected people had increased in huge numbers.

On the other hand, the other states in the north zone have avoided such mistakes which has lead to less cases in their respective states and saved many people that could have been deceased. Preventive measures were well and effectively taken care of by the government as well as the people.

So from the above information, it has become very essential for the people to take preventive measures in order to survive this pandemic. Social distancing is the main key to it and other precautions such as washing your hands properly with liquid hand wash, using sanitizers and disinfectants in other places to prevent the spreading of germs from other surfaces and avoiding contact of hands with your eyes, nose and mouth.

- EAST ZONE

1. Uttar Pradesh:
   A. State population: 20.42 crores
   B. Cases found: 3800+
      Cases cured: 190+
      Number of deaths: 85+

2. JHARKHAND:
   A. State population: 3.19 crores
   B. Cases found: 190+
      Cases cured: 79+
      Number of deaths: 3

3. CHHATTISGARH:
   A. State population: 2.55 crores
   B. Cases found: 59
      Cases cured: 2
      Number of deaths: None

4. SIKKIM
   A. State population: 6.19 lakhs
   B. Cases found: 0
      Cases cured: 0
      Number of deaths: 0

5. ODISHA
   A. State population: 4.6 crores
   B. Cases found: 550+
      Cases cured: 62+
      Number of deaths: 3

6. BIHAR:
   A. State population: 9.9 crores
   B. Cases found: 1000+
      Cases cured: 365+
      Number of deaths: 7

7. WEST BENGAL
   A. State population: 9.03 crores
   B. Cases found: 2300+
      Cases cured: 702
      Number of deaths: 210+
From the data collected and analysed, it can be concluded that, state of Uttar Pradesh has the highest number of COVID-19 cases.

Following are some major reasons for corona spread:

1) Due to gathering of Tabligi Jamat people in Markaz, Delhi, for religious rituals, spread of corona virus increased by 30% in Uttar Pradesh and 25% in whole country, after these people returned to their native places.

2) The migrants from another states started returning to their native places after spread increased, majorly from states like Maharashtra, Gujarat, Delhi, which caused increase in corona spread.

3) Less seriousness in people about lockdown conditions, virus infection and hygiene.

4) People returning from foreign countries (mostly European countries, which has highest spread) to their native places.

5) Poor cooperation of people with government, police and medical staff during screening and sanitization of people.

So from the above data, it can be concluded that, to avoid further transmission of COVID-19, measures should be implemented like social distancing, sanitization of the public places, cooperation with medical staff and governmental officials, implementation of rules given by state government, sanitization and cleaning of objects which can be potential carriers should be done. Also number of testing should be increased and for that, the production of PPE kits should be done in mass. People should try to increase their immunity by simple methods like yoga, homeopathy medicines and by nutritious meals.

### NORTH-EAST ZONE

1. Mizoram
   - A. State population: 11.2 lakhs
   - B. Confirmed -1
   - Recovered-0
   - Deaths-0

2. Nagaland
   - A. State population: 22.8 lakhs
   - B. Confirmed -1
   - Recovered-0
   - Deaths-0

3. Assam
   - A. State population: 3.09 crores
   - B. Confirmed -142
   - Recovered-0
   - Deaths-4

4. Manipur
   - A. State population: 27.2 lakhs
   - B. Confirmed -9
   - Recovered-0
   - Deaths-0

5. Meghalaya
   - A. State population: 26.5 lakhs
   - B. Confirmed -13
   - Recovered-0
   - Deaths-1

6. Tripura
   - A. State population: 36.6 lakhs
   - B. Confirmed -173
   - Recovered-0
   - Deaths-0

7. Arunachal Pradesh
   - A. State population: 12.6 lakhs
   - B. Confirmed -1
   - Recovered-0
   - Deaths-0

Following are some of the reasons due to which some of the North-eastern states registered less number of cases:

1) Most of North Eastern states consist of scheduled Tribes, there is an autonomous governance that aids in maintaining discipline in the regions.

2) There is lack of number of medical colleges and testing centres in the region that may lead to less number of testing eventually adding less number of cases.

3) Door step delivery of grocery, vegetables, medicines and other essentials by groups like Mukti Sangha are helping to maintain social distancing.

4) Usually each village consists of a single tribe that has some basic community laws to be followed. As a result outsiders have to take the permission of the headman of the village.

5) Being tribal region most of them are physically fit and have stronger immunity system.

### CENTRAL ZONE

1. Maharashtra:
   - A. Population: 121,924,973
   - B. Total : 37136
   - Recovered : 9639
Deaths : 1325

2. Gujrat:
   A. Population : 64801901
   B. Total : 12140
   Recovered : 5043
   Deaths : 719

3. Rajasthan:
   A. Population : 77145824
   B. Total : 5845
   Recovered : 3337
   Deaths : 143

4. Madhya Pradesh:
   A. Population : 85047748
   B. Total : 5465
   Recovered : 2630
   Deaths : 258

5. Goa:
   A. Population : 1564349
   B. Total : 46
   Recovered : 7
   Deaths : 0

6. Dadra and Nagar haveli and Daman and Diu :
   A. Population : 774045
   B. Total : 1
   Recovered : 0
   Deaths : 0

7. Lakshadweep:
   A. Population : 64429
   B. Total : 0
   Recovered : 0

Deaths : 0

From the data collected and analysed, it can be inferred that the state of Maharashtra has the highest number of COVID-19 cases. The prime reason being the high number of travelers in Mumbai, along with other major cities of the state. The delay in screening of incoming travelers on the Mumbai airport and not terminating international flights on time resulted in high number of infected tourists spreading the virus throughout the zone and the country.

Another reason for the high numbers in the zone is the poor co-operation of the citizens to the lockdown declared by government. Improper implementation, administration's soft approach and less seriousness about the disease eased the transmission of the Chinese virus. Migration of workers to their home states like Madhya Pradesh and Rajasthan increased the count in such states.

From the above data, it can be concluded that, to avoid further transmission of this disease, preventive measures such as following rules of social distancing, sanitizing oneself along with items and objects that can be potential carriers, are required to be taken by the citizens along with authority's help. Also, to avoid another pandemic, the health and medical systems along with national infrastructure has to be developed and upgraded so as to avoid panic in such times. People should also try to boost their immunity to reduce risk of becoming seriously ill from such unknown viruses.

- SOUTH ZONE:
  1. Kerala:
     A. Total population – 3.48 crores.
     B. Confirmed cases-642+
     Recovered- 497(77.41%)
     Deaths- 3
  2. Karnataka:
     A. Total population – 6.41 crores.
     B. Confirmed cases- 1056+
     Recovered- 480+(45.45%)
     Deaths- 36+
3. Tamil Nadu:
   A. Total population – 6.79 crores.
   B. Confirmed cases- 10585+
   Recovered-3538+ (33.42%)
   Deaths- 74+

4. Telangana:
   A. Total population – 3.52 crores.
   B. Confirmed cases- 1597+
   Recovered- 992+_
   Deaths- 35+

5. Andhra Pradesh:
   A. Total population – 4.97 crores.
   B. Confirmed cases- 2339+
   Recovered- 1621+
   Deaths-52

6. Puducherry:
   A. Total population – 2.42 lakhs.
   B. Confirmed cases- 18
   Recovered- 9
   Deaths-1

7. Andaman Nicobar Islands:
   A. Total population – 3.81 lakhs.
   B. Confirmed cases- 33
   Recovered-0
   Deaths-0

From the above data, regarding the south of India, it can be concluded that,

1. Even though first case in India was found in South India, the virus was controlled in a very effective manner especially Kerala.

2. The main reasons for spread of coronavirus was Indian students returning from Wuhan and migrants from other states and countries like Dubai.

3. Increase in the number of cases was basically due to the crowding of public places mainly in Tamil Nadu.

4. The spread of virus was controlled due to strict actions taken by the government, imposing strict laws, creating awareness, carrying out campaigns and provision of applications which keep a track of all the patients and other necessary information regarding the virus.

It can be stated that, South India has been quite successful in controlling the virus from spreading specially Kerala except for Tamil Nadu. But the necessary actions are been taken to stop the Corona virus from spreading.

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Introduction to Recent Development in Heat Pipe & their Applications

MR. JADHAV OMKAR BALASAHEB
Department of Mechanical Engineering, Dhole Patil College of Engineering, Pune

ABSTRACT
Heat pipe is the apparatus which is very much in talk as a heat transfer device in the recent scenario of heat transmission efficiently. Heat pipe applies the principle of evaporation and condensation of fluid to transfer heat. Heat pipe has a wide range of applications in aerospace, electronics packaging, building thermal management, material processing, nuclear, thermo-electro-mechanical device, heat pipe, heat exchanger and thermo siphon designers and manufacturers; mechanical, electrical and civil engineering students. This study enables to highlight the main advances on heat pipe science of the last few years. In general, it provides overview on the construction, operation, advantages, and classifications of heat pipes ispresented.

Keywords— Evaporation & Condensation, Thermosyphon, Pulsating, Capillary Action

INTRODUCTION
The world’s needs for effective heat transfer devices/mechanisms are increasing so on minimize heat losses, minimize systems cost, enhance heat removal and transportation also on increase lifespan of some devices. In some instances, heat is required to be removed from a system like solar photovoltaic, electrical devices, turbine blades, etc.; in order to keep it at a certain operation temperature, while in other cases, it is required to be transferred to a certain region to keep it at high temperature. Some elements/metals such as copper and aluminium are found to be good conductors of heat as they transfer heat effectively from one region to another. Their ability to transfer heat effectively is due to their molecular arrangements and type of bonds between their molecules. Various systems like aircraft, electronics, heat exchangers, solar collectors, etc. require effective means of heat transfer. One of the devices recognized as effective means of warmth transfer is heat pipe, whose idea was introduced by Graugler in 1942, but its first unit was invented by Grover in 1962; then, its important properties were studied and identified, and its development started. Hence, with the growing need for efficient heat transfer devices, interest in the use of heat pipes for various applications is increasing due to the roles they play in improving the thermal performance of solar collectors and heat exchangers particularly in energy savings and increasing efficiency of the systems. A heat pipe may be a device that efficiently transports thermal energy from its one point to the opposite. It utilizes the heat of transformation of the vaporized working fluid rather than the sensible heat. As a result, the effective thermal conductivity could also be several orders of magnitudes above that of the great solid conductors. A heat pipe consists of a sealed container, a wick structure, a little amount of working fluid that's just sufficient to saturate the wick and it's in equilibrium with its own vapor. The operating pressure inside the warmth pipe is that the vapour pressure of its working fluid. The length of the warmth pipe are often divided into three parts viz. evaporator section, adiabatic section and condenser section. In a standard heat pipe, the within of the container is lined with a wicking material. Space for the vapor travel is provided inside the container. Heat pipe is an efficient two-phase heat transfer device which uses latent heat of fluids to transfer energy from one place to another by means of simultaneous evaporation and condensation in a sealed container. It consists of evaporator and condenser sections with or without adiabatic section in between them. Depending on the sort, heat pipe may have wick materials on its internal surface where the simultaneous evaporation and condensation happen within the wick structure. In such sorts of heat pipe, evaporator section is often placed at the highest, since the wick structure can return the condensate from the condenser section against gravity. Hence, during a wick heat pipe, the condensed liquid is returned to the evaporator by capillary effects with the help of the wick materials. However, many applications don't require inserting wick material on the inner surface of the pipe, because the condenser section are often placed at the highest, in order that the condensed liquid returns to the evaporator by gravity. This type of wickless heat pipe is called thermosyphon as shown in Figure 2 Hence, for thermosyphon, the condenser must be above the evaporator, while for the wick heat pipe, the capillary forces in the wick ensure the condensate returns to the evaporator regardless of itsposition.
LITRATUREREVIEW

H. Joubara[1], This paper provides a comprehensive review of the state-of-the-art application discussion. The low and heat sections present an extended list with suitable working fluids and operating temperatures, alongside their compatibility with casing materials. Furthermore, the sections specialize in a number of the foremost widespread industrial applications, like solar, nanoparticles, Rankine cycles, nuclear, thermoelectric modules and ceramics, during which heat pipe technologies offer many key advantages over conventional practices. The third part of the paper consists of a radical analysis of the thermal modelling side of warmth pipes. Internal and external thermal modelling techniques, theories and methodologies are presented during this section, for various applications like non-Newtonian fluids, nano-fluids, solar, geothermal, automotive, hybrid storage and nuclear systems. The final part of the paper discusses the limitations of heat pipes and the reasons why they are not implemented in more aspects of our lives. Operational limitations, cost concerns and therefore the lack of detailed theoretical and simulation analysis of warmth pipes are a number of the purpose covered during this section. Finally, some of the recent and future developments in the field are discussed.

Bhavin Shah[2], tells that heat pipe is very important and versatile device to have efficient heat transmission over a wide range of applications. In the current market scenario applications of heat pipe has been increased to get the desired cooling effect as per discussion which may increase the demand of heat pipe in the coming future. Heat pipe has been encouraging advantages when it's utilized in energy recovery application. It is also relevant for cooling in automobile, air conditioning, electronic component etc. Heat pipe also utilized in solar application for power generation or water heating application. It is also accomplished that the use of heat pipe in any function gives better thermal performance as well as economic benefit. Pulsating heat pipes (PHPs) have emerged as interesting alternatives to conventional heat transfer technologies. These simple looking devices have intriguing thermo-hydrodynamic operational characteristics. In fact, it's rare to seek out a mixture of such events and mechanisms like bubble nucleation and collapse, bubble agglomeration and pumping action, flow regime changes, pressure/temperature perturbations, dynamic instabilities, metastable non-equilibrium conditions, flooding or bridging etc., all at once contributing towards the thermal performance of a tool. Yet, the very definition of PHPs is sort of vague. The paper addresses this fundamental issue and attempts to define the device in terms of controllable thermo-mechanical boundary conditions. Such an exercise is deemed necessary to benchmark the operational performance limits and to assist in system analysis.

Xiaoli Ma[5], presents a three-part overview of progress in heat pipe technology and applications over the last 5 years. Part I contains a review of developments and research into new types and heat pipes. This includes an outline of the operational principles and performance characteristics of the varied sorts of heat pipe. Part II contains a review of the applications of specific heat types and part III introduces novel mathematical methods used in heat pipe research, including CFD, optimization design and modelling.

HEATPIPE

Construction

A typical heat pipe consists of a sealed hollow tube, which is formed from a thermoconductive metal like copper or aluminium. The pipe contains a comparatively small quantity of "working fluid" (such as water, ethanol or mercury) with the rest of the pipe being crammed with vapor phase of the working fluid. On the interior side of the tube's sidewalls a wick structure exerts a capillary force on the liquid phase of the working fluid. This is typically a sintered metal powder (sintering may be a method for creating objects from powder, by heating the fabric until its particles adhere to every other) or a series of grooves etched in the tube's inner surface. The basic idea of the wick is to take in the coolant. Heat pipes contain no moving parts and need no maintenance and are completely noiseless. In theory, it's possible that gasses may diffuse through the pipe's walls over time, thus reducing this effectiveness. The overwhelming majority of warmth pipes uses either ammonia or water as working fluid. Extreme applications may involve different materials, like liquid helium (for coldness applications) or mercury (for extreme heat applications).

Fig 1: Constructional Details of Heat Pipe
The advantage of warmth pipes is their great efficiency in transferring heat. They are actually a better heat conductor than a mass of solid copper [3]. As previously mentioned, there's liquid vapor equilibrium inside the warmth pipe. When thermal energy is supplied to the evaporator, this equilibrium breaks down because the working fluid evaporates. The generated vapor is at a better pressure than the section through the vapor space provided. Vapor condenses making a gift of its heat of transformation of vaporization to the warmth sink. The capillary pressure created within the menisci of the wick, pumps the condensed fluid back to the evaporator section. The cycle repeats and therefore the thermal energy is continuously transported from the evaporator to condenser within the sort of heat of transformation of vaporization. When the thermal energy is applied to the evaporator, the liquid recedes into the pores of the wick and thus the menisci at the liquid-vapor interface are highly curved. This phenomenon is shown in figure. At the condenser end, the menisci at the liquid-vapor interface are nearly flat during the condensation thanks to the difference within the curvature of menisci drive that circulates the fluid against the liquid and vapour pressure losses and body forces like gravity.

How a Heat Pipe Works

A heat pipe may be a closed evaporator-condenser system consisting of a sealed, hollow tube whose inside walls are lined with a capillary structure or wick. Thermodynamic working fluid, with substantial vapour pressure at the specified operating temperature, saturates the pores of the wick during a state of equilibrium between liquid and vapor. When heat is applied to the warmth pipe, the liquid within the wick heats and evaporates. As the evaporating fluid fills the warmth pipe hollow centre, it diffuses throughout its length. Condensation of the vapor occurs wherever the temperature is even slightly below that of the evaporation area. As it condenses, the vapor gives up the warmth it acquired during evaporation. This effective high thermal conductance helps maintain near constant temperatures along the whole length of the pipe.

Fig 2: Working of Heat Pipe

Attaching a conductor to some of the warmth pipe makes condensation happen at now of warmth transfer and establishes a vapor flow pattern. Capillary action within the wick returns the condensate to the evaporator (heat source) and completes the operating cycle. This system, proven in aerospace applications, transmits thermal energy at rates hundreds of times greater and with a far superior energy-to-weight ratio than can be gained from the most efficient solid.

1. DIFFERENT TYPES OF HEATPIPES(RECENT Devolve ment)

Vapor Chamber or Flat Heat Pipes

Thin planar heat pipes (heat spreaders) have an equivalent primary components as tubular heat pipes: a hermetically sealed hollow vessel, a working fluid, and a closed-loop capillary recirculation system. In addition, a series of posts are generally utilized in a vapor chamber, to stop collapse of the flat top and bottom when the pressure is less than atmospheric, which is 100 °C for water vapor chambers. There are two main applications for vapor chambers. First, they're used when high powers and warmth fluxes are applied to a comparatively small evaporator. Heat input to the evaporator vaporizes liquid, which flows in two dimensions to the condenser surfaces. After the vapor condenses on the condenser surfaces, capillary forces within the wick return the condensate to the evaporator. Note that the majority vapor chambers are insensitive to gravity, and can still operate when inverted, with the evaporator above the condenser. In this application, the vapor chamber acts as a heat flux transformer, cooling a high heat flux from an electronic chip or laser diode, and reworking it to a lower heat flux which will be removed by natural or forced convection. With special evaporator wicks, vapor chambers can remove 2000 W over 4 cm², or 700 W over 1 cm². Second, compared to a one-dimensional tubular heat pipe, the width of a two-dimensional heat pipe allows an adequate cross section for warmth flow even with a really thin device. These thin planar heat pipes are finding their way into —height sensitivel applications, like notebook computers and surface
mount circuit card cores. These vapor chambers are typically fabricated from aluminium extrusions, and use acetone as the working fluid [11]. It is possible to supply flat heat pipes as thin as 1.0 mm (slightly thicker than a 0.76 mm credit card).

**VARIABLE CONDUCTANCE HEAT PIPES (VCHPs)**

Standard heat pipes are constant conductance devices, where the warmth pipe operating temperature is about by the source and sink temperatures, the thermal resistances from the source to the warmth pipe, and therefore the thermal resistances from the warmth pipe to the sink. In these heat pipes, the temperature drops linearly because the power or condenser temperature is reduced. For some applications, like satellite or research balloon thermal control, the electronics are going to be overcooled at low powers, or at the low sink temperatures. Variable Conductance Heat Pipes (VCHPs) are used to passively maintain the temperature of the electronics being cooled as the power and sink conditions change [5].

**Fig 3: Working Principle of Variable Conductance Heat Pipes [12]**

VCHPs have two additions compared to a standard heat pipe: First A reservoir, and Second A Non-Condensable Gas (NCG) added to the warmth pipe, additionally to the working fluid; see the image within the Spacecraft section below. This NCG is usually argon for normal VCHPs, and helium for thermosyphons. When the warmth pipe isn't operating, the NCG and dealing fluid vapor are mixed throughout the warmth pipe vapor space. When the VCHP is working, the NCG is swept toward the condenser end of the warmth pipe by the flow of the working fluid vapor. Most of the NCG is found within the reservoir, while the rest blocks some of the warmth pipe condenser. The VCHP works by varying the active length of the condenser. When the facility or conductor temperature is increased, the warmth pipe vapor temperature and pressure increase. The increased vapour pressure forces more of the NCG into the reservoir, increasing the active condenser length and therefore the heat pipe conductance. Conversely, when the facility or conductor temperature is decreased, the warmth pipe vapor temperature and pressure decrease, and therefore the NCG expands, reducing the active condenser length and warmth pipe conductance. The addition of a little heater on the reservoir, with the facility controlled by the evaporator temperature, will allow thermal control of roughly ±1-2 °C. In one example, the evaporator temperature was maintained during a ±1.65 °C control band, as power was varied from 72 to 150 W, and warmth sink temperature varied from +15 °C to -65 °C. Pressure Controlled Heat Pipes (PCHPs) are often used when tighter temperature control is required. In a PCHP, the evaporator temperature is employed to either vary the reservoir volume, or the quantity of NCG within the heat pipe. PCHPs have shown milli-Kelvin temperature control.

**THERMOSYPHONS**

Most heat pipes use a wick and capillarity to return the liquid from the condenser to the evaporator. The liquid is sucked up to the evaporator, almost like the way that a sponge sucks up water when a foothold is placed in touch with a water pool. The wick allows the warmth pipe to work in any orientation, but the utmost adverse elevation (evaporator over condenser) is comparatively small, on the order of 25 cm long for a typical water heat pipe. Taller heat pipes must be gravity aided. When the evaporator is found below the condenser, the liquid can drain back by gravity rather than requiring a wick. Such a gravity aided heat pipe is understood as a Thermosyphon. Thermosiphon (or thermosyphon) may be a method of passive heat exchange, supported natural convection, which circulates a fluid without the need of a mechanical pump. Thermosiphoning is employed for circulation of liquids and volatile gases in heating and cooling applications like heat pumps, water heaters, boilers and furnaces. Thermosiphoning also occurs across air temperature gradients such as those utilized in a wood fire chimney or chimney. This circulation can either be open-loop, as when the substance during a holding tank is passed in one direction via a heated transfer tube mounted at rock
bottom of the tank to a distribution point even one mounted above the originating tank or it are often a vertical closed-loop system circuit with return to the first container. Its purpose is to simplify the transfer of liquid or gas while avoiding the cost and complexity of a conventional pump [4]. In a thermosyphon, liquid working fluid is vaporized by a heat supplied to the evaporator at rock bottom of the warmth pipe. The vapor travels to the condenser at the highest of the warmth pipe, where it condenses. The liquid then drains back to rock bottom of the warmth pipe by gravity, and therefore the cycle repeats. Thermosyphons also act as diode heatpipes.


When heat is applied to the condenser, there's no condensate available, and hence no thanks to form vapor and transfer heat to the evaporator. While a typical terrestrial water heat pipe is a smaller amount than 30 cm long, thermosyphons are often several meters long.

LOOP HEAT PIPE

A loop heat pipe (LHP) may be a passive two-phase transfer device associated with the warmth pipe. It can carry higher power over longer distances by having co-current liquid and vapor flow, in contrast to the counter-current flow during a heat pipe. This allows the wick during a loop heat pipe to be required only within the evaporator and compensation chamber.

Fig 5: Working Principle of Loop Heat Pipes [2]

PULSATING HEAT PIPE

An oscillating heat pipe, also referred to as a pulsating heat pipe, is merely partially crammed with liquid working fluid. The pipe is arranged during a serpentine pattern during which freely moving liquid and vapor segments alternate. Oscillation takes place in the working fluid; the pipe remains motionless. Even the name is heat pipe, but working is extremely much different than the traditional heat pipes. It has capillary which has many bends (capillary 1mm to 3mm size), capillary is first evacuated and then partially filled with working liquid.

Fig 6: Working Principle of Pulsating Heat Pipes [1]

Due to capillary, the working fluid distributed itself within the tubes as forming the alternate liquid and vapor slugs. The fluid is going to be in saturated condition, when heat is given to then the upper layer is going to be evaporated which can surround the vapor slug. The vapor expansion pushes the adjacent liquid to the condenser where absorbed heat is often released to the condenser. So, the heat transfer takes place due to oscillation and circulation of fluid inside the tube [3].

2. APPLICATION

Spacecraft: Heat pipes and loop heat pipes are used extensively in spacecraft, since they don't require any power to operate, operate nearly isothermally, and can transport heat over long distances. Grooved wicks are
utilized in spacecraft heat pipes, as shown within the first photograph during this section. The heat pipes are formed by extruding aluminum, and typically have an integral flange to extend the warmth transfer area, which lowers the temperature drop. Grooved wicks are utilized in spacecraft, rather than the screen or sintered wicks used for terrestrial heat pipes, since the warmth pipes do not have to work against gravity in space. This allows spacecraft heat pipes to be several meters long, in contrast to the roughly 25 cm maximum length for a water heat pipe operating on Earth. Ammonia is that the commonest working fluid for spacecraft heat pipes. Ethane is used when the heat pipe must operate at temperatures below the ammonia freezing temperature[1].

Solar Thermal: Heat pipes are also widely used in solar thermal water heating applications in combination with evacuated tube solar collector arrays. In these applications, water is usually used because the heat transfer fluid inside a sealed length of copper tubing that's located within an evacuated glass tube and oriented towards the sun. In connecting pipes, the heat transport occurs in the liquid steam phase because the thermal transfer medium is converted into steam in a large section of the collecting pipeline.

Permafrost Cooling: Building on permafrost is difficult because heat from the structure can thaw the permafrost. Heat pipes are utilized in some cases to avoid the danger of destabilization. For example, within the Alaskan pipeline System residual ground heat remaining within the oil also as heat produced by friction and turbulence within the moving oil could conduct down the pipe's support legs and melt the permafrost on which the supports are anchored. This would cause the pipeline to sink and possibly be damaged. To prevent this, each vertical support member has been mounted with four vertical heat pipe thermosyphons[8]. The significant feature of the thermosyphon is that it's passive and doesn't require any external power to operate. During the winter, the air is colder than the ground around the supports. The liquid ammonia at rock bottom of the thermosyphon is vaporized by heat absorbed from the bottom, cooling the encompassing permafrost and lowering its temperature. During the summer, the thermosyphons stop operating, since there's no liquid ammonia available at the highest of the warmth pipe, but the acute cooling during the winter allows the ground to remain frozen. Heat pipes also are wont to keep the permafrost frozen alongside parts of the Qinghai–Tibet Railway, where the embankment and trackabsorbsorbs the sun's heat. Vertical heat pipes oneither side of relevant formations prevent that heat from spreading any longer into the encompassing permafrost.

Nuclear Power Conversion: Grover and his colleagues were working on cooling systems for nuclear power cells for space craft, where extreme thermal conditions are encountered. These alkaline metal heat pipes transferred heat from the warmth source to a thermionic or thermoelectric converter to get electricity. Since the early 1990s, numerous nuclear reactor power systems have been proposed using heat pipes for transporting heat between the reactor core and the power conversion system.[10] The first nuclear reactor to produce electricity using heat pipes was first operated on September 13, 2012 in a demonstration using fasttopfission.[12]

Ventilation Heat Recovery: The device consists of a battery of multi-row finned heat pipe tubes located within both the supply and exhaust air streams. Within the exhaust air side of the warmth pipe, the refrigerant evaporates, extracting heat from the exhaust air. The refrigerant vapor moves towards the cooler end of the tube, within the availability air side of the device, where it condenses and releases heat. The condensed refrigerant returns by a mixture of gravity and capillarity within the wick. Thus, heat is transferred from the exhaust air stream through the tube wall to the refrigerant, then from the refrigerant through the tube wall to the availability air stream. Because of the characteristics of the device, better efficiencies are obtained when the unit is positioned upright with the availability air side mounted over the exhaust air side, which allows the liquid refrigerant to flow quickly back to the evaporator aided by the force of gravity. Generally, gross heat transfer efficiencies of up to 75% are claimed by manufacturers. Etc.

3. SUMMARY
Heat pipe is a thermal super conductor under certain heat transfer condition they can transfer the heat energy 100 times more than available best conductive materials, because of negligible temperature gradient exist in heat pipe. The heat pipe has compactness, light weight, reversible in operation and high thermal flux handling capability makes heat pipe to use new modern era and in many wide variety applications to overcome critical heat dissipation problem. One can also expect that the progresses in other research fields will bring new tools enabling to improve the current systems. For instance, the progress in high frequency microelectronics opens the way for active control of heat pipes and the continuous development of new materials awake hopes of real flexible and lightweight heat pipes if the current problems of fluid/material compatibility on plastic heat pipes are solved. Anyway, one can conclude that the study of heat pipes will remain a challenging and exciting
topic at least for the next couple of decades.

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Recent Patents on Mechanical Engineering 2013, 6, 169-184 (China), August 27, 2013, Micro Flat Heat Pipes for Microelectronics Cooling: Review LuC.
Quad Bike Differential

Piyush A. Dalke¹, Dr.Girish P. Deshmukh², Omkar D. Raut³, Sanjeeb R. Pal⁴, Omkar R. Kothare⁵

¹Research Scholar, Department of Mechanical Engineering, CSMU Navi Mumbai
²Professor, Department of Mechanical Engineering ACP College of Engineering (Mumbai University)
³UG, Department of Mechanical Engineering ACP College of Engineering (Mumbai University)
⁴UG, Department of Mechanical Engineering ACP College of Engineering (Mumbai University)
⁵UG, Department of Mechanical Engineering ACP College of Engineering (Mumbai University)

ABSTRACT

A belt drive differential with an output shaft, two planet sprockets rotatably mounted to a carrier to orbit in a circular path about a carrier axis coaxial with the output shaft, a first output sprocket attached to an output shaft, and a toothed power transmission belt connecting the sprockets. A differential assembly in which a belt links gears on opposite sides of a carrier by idlers, which idlers are spaced to have synchronous interfittment of the belt teeth with the gear teeth and peripherally shaped to turn the belt flat for gear engagement with a minimum arc of partial engagement.

INDEX TERMS

Differential, Belt Drive, Shaft, Transmission

1. INTRODUCTION

We are introducing a concept of transmitting power i.e. Differential with Belt drive in our Quad Bike.

A differential consists of one input, the drive shaft, and two outputs which are the two drive wheels. However the rotation of the drive wheels are coupled to each other by their connection to the roadway. Under normal conditions, with small tier slip, the ratio of the speeds of the two driving wheels is defined by the ratio of the radii of the paths around which the two wheels are rolling, which in turn is determined by the track-width of the vehicle (the distance between the driving wheels) and the radius of the turn.

The belt drive makes the transmission smooth, silent and requires less frequent routine of maintenance. Compared to chains and shaft drive, they’re also lighter too, which is important to reduce unsprung and rotating weight.

A. There are various types of differential as follows-

- An open differential (OD) is the most common type.
- A limited slip differential (LSD) overcomes this problem.
- A locking differential (locker) is able to lock the two drive wheels on an axle together.

B. How an Open Differential with belt drive works?

A vehicle with two drive wheels has the problem that when it turns a corner the drive wheels must rotate at different speeds to maintain traction. The automotive differential is designed to drive a pair of wheels while allowing them to rotate at different speeds. In vehicles without a differential, such as karts, both driving wheels are forced to rotate at the same speed, usually on a common axle driven by a simple chain-drive mechanism.

When cornering, the inner wheel travels a shorter distance than the outer wheel, so without a differential either the inner wheel rotates too quickly or the outer wheel rotates too slowly, which results in difficult and unpredictable handling, damage to tires and roads, and strain on (or possible failure of) the drivetrain.

In rear-wheel drive automobiles the central drive shaft (or prop shaft) engages the differential through a hypoid gear (ring and pinion). The ring gear is mounted on the carrier of the planetary chain that forms the differential. This hypoid gear is a bevel gear that changes the direction of the drive rotation.

Transmitting power from engine through belt drive is more efficient as well as belt drives do not have ‘play’ like a chain drive, and are to a certain extent, elastic. Chains require some slack and are very inelastic.

2. GUIDELINES FOR MANUSCRIPT PREPARATION
Differential Assembly

Race cars often use open differential belt drive in order to maintain traction during high speed maneuvers or when accelerating at extreme rates. Additionally, vehicle dynamics are made more predictable when there is a loss of traction, as the driver knows that neither wheel will suddenly sap power if it encounters a low-friction surface.

Some utility vehicles such as tow trucks, forklifts, tractors, and heavy equipment use open differentials to maintain traction, especially when driving on soft, muddy, or uneven surfaces.

Explode View of Assembly

Four-wheel drive vehicles that drive off-road often use an open differential belt drive to keep from getting stuck when driving on loose, muddy, or rocky terrain. Open differentials are considered essential equipment for serious off-road driving. Many such vehicles have an open differential chain drive on the rear side differential; or any combination of any of the three. Differential locks are also used on some "non-utility" four-wheel-drive vehicles (such as the Mitsubishi Shogun) to compensate for a relative lack of axle articulation (vertical wheel movement). High amounts of articulation are desirable for off-road driving, to allow the wheels to maintain ground contact over uneven surfaces, but this can lead to excessive body-roll at high speeds on the road, as well as vague steering. If articulation is limited, one wheel on an axle may be lifted off the ground by rough terrain, thus losing all traction to all wheels (all power goes to the lifted wheel which spins freely). A rear open differential belt drive is often supplied to make up for this compromise – if a wheel is lifted off the ground, the open differential belt drive can be brought into play, driving the wheel that remains on the ground.

A. Requirement of Differential-

Thus above explained that open differential works thus this fundamental of various automobile vehicle where the one end are connected to the wheel and the other is connected to the open differential belt drive box where it helps while turning. Where the inner wheel should rotate minimum less than that of the outer wheel. If this is not used while riding the rider will experience an overturn while this overturn the quad bike may go off road.

There are certain achievements that are obtained from differential with belt drive:

- Noise and vibration are damped out as well as due to this the machine life is increased because the load fluctuations are shock absorbed.
- The less the shock better is the power output obtained from the belt drive due to which the efficiency is increased up to (95-98)%.
- As in chain drive we frequently give lubrication but in belt drive we do not need any lubrication system so the maintenance cost of belt drive is much lesser as compare to chain drive
- The overall assembly of the chain drive is somehow economical high as compare to belt drive so by using belt we can reduce the cost as well as we can achieve the required speed.

The torque applied to each driving wheel is the result of the engine, transmission, and drive axle which is applying a twisting force against the resistance of the traction at that road wheel. In lower gears and at lower speeds, unless the load is exceptionally high, the drivetrain can supply as much torque as necessary, so the limiting factor becomes the traction under each wheel. It is therefore convenient to define traction as the amount of force that can be transmitted between the tire and the road surface before the wheel starts to slip. If the torque applied to one of the drive wheels exceeds the threshold value of traction, then that wheel will spin and will provide torque only at the other driven wheel which is equal to the sliding friction at the wheel. The reduced net traction may still be enough to propel the vehicle slowly. This slowdown of the wheel helps for the proper turning effect on the wheel which leads to the friction on the tire side.
3. DESIGN PARTS & CALCULATIONS

The Differential is used for getting the quad bike a proper turning effect and to know how the differential is used to maintain balance of the wheel and the driver too while he/she is riding a Quad Bike. This idea of using a differential in the quad is to get proper control and maintain constant accuracy in the bike. If the wheels are perfectly balanced by each other, a smooth and finished movement is obtained.

A. Speed Characteristics:-
Maximum speed of Engine = 60 Km/hr = 16.67 m/s

D1 = diameter of engine output sprocket = 0.863 m
Velocity of engine output sprocket = V1

So, \( V_1 = \frac{\pi \times D1 \times N1}{60} \)

\( N1 = 368.91 \text{ rpm} \)

Therefore we obtain rotation of output engine sprocket.

Through Gear ratio we obtain rotation of spindle (N2) = 846.32 rpm

D2 = diameter of spindle gear = 0.095 m

Speed of spindle = \( V_2 = \frac{\pi \times D2 \times N2}{60} \)

\( V_2 = 4.209 \text{ m/s} \)

D3 = diameter of flywheel = 0.22 m

Velocity of flywheel = Velocity of spindle

\( V_3 = V_2 = \frac{\pi \times D3 \times N3}{60} \)

\( N3 = 365.4 \text{ rpm} \)

Therefore N3 is maximum rotation of wheel.

B. Gear Parameters:-

Dp = Diameter of pinion = 77mm

Zp = Teeth of pinion = 14

Dg = Diameter of engine output gear = 92mm

Zg = teeth of engine output gear = 11

m = module

\( Dp = m \times Zp \)

\( m = 5.5 \text{ mm} \)

\( Dg = m \times Zg \)

\( m = 5.5 \text{ mm} \)

Pitch:

\( P = \pi \times m = 17.27 \text{ m} \)
IMPACT ON ENVIRONMENT

Off-Roading puts automobiles in areas that are not designed for automobiles. This has a variety of effects on the natural environment as briefed below:-

- There are additional belt design specifications that can be selected depending on the application. Some drive system applications may be vulnerable to fire and/or malfunction as a result of static discharge from the build-up during operation of the drive. In such cases, a specialized, anti-static belt can be specified in order to guard against this concern. In other applications where belt drive systems are to be employed used to directly contact and transport food, a specialized belt can be specified that adheres to rigorous food sanitation laws.

- If the chain stops due to some reason then the bike stop but if the belt-drive stops, the rear wheel keep on moving and prevent from some accident.

- The principal advantage is the positive effect on ride quality and handling. The wheel will move independently in response to bumps. It is mainly useful in the muddy areas or hilly regions.

- In hilly areas due to uneven bumps the differential will help to create stability where as belts used in such area does not jam.

A. Reliability of the Differential through the event:

Differential act as a support system in the overall vehicle by distributing power torque generated while steering. The tires are mainly controlled by the differential by providing sufficient amount of torque to the front tires set, as well as maintaining the control while the bike is in turning or in slope.

Live axle are relatively simple, lower manufacturing costs, lighter overall vehicle weight, and the facts that the axle and suspension takes a little interior volume because the axle assembly is a fairly simple and rigid arrangement, it can easily be made strong and robust which is an advantage for vehicle with substantial power or that are intended for use in rugged environment or off road usage.

A future advantage of a live/beam axle in off road use is that ground clearance under the axle remains constant even if one wheel rises up over a bump and the other doesn’t.

CONCLUSION

We have seen the importance of differential, it’s working and different types of aspects of how differential and belt drive works together. In automobile and other wheeled vehicles, normally the differential allows each of the driving wheels to rotate at different speeds, while supplying equal torque to each of them. This is effective in the bumpy areas where differential work along with the belt present, which helps to transmit the power from output engine gear to the spindle, but here the belt drive does not slip or doesn’t move out of the drive and gives effective power transmission. That’s why we are using the differential along with the belt drive.

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About the Authors:

Mr. Piyush A. Dalke is a young faculty working as Assistant Professor at JSPM’s/TSSM’s Padmabhooshan Vasantdada Patil Institute of Technology Pune completed his BE Mechanical in 2015 and his M-Tech in CAD/CAM in 2017. He is also pursuing his PhD from CSMU Panvel Navi Mumbai University. He has teaching experience of 05 year with 15 national and international patents filed and published. He has also published 04 books with national publisher and 01 book with international publisher. His area of expertise is subject like Engineering Graphics, System Mechanical Engineering, Production Technology, Manufacturing Process etc. His areas of research interests are Nano-fluid, Hybrid Engine, Plastic, IOT, Clean air, Agriculture, Smart environment-friendly innovation and owns a youtube channel teaching these subjects.

Email: patilpiyush101@gmail.com

Dr. Girish P. Deshmukh I have been working as a Professor and Head of Mechanical Engineering Department in A C Patil college of Engineering Navi Mumbai from last 27 years. I have completed BE, ME and PhD from Amravati University.

Published more than 10 research papers in reputed international journals and conferences and working as a reviewer in two international journals, also filed and published five patents at national and international level.
Hybrid Compressed Air Drive System

(Patent App. no. 201921023056, CBR No.13071 Application types E-12/47/2019-MUM.)

Piyush A. Dalke¹, Dr. Girish P. Deshmukh², Rushikesh R. Rayrikar³, Chetan S. Deore⁴

¹Research Scholar, Department of Mechanical Engineering, Chhatrapati Shivaji Maharaj University, Panvel, Maharashtra, India, 410206
²Professor, Department of Mechanical Engineering A.C.Patil College of Engineering (Mumbai University), Kharghar, Navi Mumbai, Maharashtra, India, 410210
³Student of Mechanical Engineering, A. C. Patil College of Engineering (Mumbai University), Kharghar, Navi Mumbai, Maharashtra, India, 410210
⁴Student of Mechanical Engineering, A. C. Patil College of Engineering (Mumbai University), Kharghar, Navi Mumbai, Maharashtra, India, 410210

ABSTRACT

The present disclosure relates to a compressed air driven vehicle while the compression of air is assisted by solar operated motor. The hybrid compressed air drive system include a solar panel connected to a battery to keep the battery charged. The battery powers a compressor and a solenoid actuated Directional Control Valve. The battery powered compress or continuously supplies air to the compressed air tank which is maintained at a pressure and supplies compressed air to the solenoid actuated Directional Control Valve. An Electronics Control Unit attached to the system controls the flow and supply of air to the Directional Control Valve as per need. The solenoid actuated Directional Control Valve is controlled by a Timer IC which controls the actuation of a pair of bidirectional pneumatic actuators which are actuated sequentially in order to rotate the sprocket attached to the pedal which in turns rotate the rear wheel.

INDEX TERMS

Pneumatic System, Electronic Control Unit, Pressurized Air Energy, Eco-Friendly & Economical Vehicle.

1. INTRODUCTION

Fossil fuels which meet most of the world's energy demand today are being depleted rapidly. Combustion products of fossil fuels are causing global problems, such as the greenhouse effect, ozone layer depletion acid rains and pollution. These factors are leading automobile manufactures to develop cars fuelled by alternatives energies. Hybrid cars, Fuel cell powered cars, Hydrogen fuelled cars will be soon in the market as a result of it. One possible alternative is the air powered vehicle. Air, which is abundantly available and is free from pollution, can be compressed to higher pressure at a very low cost, is one of the prime option since atmospheric pollution can be permanently eradicated. [4][8]

A. The History Of Compressed Air Vehicles

The first compressed-air vehicle was devised by Bompas, a patent for a locomotive being taken out in England in 1828. There were two storage tanks between the frames, with conventional cylinders and cranks. It is not clear if it was actually built. (Knight, 1880).

The first recorded compressed-air vehicle in France was built by the Frenchmen Andraud and Tessie of Motay in 1838. A car ran on a test track at Chaillot on the 9th July 1840, and worked well, but the idea was not pursued further.

In 1848 Barin von Rathlen constructed a vehicle which was reported to have been driven from Putney to Wandsworth (London) at an average speed of 10 to 12 mph.

At the end of 1855, a constructor called Julienne ran some sort of vehicle at Saint-Denis in France, driven by air at 25 atmospheres (350 psi), for it to be used in coal mines.

FIGURE 1 Parsey’s Compressed Air Engine
Compressed air locomotives were used for haulage in 1874 while the Simplon tunnel was being dug. An advantage was that the cold exhaust air aided the ventilation of the tunnel.[2][8]

2. LITERATURE SURVEY

Recent journals and various publications suggest that many experiments and investigations have been performed on the various methods adopted for achieving less costly and eco-friendly vehicles. These investigations have led to a better understanding towards the automotive sectors.

John Puchera et al. (1999) researched on recent trends and alternative policies to promote bicycling. They gave information about how the number of bicycle trips in the United States has doubled. Since 48% of trips by all modes in American cities are shorter than three miles. They published that how government of North America spends on bicycle facilities. But, as long as car use remains cheap and transportation policy remains dominated by motoring. Bicycles will be used primarily for recreation and not for daily urban travel in North America.[1]

S. S. Verma (2008) has investigated various advantages & limitations of compressed air vehicle (CAV). He has also gave the information about the air powered moped which has been developed by an English inventor, James Stanfield. This has been done by equipping the scooter with a compressed air engine and air tank. He created the bike by strapping two high-pressure tanks onto the side of his Puch moped. He uses the electricity from his house to fill the tanks. The power is then "stored" there, much like a battery, ready for use. The tanks used are carbon-fibre tanks of the sort used by firefighters for oxygen. The top speed is about 18 mph, and a lot more power could probably be pulled by tweaking his configuration. A small gear on the end of the air drill, connected to the chain of the bike would make a much more elegant solution.[2]

In some of his other references S. S. Verma (2013) has investigated the latest developments of compressed air vehicle along with an introduction to various problems associated with the technology & their solution. He suggested various obstacles for developers & manufactures to design the engine of compressed air vehicle. He also suggested parameters like temperature, energy density, requirement of input power, energy release and emission control have to be considered for the development of a safe, light and cost effective compressed air vehicle in near future.[3]

Yashwant Sharma et al. (2018) has done research and development on electric bike. In his paper he has investigate reasons behind continuous use of unfriendly transport. He has identified electric bike as an easy travel for short to moderate distances. He also found potential barriers of electric bicycle and overcame it by using redemption springer fork in front suspension with electric motor for assistance.[4]

Devashish Tiwari et al. (2018) has developed a hybrid bicycle with option of pedaling as well as pneumatic aid to reduce human power. In this the rear wheel of the bicycle was completely modified and carries all the much needed change. He has used slider crank mechanism to transfer rotational force to the pneumatic piston which works as air compressor for the air reservoir around the direction valve to the piston.[5]

Krishnamurthy et al. (2017) has found that people ride bikes to avoid walking and for personal used. In this he has turned bicycle into motorcycle by installing crank setup attached to the engine. He produced compressed air with the motion of the piston which is storied in tank which is utilized again to run the cycle.[6]

Mukeshkumar Prasad, Nilesh Nirwan (2016) has built a bicycle prototype that is capable of driving and balancing without rider. He has employed a control system to keep bicycle from falling over while in motion. For maintaining balancing he has used sensor input to detect tilt angle and correctly reacts to maintain position. The data was fed into a control system which outputs a balancing torque to a motor spinning the reaction wheel.[7]

Rajendra Beedu, Ankit et al. built a design which involves the calculation of power required to run a bicycle at a known speed (say 10 km/h) and to develop a solar powered system to produce the required power. This cycle can run at an average speed of 15 kmph (without pedalling) with a maximum of 25 kmph with pedalling. The cycle was placed in sun light and was found that it requires 7.2 hours for fully charging the battery. But with electrical charging it needs 2.4 hours. The discharge time of battery theoretically is 1 hour. But it was observed that the discharge time of battery is 50 minutes and discharge takes place exponentially. The cycle was tested on plain flat road
and a maximum speed of 15 Km (figure 5) could be obtained without pedalling.[8]

Prof. B.S.Patel et al. tried to develop a compressed air engine by modifying an 4-stroke, single cylinder SI engine by replacing the spark plug with a pulsed pressure valve, and using compressed air as the working fluid. The working of the engine is explained theoretically and the cost analysis is made which shows that the compressed air engine is cheap when compared to the conventional SI engine. Dr. Bharat Raj Singh and Dr. Onkar Singh conducted an experiment in which they used a vaned type novel air turbine as a prime mover for a motor bike. In this experiment they tried to gain an output of 6.50 to 7.20 HP for the starting torque requirements of 500 to 750 rpm at 4 to 6 bars air pressure to running speeds of 2000 to 3000 rpm using 2 to 3 bars air pressure. At the end of this review they conclude that the compressed air technology can be tested and developed using the Vaned Type Novel Air Turbine as there are minimal losses and practically their efficiency varies from 72-97% which is very high when compared to a conventional IC engine. Future developments can be made by designing an ideal vehicle for this kind of engine.[9]

3. PROBLEM DEFINITION

- Limited Running time.
- Weight balancing is most important aspect while making such a bicycle.
- Product should be cost effective.
- As long as car use remains cheap and transportation policy remains dominated by motoring, Bicycles will be used as primary option. Hence, there will be need of promotion of bicycling throughout the world.

A. Existing System

Vehicle or bicycle running on Compressed air is already being explored. But, problem with existing developed inventions is that those vehicle are not capable of continuous run. Also, these vehicles or bicycles have some issues either with their weight balancing or their Capital cost of production.

A. Proposed System

However, with the integration of compressor the same problem can be eliminated. Also, the problems like Light in weight, Safe, Cost effective, Etc, can be eliminated at certain level are possible by such bicycle.

4. METHODOLOGY

Combustion engine commonly used in vehicles are generally powered by gasoline, diesel or other that produces significant emission due to the combustion of fuel. Also in traditional bicycle lot of man power is required to pedal the bicycle. With the help of our project this problems are eliminated. In our project weight balancing and cost are two important factors.

Figure shows the steps involved in building an air compressed bicycle. It begins with the problem definition. Each and every component is designed and optimum material selection is carried out. Compressor is assembled to the cylinder which supplies the air inside to run the bicycle.

![FIGURE 2 Methodology in design and fabrication of a compressed air bicycle](image-url)
easily. Also, Pneumatic cylinders or air cylinders are mechanical devices which use the power of compressed air to produce a force in a reciprocating linear motion or cylinders which converts pneumatic power into mechanical power. Compressed air forces the piston to move in the desired direction. Because air is an expandable substance, it is dangerous to use pneumatic cylinder at high pressure so they are limited to 8 bar (gauge) pressure. Consequently they are constructed from lighter material. Because gas is compressible substance, the motion of pneumatic cylinder is hard to control precisely.

Cost effectiveness as the modern two wheeler like Scooty are easily available in market with very effective price range of 30-40,000 Rs. Hence, cost is another main point while Model design to make the bicycle cost effective.

A. Working Principle
Today, internal combustion engines in cars, trucks, motorcycles, aircraft, construction machinery and many theirs, most commonly use a four-stroke cycle. The four strokes refer to intake, compression, combustion (power), and exhaust strokes that occur during two crankshaft rotations per working cycle of the gasoline engine and diesel engine.

In our project, the compressed air tank of the bike stores the compressed air. The high pressure air is given into the air cylinder or actuator at required pressure with the help of valves which is connected to the sprocket. Compressed air has stored energy in it. Once compressed air enters into the actuator and it expands inside the space inside the actuator. This expansion of high pressure air causes piston to move in downward direction, due to this motion pedal sprocket start rotating. Thus linear motion of piston rod is converted into rotational motion through connecting rod and crank mechanism. In this way the pneumatic energy is converted into useful shaft work. Expanded air is then released into the atmosphere through an exit port as exhaust. The exhaust is usually just air and cool exhaust is generated. There is only one gear, which is just a sprocket bolted directly to the axis of the main sprocket and chained to the rear wheel.

5. CONSTRUCTION
Two pneumatic actuators of size 300x20 mm are fitted to the pedal of the bicycle. To support pneumatic actuators a frame is mounted on the bicycle. A compressor of capacity 300 psi, 12 V, battery of capacity 12 V, storage tank and the solar panel is mounted on the carriage of the bicycle. Hose pipes are used for the connection between the parts. Pneumatic direction control valve is used to connect between the actuator and the storage tank. On/Off switch is mounted on the handle of the bicycle to operate the compressor.

![FIGURE 3 Model Design](image)

6. WORKING
First of all we took the measurement to locate the actuator position for movement of the bicycle pedal. To support the actuators we made a frame of metal strip. Initial for testing of actuators we arranged the compressor and storage on the carriage of the bicycle.

![FIGURE 4 Basic Working Layout](image)

We know that, to get output we have to match the stroke of the double acting pneumatic actuators. 5/2 pneumatic valves are used for controlling double acting
pneumatic cylinders. They have 2 output ports, commonly designated A & B or 2 & 4. They have one inlet port, designated P or 1, and two exhaust ports, designated R & S or 3 & 5. In one position, inlet port P or 1 is connected to output port A or 2, while the port B or 4 is exhausted through exhaust port S or 4.

This means the pneumatic cylinder is extended. In the other position of the valve, P or 1 is connected to port B or 4, and port A or 2 is connected to the exhaust port R or 3. This means the cylinder is retracted. The valve is shifted from one position to the other by various means; for example, a couple of solenoids or pilot connections. Many a time, one default position is achieved by means of a spring and the other through a solenoids or a pilot connection.

7. ADVANTAGES

- Environmental friendly design as it works on air which will might be reduce air pollution to large extent.
- It can be designed as a pneumatic powered three wheeler bicycle in the sense that will be useful for handicapped people also.
- One time investment as it does not require any medium to run, it can be usable anywhere as works only on atmospheric air.
- Compressed air technology reduces the cost of vehicle production by about 20%, because there is no need to build a cooling system, fuel tank, Ignition Systems or silencers.
- Air, on its own, is non-flammable.
- Low manufacture and maintenance costs as well as easy maintenance.

8. CONSTRUCTION

The model designed by us is a small scale working model of the compressed air bicycle. When scaled to higher level it can be used for driving automobiles independently or combined (hybrid) with other engines like I.C. engines. Efforts should be to make them light, safe, cost effective and economical for driving. Overall weight of product should be balanced. Efforts should be to make cost effective air powered bicycle design. Unfortunately there are still serious problems to be sorted out before air powered vehicles become a reality for common use. With the development in science & technology well supported by the environmental conscious attitude it will be possible to use such product for daily domestic use.

ACKNOWLEDGEMENT

We would like to express our deep and sincere gratitude to our Guide Dr. G. P. Deshmukh, Head of Mechanical Engineering Department, for guiding us in our project work. It was our privilege and pleasure to work under his able guidance. We are indeed grateful to him for providing helpful suggestion, from time to time. Due to his constant encouragement and inspiration we are able to present this project.

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MR. PIYUSH A. DALKE is a young faculty working as Assistant Professor at JSPM’s/TSSM’s Padmabhooshan Vasantdada Patil Institute of Technology Pune completed his BE Mechanical in 2015 and his M-Tech in CAD/CAM in 2017. He is also pursuing his PhD from Chhatrapati Shivaji Maharaj University Panvel Navi Mumbai University. He has teaching experience of 05 year with 15 national and international patents filed and published. He has also published 04 books with national publisher and 01 book with international publisher. His area of expertise is subject like Engineering Graphics, System Mechanical Engineering, Production Technology, Manufacturing Process etc. His areas of research interests are Nano-fluid, Hybrid Engine, Plastic, IOT, Clean air, Agriculture, Smart environment- friendly innovation and owns a youtube channel teaching these subjects.
Email: patilpiyush101@gmail.com

MR. RUSHIKESH R. RAYRIKAR was born in Kothrud, Pune, India in 1997; received B.E. Degree in Mechanical Engineering from Mumbai University, in 2019. He is currently working as a CAD/DESIGN ENGINEER at Milestone PLM Solutions Pvt. Ltd., Thane. He has one year experience in Design Field & has a great knowledge in 3D Modelling Software’s, especially SolidWorks.
Email: rushikeshrayrikar1997@gmail.com

MR. Chetan S. Deore was born in Dhule, Maharashtra, India in 1997; received his B.E Degree in Mechanical Engineering from University Of Mumbai in 2019. He is currently working as Production and Quality Engineer in Airpro Engineers Pvt. Ltd., Thane. He has one year experience of production works and QAQC terms related in HVAC industries.
Email: chetandeore786@gmail.com

DR. GIRISH P. DESHMUKH has been working as a Professor and Head of Mechanical Engineering Department in A C Patil college of Engineering Navi Mumbai from last 27 years. He has completed BE, ME and PhD from Amravati University. Published more than 10 research papers in reputed international journals and conferences and working as a reviewer in two international journals, also filed and published five patents at national and international level.
Residual Stress Effect Due To Autofrettage in Hydraulic Cylinders for Thick Cylinder Optimization

Patil Shrinivas Kiran¹, Sharanabasappa C. Sajjan²
¹Dept. of Mechanical Engineering, KLE Institutes of Technology, Hubballi, Karnataka, India
²Dept. of Mechanical Engineering, KLE Institutes of Technology, Hubballi, Karnataka, India

ABSTRACT

In Autofrettage cylinder is subjected to internal pressure to cause plastic expansion of some or the entire tube wall. The stresses are created in the near-bore region while residual tensile hoop stresses are created in the outer-bore region. The resulting residual stress leads to a decrease in the value of maximum Von-Mises stress in the next loading stage. Abaqus FEA package is used for analysis & three different Models of Structural steel hydraulic cylinders are made to analyze the impact of Residual stresses in it. Same results are validated at working loading stage by using Lame’s Equation. Considerable saving of maximum induced stress is observed & same is discussed in next few pages of this article. As a future scope Re-autofrettage is considered to address stress distribution problems along with crack formations.

INDEX TERMS
Autofrettage, Von-Mises stress, Isotropic elastic model, Kinematic hardening model, heat soak treatment etc

1. INTRODUCTION TO AUTOFRETTAGE

In this technique, the cylinder is subjected to internal pressure to cause plastic expansion of some or the entire tube wall. The stresses are created in the near-bore region while residual tensile hoop stresses are created in the outer-bore region. The resulting residual stress leads to a decrease in the value of maximum Von-Mises stress in the next loading stage. That means the increase in the pressure capacity of the cylinder in the next loading stage.[2]

The start point is a single steel tube of internal diameter slightly less than the desired caliber. The tube is subjected to internal pressure of sufficient magnitude to enlarge the bore and in the process the inner layers of the metal are stretched beyond their elastic limit. This means that the inner layers have been stretched to a point where the steel is no longer able to return to its original shape once the internal pressure in the bore has been removed.[4] Basic process is as shown in Figure-1.
Table-1: Cylinder Model Dimensional Specifications.

The material properties are defined as per elastic & plastic limits separately for Alloy structural steel. For elastic phase isotropic elastic model is been selected & properties are fed as per table-2.

<table>
<thead>
<tr>
<th>Cylinder Model dimensions in mm</th>
<th>Model -I</th>
<th>Model -II</th>
<th>Model -III</th>
</tr>
</thead>
<tbody>
<tr>
<td>Outer Diameter</td>
<td>120.65</td>
<td>130.6</td>
<td>126.0</td>
</tr>
<tr>
<td>Inner Diameter</td>
<td>101.60</td>
<td>101.60</td>
<td>101.60</td>
</tr>
<tr>
<td>Length</td>
<td>57.15</td>
<td>57.1</td>
<td>57.15</td>
</tr>
<tr>
<td>Thickness of wall</td>
<td>9.52</td>
<td>14.5</td>
<td>12.20</td>
</tr>
</tbody>
</table>

Table-2: Material Properties at Elastic Phase

Kinematic hardening model is been selected for plastic zone. Then material properties for plastic zone are defined as per table-3.

<table>
<thead>
<tr>
<th>Yield Stress in MPa</th>
<th>Value of µ [Poisons Ratio]</th>
</tr>
</thead>
<tbody>
<tr>
<td>200 MPa</td>
<td>0.3</td>
</tr>
</tbody>
</table>

Table-3: Material Properties at Plastic Phase

<table>
<thead>
<tr>
<th>Stress Component</th>
<th>Value of µ [Poisons Ratio]</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

As meshing is also a important parameter in determining the nodes & sensitivity of the results. Mesh Size is been selected as 2 mm by greed independence. After sectioning & selecting proper instances analysis is performed & then yielding pressures for each cylinder are find out which is as per table-4.

Table-4: Yielding pressure values for respective cylinder

Now the working pressure should has lower values than the Yielding pressure, However Autofrettage pressure should has higher value than that of yielding pressure.

<table>
<thead>
<tr>
<th>Cylinder Model</th>
<th>I</th>
<th>II</th>
<th>III</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yielding Pressure in MPa</td>
<td>29.08</td>
<td>39.47</td>
<td>34.97</td>
</tr>
</tbody>
</table>

Table-5: Abaqus CAE results post loading.

3. ANALYTICAL VERIFICATION OF FEM RESULTS

Above results can be verified in working phase, where stresses are below yielding stress. In elastic limit for Structural Steel Lame’s equation is quite appropriate. Equation value of the Lame’s equation is taken as below:

\[
\sigma_r = \frac{a - \frac{b}{r^2}}{480 \text{ MPa}}
\]

\[
\sigma_c = a + \frac{b}{r^2}
\]

Circumferential Stress is given by Equation 2 as below-

By putting conditions in above.
equations, after solving simultaneously following values can be obtained as per table-6.

<table>
<thead>
<tr>
<th>Model</th>
<th>Model- I</th>
<th>Model- II</th>
<th>Model- III</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pressure considered in MPa [Below yielding]</td>
<td>27</td>
<td>35</td>
<td>30</td>
</tr>
<tr>
<td>Value of ‘a’</td>
<td>66</td>
<td>53.70</td>
<td>55.76</td>
</tr>
<tr>
<td>Value of ‘b’</td>
<td>0.24</td>
<td>0.229</td>
<td>0.2213</td>
</tr>
<tr>
<td>Analytical value of Maximum Stress in MPa.</td>
<td>159.00</td>
<td>142.44</td>
<td>141.51</td>
</tr>
</tbody>
</table>

Table-6: Analytical Values of Maximum Stress during working loading.

Sample Abaqus result for Model-I cylinder with 27 MPa working loading is shown in figure-2.

![Stress analysis of Model-I Cylinder for working pressure of 27 MPa.](image)

Figure-2: Stress analysis of Model-I Cylinder for working pressure of 27 MPa. [Maximum Stress is noted as 169.4 MPa]

4. RESULTS

Similarly for all three Models analytical & FEM results are compared as per table-7 which is shown below-

<table>
<thead>
<tr>
<th>Cylinder Model</th>
<th>Model- I</th>
<th>Model- II</th>
<th>Model- III</th>
</tr>
</thead>
<tbody>
<tr>
<td>Working Pressure considered in MPa [Below yielding]</td>
<td>27</td>
<td>35</td>
<td>30</td>
</tr>
<tr>
<td>Analytical value of Maximum Stress in MPa.</td>
<td>159.00</td>
<td>142.44</td>
<td>141.51</td>
</tr>
</tbody>
</table>

| Value of Maximum stress in MPa by FEM | 169.40    | 158.5     | 154.6     |
| % Variation between FEM Analytical results. | 6.14      | 10.10     | 8.47      |

Table-7: Comparison of FEM results & Analytical results during working pressure range

5. DISCUSSION

FEM analysis of three cylinder models of different dimensions is done. For Model-I, stress reduction in maximum stress due to Autofrettage is observed as 7.6%. For Model-II, stress reduction in maximum stress due to Autofrettage is observed as 9.21%. For Model-III, stress reduction in maximum stress due to Autofrettage is observed as 7.56%.

Same FEM results are compared with analytical results during working pressure range. Average variation between FEM results & Analytical results is 8%. This may be due to properties variation, actual yielding, and porosity of material.

As a future scope Re-autofrettage concept can be proposed to have optimization in materials, uniformities in stress distributions & to eliminate hardening of materials. Experimentation can be done by hole drilling method & heat soak treatment can be imparted.

6. CONCLUSION

As stated above by Autofrettage we reduced stress generated amongst the cylinders. Our analytical outcomes are in line with Abaqus FEA outcomes with 6.14 to 10.10% variations.

As a future scope Re-autofrettage concept can be proposed to have optimization of materials, uniformities in stress distributions and also used for eliminating hardening of materials. For this new technique experimental checking can be done by slicing method for checking influence of residual stresses.
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PATIL SHRINIVAS KIRAN is currently working as Assistant Professor, Mechanical Engineering Department at MIT College of Railway Engineering, Barshi, Dist.- Solapur, MH, India. Total 6 Papers are on his credit which were published in International Journals. Currently he is pursuing Ph. D. from VTU Belgavi, Karnataka. He is having 13 years of experience from Academia & Industry.

SHARANABASAPPA C. SAJJAN is currently working as Professor & Head – Mechanical Engineering Department at KLE Institute of Technology, Hubballi, Karnataka, India. He did his Ph. D. From IIT Madras & Published more than 10 papers in reputed Journals. He is having 23 Years of Experience from Industry & Academia.
PERFORMANCE INVESTIGATION OF PV THERMAL COLLECTOR BY USING WATER COOLING.

Mr. Saurabh R. Savdekar¹, Mr. Varun S. Kingar², Mr. Ninad D. Chaudhari³, And Mr. Akshay D. Salunké⁴,
¹Dept. of E&T Engineering, Pimpri Chinchwad College Of Engineering and Research, Ravet, Pune, Maharashtra, India, 412101 ²Dept. of E&T Engineering, Pimpri Chinchwad College Of Engineering and Research, Ravet, Pune, Maharashtra, India, 412101 ³Dept. of E&T Engineering, Pimpri Chinchwad College Of Engineering and Research, Ravet, Pune, Maharashtra, India, 412101

ABSTRACT

The recent upsurge in the demand of photovoltaic systems is due to the fact that they produce electric power without causing much damage to the environment by directly converting the solar radiation into electric power. Solar energy is completely natural, it is considered as a clean energy source. So, the study on enhancing the efficiency of solar panels very necessary. Photovoltaic cells get overheated due to excess solar radiation and ambient temperature. Therefore, to rectify this problem different cooling systems are used so as to maintain the temperature of the cells the abundance of solar energy is a blessing in the Arabian Peninsula, where more than 2000 kWh/m² density has been recorded annually. This has resulted in sincere consideration of PV harvesting in the energy matrix and smart grid. However, artefacts such as degradation of PV efficiency due to the high temperature effect have to be addressed. This paper presents a novel design of a PV cooling system using water to mitigate the effect of high temperature. Several experiments have been conducted, and the results have been analyzed. It has been found that the collected water from the panel after 40 min of cooling gained a temperature of 10 °C approximately, during December 2016. Eventually, the efficiency was improved by 10.35% (without using MPPT) using water at ambient temperature and the temperature of the panel during solar peakly. These results, which are the first of their kind in Qatar, constitute good incentives and pave the way for further investigation to enhance PV efficiency in harsh environments. This would be of paramount significance, especially for scaling up PV deployment in Qatar and GCC countries in their 2030 vision.


1. INTRODUCTION

Currently the world is facing the problem of energy deficit, global warming, and deterioration of environment and energy sources; there is a need for an alternative energy resource for power generation other than use of fossil fuels, water and wind. Fossil fuel will get depleted in next few decades, hydro power plants depend on annual rainfall and wind power depends on climate changes. Like water and air, the sun is one of earth’s life support system providing heat and light. Solar energy which is renewable widely available and clean provides enough energy to meet the world’s annual consumption needs. The power from the sun intercepted by the earth is approximately 1.8×10¹¹ MW which is larger than the present consumption rate on the earth of all commercial energy sources. Thus, solar energy could supply all the present and future energy needs of the world on a continuing basis. This makes it one of the most promising of the unconventional energy sources. One of the major technologies used for harnessing the solar energy is photovoltaic solar technology. In photovoltaic solar technology a panel consisting of many solar cells is used. A solar cell is a semiconductor device that directly converts the energy from sunlight into electrical energy through the process of photovoltaic. The photovoltaic cell (solar cell) converts only a small fraction (~ less than 20%) of the irradiance into electrical energy the valves’ converted into heating of the cell. One of the important parameters that affect the energy output is the efficiency of the cell. The electrical efficiency of the cells decreases with temperature increase. Cooling can improve
the electrical production of standard flat panel PV modules, since cooling keeps the PV cells from reaching temperature at which irreversible damage occurs. It has been found that the efficiency and output power of PV module is inversely proportional to its temperature.

2. LITERATURE SURVEY

[1] Swar A. Zubeer, H.A. Mohammed, and Mustafa Ilkan [2] studied that the present article has highlighted different techniques of cooling for small domestic use photovoltaic panel. It is concluded that:

- The temperature of the PV cell decreases about 12°C by using heat sink with air cooling.
- In case of air cooling the electrical efficiency of the system does not always increase with increasing the mass flow rate of the air but there is an optimum value of mass flow rate.
- Water spray cooling has a considerable effect on the performance of the PV cell, even for the low flow rate of the water spray the performance of the system enhances remarkably.
- Water cooling has the most impact on the reduction of the operating temperature of the PV cell and improves the electrical performance of the PV panel.
- Cooling system with fins is efficient to reduce the temperature of the PV panel and enhance the electrical efficiency of the PV panel.

1. Zhijun Peng, Mohammad R. Herfatmanesh, Yiming Liu [1] studied that in this research, effects of solar PV surface temperature on output performance have been experimentally investigated under different radiation condition for exploring variation of output voltage, current, output power and efficiency. A cooled case for solar PV performance has been also performed by spreading ice on the back of solar panel. Based on those results, a cooled solar PV system has been proposed for resident application. By analyzing the electric and hot water output, the lifecycle assessment for comparing non-cooled and cooled solar PV systems, in terms of their payback time of system cost, was conducted. With those investigations, the following conclusions have been derived.

1. Under different radiation condition there exists an optimal surface temperature for solar PV to produce the maximum efficiency. The higher the radiation is, the higher the optimal surface temperature.
2. When solar panel is cooled down, the efficiency can have significant increase. The optimal surface temperature for highest efficiency can have obvious increase for cooled condition, compared to non-cooled condition.
3. In this research with ice for providing cooling function on the back of solar PV panel, the efficiency of solar PV can have an increasing rate of 47% with cooled condition.
4. A cooling system has been proposed for possible system setup of residential application to cool down the solar panel. Life cycle assessment suggests that the cost payback time can be reduced to 12.1 years, compared to 15 years of the baseline of a similar system without cooling sub-system.

3. Nair Milind, Midhun Antony, Febin Francis, Jithu Francis, Joson Varghese, Sajith U K [3] reviewed that A solar cell is a semiconductor device that directly converts the energy from sunlight into electrical energy through the process of photovoltaic. The photovoltaic cell (solar cell) converts only a small fraction (~ less than 20%) of the irradiance into solar energy the valences’ converted into heating of the cell. One of the important parameters that affect the energy output of the PV module or the system is the operating temperature. The electrical efficiency of the cells decreases with temperature increase. Cooling can improve the electrical production of standard flat panel PV modules, since cooling keeps the PV cells from reaching temperature at which irreversible damage occurs. It has been found that the efficiency and output power of PV module is inversely proportional to its temperature. Freeflow front water cooling of PV panels can improve the efficiency and reliability of photovoltaic energy conversion the open voltage of the panel is increasing when its temperature decreases, and due to the lower operating temperature, its life cycle could be increased.

4. J. Paul Guyer, P.E., R.A.,[4] have reviewed the state-of-the-art of solar cooling has concentrated primarily on the developmental stages of systems in the last few years. Various methods have been researched, and some demonstrated, but only a few systems have been installed for other than research purposes. Solar cooling systems are attractive because cooling is most needed when solar energy is most available. If solar cooling can be combined with solar heating, the solar system can be more fully utilized and the economic benefits should increase. Solar cooling systems by themselves, however, are usually not economical at present fuel costs, Distilled water has been suggested for use in solar collectors since it avoids some of the
problems of untreated potable water. First, since the distillation process removes contaminants such as chlorides and heavy metal ions, the problem of galvanic corrosion, though not completely eliminated, should be alleviated. However, distilled water is still subject to freezing and boiling. For this reason, an antifreeze/anti-boil agent such as ethylene glycol is often added.

5. Li Huang and Rongyue Zheng [5] have reviewed in this paper presents a performance simulation and economic analysis for both PV and thermal solar cooling systems in the hot-summer and cold-winter zone in China. It was determined that 30.7% of the annual primary energy can be saved by the PV system and 30.2% by the thermal system compared to the heat pump system. However, the payback time of the PV system is 67 years and that of the thermal system is more than 20 years. The main reason for this is that the system has high initial investment and is short of financial support from the government. Therefore, the PV system is more suitable for utilization in the hot-summer and cold-winter zone in China at present. The thermal system could be an attractive alternative when the middle and high temperature solar thermal collector technology has been further developed, as well as following mass production of small- and middle-sized chillers.

6. Nasser Ahmad, Amith Khandakar, Amir El-Tayeb, Kamel Benhmed, Atif Iqbal and Farid Touati [6] have reviewed in this paper was deliberately focused on mitigating the effect of high temperature on PV system efficiency in harsh environments like Qatar and the Middle East. To this end, a proof of concept cooling system by water has been developed, and several experimental studies during peak solar radiation were carried out on back and front PV surfaces. Water-cooling. Water flow on the front and back of PV panels cleans the pan by removing improves the efficiency by more than 10%. Furthermore, in addition to cooling PV cells, a back-cooling water reservoir supplied hot water during cooling, which can be used for other applications. Since Qatar is hot for most of the year, cooling by water could be a significant solution for PV energy improvement. However, the scaling up of this approach to large-scale PV farms would require further studies into the cost and system optimization to assess its viability.

7. Saurabh Mehrotra, Pratish Rawat, Mary Debbarma and K. Sudhakar [7] have reviewed in this article presents electrical performance of the solar photovoltaic using water immersion cooling technique. A preliminary study of applying this technology in a university building of MANIT, Bhopal has been described with different water depths in the outdoor environment during a period of 6 days from 18/04/2014 to 23/04/2014. The maximum efficiency of 4.76% was obtained under 1 cm depth of water with the proposed design and operating condition. The results show that as the depth increases, the surface temperature of the panel decreases and the electrical efficiency increases, particularly after which it begins to fall. A maximum increase of 17.8% in electrical efficiency of the panel was observed, which clearly depicts the improvement in the performance of the panel and encourage the use of water immersion cooling technique in Concentrated Photovoltaic systems where the cell temperature increases and the resulting decrease of electrical efficiency of the cell.

8. Hashim A. Hussein, Ali H. Numan, and Abdulmunem R. Abdulmunen [8] have concluded that, with increased efficiency, the payback period of the system canalsobeshortened [5]. The electrical efficiency reduction of PV modules due to their temperature increase can be partially avoided by water or air heat extraction. PV heating is mainly the result of the absorbed solar radiation that is not converted into electricity and PV cooling is considered necessary to keep electrical efficiency satisfactory level. Natural or forced air circulation is a simple and low-cost method to remove heat from PV modules, but it is less effective if ambient air temperature is over 20°C, as it is usual for many months in low latitude countries. The performance of PV panels reduces with increasing temperatures. Therefore, most panels’ will not operate under ideal conditions due to different weather conditions or real ones. Since PV panels are more efficient at lower temperatures, PV systems have to design with active and passive cooling the increase in efficiency and the power output depends largely on the cooling the temperature of the panel, which allows the greatest benefit from the whole system. Using a cooling technique of water on the rear surface of PV/T system as a coolant cools it down enough to cause it to generate more power than one without water. Experimental results showed that the PV cells power is increased due to cooling water for the photovoltaic cells. This can significantly increase the system efficiency. It was found that without active cooling, the temperature of the PV module was high and solar cells could only achieve a conversion efficiency of about 8%. However, when the PV module was operated under active water-cooling condition, the temperature was dropped to (76.8°C at 0.1L/s), (74.5°C at 0.2L/s) and (70.1°C at 0.3L/s). This temperature dropping led to increase in the efficiency of solar panel to 8.6%.
and 9.6%) respectively, depending on water mass flow rate, and the thermal efficiency to (12.3%)

9. Saad Odeh and Masud Behnia [9] concluded that the surface cooling technique of the PV module was developed in this study to improve the performance of a PV powered water pumping system. An arrangement of pipe fittings was used to allow water flow under gravity on the PV module upper surface. Tests under different weather conditions were conducted. The results showed an increase of system output in the range of 410% when the developed cooling technique was adopted. Part of this increase (50%) is due to cooling by direct contact between water and PV module surface; the other part is due to refraction of the solar beam in water layer and the increase in incident radiation. Long-term performance analysis at different sites showed that a steady annual increase in PV module output was achieved at warm weather sites. At moderate weather sites in Australia, a significant increase in PV module output is reported only during a specific period between October and March. In conclusion, the major advantages of this technique are:

- A cooling efficiency due to the direct contact between water and PV module surface.
- Solar beam refraction in water layer.
- Maintaining the PV module upper surface free of dust due to continuous water flow.
- Process due flow under gravity.
- A cooling technique that is simple and can be added to any standard module without a significant increase in cost.

10. Bhaskar B Gardas, M V Tendolkar [10] have reviewed that the increase in temperature of the panel results in decreasing its electrical efficiency. The results from the theoretical model developed are found to be in better agreement with those mentioned in the reference. The discrepancy between the two values is attributed to the unaccounted losses occurring in practice. Also, the relative efficiency and cell efficiency temperature coefficient values (Eq. 8 in Section VI) of both the papers are different. The reference efficiency of 12.7% and cell efficiency temperature coefficient of 0.0063 is used in thereference [20], whereas in the present work the relative efficiency of 15% and cell efficiency temperature coefficient 0.0045 are used. The electrical power output increases with the increase in solar irradiance, being a direct function of solar irradiance. Solar cells generate more electricity when receiving more solar radiation but the efficiency drops when temperature of solar cells increases. Hybrid photovoltaic and thermal collector is the solution to this problem. Simulation model for single pass, single duct solar collector with fins is developed and performance curves are analyzed. The simultaneous use of hybrid PV/T and fins has a potential to significantly increase in power production and reduce the cost of photovoltaic electricity. Seven gases are passed through the duct to identify the gas which would give the maximum heat transfer, with minimum mass flow rate & minimum number of fins. The gas identified is hydrogen. For hydrogen, the system requires a mass flow rate of 0.00275 kg/s, which is the least of all other gas mass flow rate values & Number of fins required are 3.46.

11. Mohammad Alobaid, Ben Hughes, Dominic O’Connor, John Calautit, Andrew Heyes [11] This research describes the design and analysis of a PVT system for producing electricity and thermal energy. The performance of the PVT systems is based on several factors that include PVT’s materials, design, ambient temperature, inlet and outlet fluid temperature and PV cell temperature. The overall PVT system performance is calculated by using mathematical method. The results which were based on the climate conditions, show that the PVT performance was improved. Increasing incident solar radiation on PV module due to were influenced by several factors that included instantaneous solar radiation, ambient temperature, inlet fluid temperature, PV cell temperature and back surface temperature. Elimination of the circulating pump required for the cooling process due to the effect of back surface temperature on thermal efficiency. Electrical efficiency was in the range of 14.7% to 15.5% and sensitive to the PV cell temperature. It decreased from 14.72% to 14.27% due to the increase in temperature from 29.1°C to 35.8°C. The efficiency value of the system is 14.27% due to the increase in PV cell temperature from 29.1°C to 35.8°C. Thermal efficiency was in the range of 72% to 83% and was influenced by several factors such as instant solar radiation, ambient temperature, inlet temperature and outlet fluid temperature. Sensitive study is required to investigate the effect of back surface temperature on thermal efficiency. A PVT arrangement was proposed which connects cells thermally in series in the same panel. Cell temperatures increased from inlet to the outlet due to the increase in water temperature. PVT electrical efficiency decreased from 14.33% at the cell to 14.22% at the outlet cell due to the increase in the PV cell temperature. PVT thermal efficiency decreased from 70.79% at the cell to 69.74% at the outlet cell due to the increase in water temperature through the cells. Another arrangement was proposed for a PVT system, which based on 72 panels connected in one array. PVT performance curves were worked out for different inlet water temperature. Different configurations of connecting panels in series

VOLUME 01, EDITION 01, 2020 Pimpri Chinchwad College Of Engineering and Research, Ravet  Page 258
important factor to select the configuration, which should not exceed the manufacturing specification for the maximum temperature.

12. Rahul S, Hariharan [12] concluded that after the detailed reference and performance study of various factors like electrical efficiency, thermal efficiency and power outputs, it can be concluded that cooling of the solar panel increases the electrical efficiency and also improves power output values. Using two systems namely a water-based PV/T system and an air-based PV/T system both systems used for the cooling of the panel and thus improvement in the efficiencies and power output values are obtained. In this analysis water cooling method and air-cooling method are used and the efficiencies are increased by considerable amount. When the temperature of the panel decreases the performance factors varies very effectively, by lowering the value of temperature ultimate efficiency of the solar panel can be increased. This cooling method is also an effective method of improving the cell efficiency and the other important factor in this analysis is we can use the heated water or heated air for other useful purposes. That is the main advantage of the system, separate installation of water heater or air heater can be avoided, this can be used for both purposes, for increasing the cell efficiency and usage of heated water or heated air for other useful purposes.

13. Rajat Sharma, Ayush Gupta, Gopal Nandan, Gaurav Dwivedi, Satish Kumar [13] have reviewed that the maximum conversion efficiency of solar photovoltaics technology module is 4.17%. Rest of the solar energy incident on panel is either absorbed by photovoltaics panel or is lost to the surroundings. As the operating temperature of the panel increases, the conversion efficiency decreases. The factors on which the temperature of module depend are incident solar radiation, reflection of solar radiation, radiation and convection loss from PV module and various ambient conditions. Efficiency of PV system increase when temperature of PV module decreases therefore is important to cool the PV modules to operate at maximum efficiency. The maximum power output decreases 0.4% per degree Celsius rise in cell temperature. The lifespan of panel also decreases due to operation at high temperature. Various cooling techniques have been proposed in the literature to get maximum overall module efficiency. The use of water as coolants has been used by various researchers to cool it. Researchers used water to front surface of the PV system, rear surface of PV system, both front and rear surface of PV module or completely immersed the module in water. This reduced panel operating temperature. Besides the efficiency improvements due to cooling, the film of water also kept the panels clean, avoiding any reduced power output caused by panel soiling. For cooling of solar photovoltaics panel active technique have been reported. The temperature pro-rates for front panel were from 2°C/min to 4.5°C/min have been reported.

14. Y.M. Irwan, W.Z. Leow, M. Irwanto, Fareq M, A.R. Amelia, N. Gomesh, I. Safwati [14] concluded that the solar simulator system with halogen lamp bulbs has been successfully designed and fabricated in this experiment. With a solar simulator, tests of PV panel performance can be carried out at any chosen time, continued for 24 hours a day. The main objective of the solar simulator is to analyze the performance of the panel with and without the water-cooling mechanism in indoor tests. The electrical efficiency of PV panel depends on many environmental factors, one of which is the operating temperature of PV panels. The increase in operating temperature of PV panel significantly decreases the electrical yield of PV panels. DC water cooling mechanism was used to solve this problem. A DC water pump will be spraying water over the PV surface for cooling of PV panel. Water has the ability to exhaust more heat out of the PV panel. The pump will be spraying water over the PV panel when it is operating at high temperatures. The reflection of solar radiation that absorbs by PV panel also decreases the electrical yield of PV panels. Water can be used to cool the panel at high temperatures. In the comparison between performance of PV panels with and without water cooling mechanism, water flow over the front surface of PV panel can be reduced the operating temperature of PV panel, which results in increased the electrical energy efficiency. The experimental results mentioned that the decrement of operating temperature was around 5 - 23 °C increase in the power output of the PV panel with a water-cooling mechanism by 9 - 22%. The increment of power output will have a significant contribution to the PV system applications. An increase in efficiency of PV panel, investment payback period of the system can
reduce and the lifespan of PV panel will also belonger.

15. H. Bahaidarah, Abdul Subhan, P. Gandhidasan, S. Rehman [15] have reviewed Numerical and Experimental analysis of a PV-water cooled hybrid system is studied regarding its electrical and thermal performance. The system is tested under the climatic conditions of Dhahran, Saudi Arabia. Based on the results obtained, the following conclusions are drawn:

1. A detailed numerical model (coupled electrical and thermal) capable of predicting the thermal and electrical performance of the water-cooled PV system is developed using EES software.

2. A solar thermal collector (cooling panel) is fitted underneath of the PV panel which captures the waste heat from the panel producing hot water and increased electrical power. The effect of incorporating a solar thermal collector with the PV module is investigated experimentally.

3. There is a good agreement between the numerical and experimental results for module surface (front and back) temperatures, outlet water temperature, thermal gain, maximum power output and efficiency.

4. The PV panel efficiency is sensitive to the panel temperature and decreases as the temperature of the panel increases. With active cooling technique, the operating temperature of the module dropped significantly to about 20% and an increase of 9% in the electrical efficiency was observed.

16 Linus Idoko, Olimpo Anaya-Lara, Alasdair McDonald [16] This experiment achieved the following results:

- An appreciable increase in the module output power with module + Al heat sink & water-cooling of the module surface temperature
t power increase of 20.96 W at 12:45 pm at 80% derating factor used in order to account for losses. This increase in output exceeds 250 Watts with 0% losses.
- An increase in efficiency above 3%, hence the PV module and the power output were enhanced using the multi-concept cooling technique.

A 250 W PV module considered with a derating factor of 80% implies that the power output expected from the module in an ideal situation is 200 W. Since the maximum power expected from the PV module is 200 W, power output in excess of 200 W is an addition. module + Al heat sink & water-cooling generated more power than the module without Al heat sink and the higher power output generated by the PV module

was achieved with module + Al heat sink & water- 13:45 pm and 14:45 pm, power output exceeded 200 W by 20.96 W, 0.72 W and 15.85 W respectively.

17. Muhammad Faizan Younas, Muhammad Abubaker, Hafiz Muhammad Ali, Muhammad Ahsan Nawaz [17], studied the Effect of water-based cooling was investigated on the performance of photovoltaic panel using steel channel on its rear side. Data was recorded for the month of May, 2018. Results showed high effectiveness of cooling technique as panel temperature dropped as high as 27.5 ºC when compared with reference solar panel. This resulted in increase in all performance related parameters: i.e. power output, efficiency and performance ratio. Overall efficiency was recorded to be 16.99 % for steel channeled panel while for reference panel it was measured to be 15.38 %. Similarly, power output enhances to 12.85 % for steel channeled PV panel. This research not only shows the strong potential of solar energy in areas like Sahiwal, Pakistan, but it also serves an attempt to improve the PV panel performance panel. Further research can be carried out to find out the optimum water flow rate and to find more suitable material for channels for water circulation.

18. Billel Boumaarafa, Khaled Touafekb, Mohamed Salah Ait-cheikha, Mohamed El Amine Slimanic [18]. The paper provides a comparison study between a classical PV generator and water glazed PVT collector. Two numerical models have been developed and evaluated through a simulation under the MATLAB environment. The classical PV generator has been validated experimentally. Electrical and thermal performance evaluations for both systems have been done under Ghardaïa city climatic condition. The electrical efficiencies reach 7% and 6.26%, for the classical PV generator and the glazed PVT collector respectively while the overall thermal efficiencies reach 18.43% and 74.2%, for the two systems respectively; the simulation environment is considered with a mass flow of 0.0125 kg/s Finally from this comparative study, we can conclude that:

- The glass-cover produces an increase in the temperature range between the same layer and the other layers of the PVT.

- The electrical efficiency of the classical PV generator is higher than that of the glazed PVT.

- As predicted. In terms of overall energy output, the classical PV generator presents the lowest daily mean of the
overall thermal efficiency

19. Calebê Abrenhosa Matias, Licínio Moraes Santos, Aylton José Alves, Wesley Pacheco Calixto [19] This work showed that decreasing the panel operating temperature, when subjected to cooling apparatus, is the factor responsible for the increase of the voltage and consequently the increase of the amount of energy produced. In initial conditions, without cooling apparatus, the photovoltaic panel produced 62 W/h; after using a water flow rate of 2 L/min it produced around 77 W/h, a gain of 24%. A hypothetical case of water transport was implemented to simulate the amount of energy needed to cool the panel for 1 hour. Then the comparative analysis of the increase in efficiency using the cooling apparatus revealed that the water flow rate of 2 L/min on the front surface of the panel provides the highest net power increase, 16.66%. The apparatus, consequently, can be implemented in industrial facilities, where there is reuse water potential, in order to increase the amount of energy produced and/or reduce the payback period of the investment. The results show that the water distribution system, under the PV panel can be improved to optimize the efficiency of the water flow used.

20. Ahmed Amine Hachicha, Chaouki Ghenai, Abdul Kadir Hamid [20] concluded that the electrical performance of a PV panel is sensitive to its operating temperature and can significantly affect when cell temperature starts to rise. In order to overcome this problem, a cooling system is required to decrease the temperature and enhance the electrical performance. Different cooling methods are presented and analyzed to improve the operation of the photovoltaic system. Cooling the PV panel is more effective from the front side than the back side and may also increase the optical efficiency by removing the dust and impurities from the PV surface. Module temperature is decreased by 11% using front cooling while it is decreased by less than 2% with back cooling. In this study, the temperature of the PV cell is reduced by up to 18% when water is circulated in the front and back side of the PV module. As a consequence, the electrical efficiency is increased by 4%. Such solution can be combined with a solar thermal system to produce hot water while cooling the PV panel and achieving higher energy conversion of the absorbed solar radiation melting characteristics, to test their efficiencies.

21. Jin-Hee Kim, Se-Hyeon Park, Jun-Tae Kim [21], concluded in this study, a PVT air collector with a mono-crystalline PV module was designed, and an experiment was performed in order to confirm its electrical and thermal performance in an outdoor environment. From the experimental results, it was found that the heated air from air-higher temperature than the outdoor air. The experimental results indicated that the thermal and electrical efficiencies of the PVT collector were, on average, 22% and about 15%, respectively. For the electrical efficiency, the PVT air collector was operated as the maximum output due to the prevention of PV temperature rise through forced exhaust. These mean that the performance of the PVT air collector was similar to performance of standard test condition (STC) without a decrease in efficiency due to PV temperature. Therefore, it was concluded that the heated air taken from the PVT collector can be supplied into the ventilation system in building as pre-heated fresh air, and contribute to better electrical performance at the same time. Verification of the performance of this PVT collector under standard test conditions is needed, and further studies are required to establish an experimental model of the PVT collector linked to a building system such as heating and heat recovery ventilation in order to assess the contribution of the collector to the building energy performance.

22. K.A. Moharram, M.S. Abd-Elhady, H.A. Kandil, H. El-Sherif [22] have reviewed that the objective of this research is to cool the PV panels using the least amount of water and energy. A non-pressurized cooling system has been developed based on spraying the PV panels by water once in a while. A cooling rate model has been developed to determine how long it will take to cool the PV panels by water spraying to its operating temperature. A mathematical model has been used to determine the heating rate of the PV panels, in order to determine when to start cooling. An experimental setup has been developed to validate both models, i.e., the heating and the cooling rate models, experimentally, and to study the influence of cooling on the performance of PV panels. It can be concluded from the results of this study that:

1. It is possible to cool and clean the PV panels using the proposed cooling system in hot and dusty regions.
2. The cooling rate for the solar cells is 2°C/min based on the concerned operating conditions, which means that the cooling system will be operated at a time of 5 min, inorder to decrease the module temperature by 10°C. The result of the cooling rate model has shown good agreement with the experimental measurements.
3. Both the heating rate and the cooling rate models
have been validated experimentally.

4. The PV panels yield the highest output energy if cooling of the panels starts when the temperature of the PV panels reaches the maximum allowable temperature (MAT), i.e.,

5. C. The MAT is a compromise temperature between the output energy from the PV panels and the energy needed for cooling.

23. Raudensky M.*, Astrouski I., Reppich M. and Schmidt M. [23] concluded that all of the tests showed that cooling the module improves its efficiency. The mean efficiency increase is about 50% and it is expected that it can be even more for high-efficiency modules. The investigation of new commercially available photovoltaic modules could show how high the appropriate additional income would be. On the other hand, this increases the cost and requires energy to operate the pump in the hydraulic circuit of the coolant. These efforts are particularly advantageous in limited space because the electrical power generated per square meter increases and thermal energy can be produced without the installation of additional devices. Although cooling of PV panel with hollow fibers is feasible (up to 1 kW of heat can be removed by cooling system reducing the module temperature from to about 50 °C) further research is still required. It is associated with both economic reasonability and durability of the fiber cooling system. The approach using the fibers with feeders was not reliable enough and should be reconsidered. Overall, the durability of polypropylene fibers is still questionable, and the possible application of more resistant kinds of plastic, such as polyamide, would be reasonable. The experimental results have shown how quickly an uncooled or insufficiently cooled photovoltaic module reaches temperatures that are quite close to the temperature at which polypropylene loses its mechanical strength.

24. Matthew K. Smith, Hanny Selbak, Carl C. Wamser [24] have reviewed that although surface cooling systems have been examined in the past, this study reveals that there are scenarios in which such a system can be particularly advantageous. Surface cooling with flowing water becomes more effective when used on solar installations where the panels are being exposed to unusually high temperatures because of their racking configuration (e.g., mounted directly on a roof surface with no ventilation) or a naturally hot climate or both. The requirements for such a system are remarkably simple: an inexpensive (aquarium) pump, a mechanism for uniform dispersal of a thin film of water, and a tank and distribution system to recirculate the water. The power required by the pump is generally substantially less than the power improvement created by the cooling effect. Water losses due to evaporation are small, but a system for monitoring water levels and periodic replenishment would be necessary. Finally, it has been demonstrated that the proposed cooling system is capable of maintaining low operational temperatures even when the panels are exposed to concentrated sunlight. Thus, the cooling system could be used to address the significant temperature increases that are the primary concern of low concentration PV systems.

3. CONCLUSION

The objective of this research is to cool the PV panels using the least amount of water and energy. A non-pressurized cooling system has been developed based on circulating the water from spiral copper cooling the panels at backside of the PV panels once in a while. It is possible to cool and clean the PV panels using the proposed cooling system in hot and dusty regions. Water cooling of PV panels can improve the efficiency and reliability of photovoltaic energy conversion when the open voltage of the panels is increasing as its temperature decreases. It has been concluded that the PVT Collectors need to be optimized so as to improve its thermal and electrical efficiencies.

- The electrical efficiency of the PV panel is to be improved with more effective cooling techniques.

- Studies on the effect of geological conditions and its effect on performance and efficiency are a matter of concern.

- Studies on mass flow rate and its effect on efficiency of hybrid panel needs to be done thoroughly.

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AUTHORS PROFILE

FIRST A. Saurabh
Ravindra Savdekar
Mechanical Engineering
JSPM’S RSCOE, Pune.

SECOND B. Varun Sunil Kingar
Mechanical Engineering
SPM’S RSCOE, Pune.

THIRD C. Ninad Dhiraj Chaudhari
Deepak Salunke
Mechanical Engineering
JSPM’S RSCOE, Pune.
A Comprehensive Analysis of Designing and Manufacturing Dies for a Plastic Moulding Production

Akshat M. Akut¹, Tanmay N. Salke², Ajinkya P. Barbade³, and Omkar U. Mulay⁴

¹Department of Mechanical Engineering, NBN Sinhgad School of Engineering, Ambegaon, Pune, Maharashtra, India, 411041
²Department of Mechanical Engineering, NBN Sinhgad School of Engineering, Ambegaon, Pune, Maharashtra, India, 411041
³Department of Mechanical Engineering, NBN Sinhgad School of Engineering, Ambegaon, Pune, Maharashtra, India, 411041
⁴Department of Mechanical Engineering, NBN Sinhgad School of Engineering, Ambegaon, Pune, Maharashtra, India, 411041

ABSTRACT In earlier decades die manufacturing was highly costly and complex process. Conventional die was manufactured on lathe machine and moulding was done by hand moulding machine. This process was less accurate, time consuming and required more labour. However, in recent years due to development of advance manufacturing processes there has been significant decrease in cost of die manufacturing, also increased accuracy and increased productivity. Recent developments in CAD-CAM software products have helped this process for better research and development. The current die manufacturing procedures are very costly, with an average die costing for about 2 lakh rupees. The aim of this paper is to provide an up-to-date survey with graphical representation for easy understanding of the past, present and future of all the domains included in this project which are designing and manufacturing of a die for an object which is to be produced by plastic moulding by a production enterprise. The flow of this paper includes a brief introduction to all the above stated topics, their approaches, discussions and conclusion.


INTRODUCTION

Plastic moulding is the process of shaping plastic using a rigid frame or mould. The technique allows for the creation of objects of all shapes and sizes with huge design flexibility for both simple and highly complex designs [5], [2]. A popular manufacturing option, plastic moulding techniques are responsible for many car parts, containers, signs and other high-volume items.

A. OVERVIEW OF PLASTIC MOULDING

The underlying concept of plastic moulding is placing liquid polymer into a hollow mould so that the polymer can take its shape, often with various ranges of pressure and heat required. There are different plastic moulding techniques available to accomplish this including rotational moulding, injection moulding, blow moulding, and compression moulding to name just a few. Each technique has its benefits and is best suited for the creation of specific items.

Plastic injection moulding uses a ram or screw-type plunger to force molten plastic material into a mould cavity; this solidifies into a shape that has conformed to the contour of the mould [3]. It is most commonly used to process both thermoplastic and thermosetting polymers, with the volume used of the former being considerably higher. Thermoplastics but are prevalent due to characteristics that make them highly suitable for injection moulding, such as ease of recycling, versatility for a wide variety of applications, and ability to soften and flow on heating [7]. Thermoplastics also have an element of safety over thermostets; if a thermosetting polymer is not ejected from the injection barrel in a timely manner, chemical crosslinking may occur causing the screw and check valves...
to seize and potentially damaging the injection moulding machine [3], [7].

A parting line, sprue, gate marks, and ejector pin marks are usually present on the final part. None of these features are typically desired, but are unavoidable due to the nature of the process [1]. Gate marks occur at the gate that joins the melt-delivery channels (sprue and runner) to the part forming cavity. Parting line and ejector pin marks result from minute misalignments, wear, gaseous vents, clearances for adjacent parts in relative motion, and/or dimensional differences of the mating surfaces contacting the injected polymer [2]. Dimensional differences can be attributed to non-uniform, pressure-induced deformation during injection, machining tolerances, and non-uniform thermal expansion and contraction of mould components, which experience rapid cycling during the injection, packing, cooling, and ejection phases of the process. Mould components are often designed with materials of various coefficients of thermal expansion [6]. These factors cannot be simultaneously accounted for without astronomical increases in the cost of design, fabrication, processing, and quality monitoring. The skillful mould and part designer position these aesthetic detriments in hidden areas if feasible.

Plastic injection moulding is used to create many things such as wire spools, packaging, bottle caps, automotive parts and components, toys, pocket combs, some musical instruments (and parts of them), one-piece chairs and small tables, storage containers, mechanical parts (including gears), and most other plastic products available today [8]. Injection moulding is the most common modern method of manufacturing plastic parts; it is ideal for producing high volumes of the same object [4].

**B. CONCEPT OF DIE MANUFACTURING**

A die is a specialized tool used in manufacturing industries to cut or shape material mostly using a press. Like moulds, dies are generally customized to the item they are used to create. Products made with dies range from simple paper clips to complex pieces used in advanced technology [9].

Forming dies were typically made by tool and die makers and put into production after mounting into a press. The die was a metal block that was used for forming materials like sheet metal and plastic. For the vacuum forming of plastic sheet only a single form was used, typically to form transparent plastic containers (called blister packs) for merchandise. Vacuum forming was considered a simple moulding thermoforming process but uses the same principles as die forming. For the forming of sheet metal, such as automobile body parts, two parts may be used: one, called the punch, performed the stretching, bending, and/or blanking operation, while another part that was called the die block securely clamps the workpiece and provided similar stretching, bending, and/or blanking operation. The workpiece may pass through several stages using different tools or operations to obtain the final form. In the case of an automotive component, there was usually be a shearing operation after the main forming was done and then additional crimping or rolling operations to ensure that all sharp edges were hidden and to add rigidity to the panel [11].

**30. LITERATURE REVIEW**

A great deal of research is being carried out to understand, identify critical factors and possibly the moulding processes [5]. Most of the work carried out in the last decade was based on: theoretical, computer-based
simulation models and practical experimental trials. Dan Tursi and Bistany (2000) attempted to study the effect of tooling factors like kind of mold material did significantly affect sink marks. Iyer and Ramani(2002) in an attempt to study the use of high thermal conductivity material, sink marks defect was taken as quality parameter. It was observed that thermal conductivity of mold material does influence sink marks. Erzurumlu and Ozcelik (2006) used Taguchi technique to minimize warpage and the sink index [1]. In their study they considered mold temperature, melt temperature, packing pressure, rib cross section and rib layout angle and material PC/ABS, POM, PA66. They find in their research that packing pressure is influence the factor for PC/ABS plastic products, rib cross section influence POM material plastic product and rib layout angle influence PA66 material plastic product significantly [1], [5].

Taguchi Method is a process/product optimization method that is based on 8-steps of planning, conducting and evaluating results of matrix experiments to determine the best levels of control factors [1]. The primary goal is to keep the variance in the output very low even in the presence of noise inputs. They are statistical methods, sometimes called robust design methods, developed by Genichi Taguchi to improve the quality of manufactured goods, and more recently also applied to engineering, biotechnology, marketing and advertising [5]. Professional statisticians have welcomed the goals and improvements brought about by Taguchi methods, particularly by Taguchi’s development of designs for studying variation, but have criticized the inefficiency of some of Taguchi’s proposals [1], [5].

The injection moulding has seen steady growth since its beginnings in the late 1800’s. The technique has evolved from the production of combs and buttons to major consumer, industrial, medical, and aerospace products [2].

In 1868, perhaps in response to a request by billiard ball maker Phelan and Collander, John Wesley Hyatt invented a way to make billiard balls by injecting celluloid into a mould. By 1872, John and his brother Isaiah Hyatt patented the injection moulding machine. The machine was primitive yet it was quite suitable for their purposes. It contained a basic plunger to inject the plastic into a mould through a heated cylinder [2].

Revolutionizing the plastics industry in 1946, James Hendry built the first screw injection moulding machine with an auger design to replace Hyatt’s plunger. The auger is placed inside the cylinder and mixes the injection material before pushing forward and injecting the material into the mould. Today, almost all injection moulding machines use this same technique [3].

Plastics are synthetically produced non-metallic compounds. It can be moulded into various forms and hardened for commercial use. Plastic moulding products can be seen everywhere. Examples are jars, protective caps, plastic tubes, grips, toys, bottles, cases, accessories, kitchen utensils and a lot more [7].
Even the keyboard and the mouse that you use are made through plastic moulding. Even the plastic parts of the chair that you are sitting on are created this way [7].

The basic idea in plastic moulding is inserting molten liquid plastic into a ready shaped mould, for example the mould of a bottle. It will be then allowed to cool, then the mould will be removed to reveal the plastic bottle [7], [8].

Plastic moulding can also custom-mould a wide variety of plastic products including: garden pots, cabinets, office trays and boxes, barriers, barricades and traffic signage and displays for product and marketing promotions [8].

A. PREVIOUS METHODS USED FOR PLASTIC MOULDING

The Plastic Moulding Processes are stated as follows according to their process characteristics: [1], [2], [3], [5]

In Injection Moulding, melted plastic is forced into a mould cavity. Once cooled, the mould can be removed. This plastic moulding process is commonly used in mass-production or prototyping of a product. Injection moulding machines were made in the 1930’s. These can be used to mass produce toys, kitchen utensils, bottle caps, and cell phone stands to name a few.

 Blow moulding is like injection moulding except that hot liquid plastic pours out of a barrel vertically in a molten tube. The mould closes on it and forces it outward to conform to the inside shape of the mould. When it is cooled, the hollow part is formed. Examples of blow moulding products are bottles, tubes and containers.

In Compression Moulding, a slug of hard plastic is pressed between two heated mould halves. Compression moulding usually uses vertical presses instead of the horizontal presses used for injection and blow moulding. The parts formed are then air-cooled. Prices of equipment used for compression moulding are moderate.

Hollow moulds packed with powdered plastic are secured to pipe-like spokes that extend from a central hub. The moulds rotate on separate axes at once. The hub swings the whole mould to a closed furnace room causing the powder to melt and stick to the insides of the tools. As the moulds turn slowly, the tools move into a cooling room. Here, sprayed water causes the plastic to harden into a hollow part. In this type of plastic moulding, tooling costs are low and piece prices are high. Cycle time takes about 40-45 minutes. This technique is called Rotational Moulding.
In Thermoforming, sheets of pre-extruded rigid plastics are horizontally heated and sucked down into hollow one-piece tools. When the hot plastic solidifies, its shape conforms to that of the mould.

Tooling costs are usually low and piece prices vary on the machinery.

Plastic moulding is a very technical process. It needs experts in this type of manufacturing business for it to be competitive in the market. Therefore, a very scientific and systematic study should be first made before going into this endeavor.

B. DIFFERENT TYPES OF DIES USED PREVIOUSLY

There are five main types of manufacturing dies available in the market which were used often in the previous times and some of them are also used nowadays. They are classified as given: Conventional dies, Inverted dies, Compound dies, Progressive dies and Combination dies.

In conventional dies, the punch holder is fastened to the press and the die shoe is fastened to the bolster plate. The punch is fastened to the punch holder and aligned with the opening in the die block using guide pins. The stripper holds the scrap strip so that the punch may pull out of the hole [9], [12].
In combination dies, the cutting operation is combined with a non-cutting operation. The cutting operations may include blanking, piercing, trimming, etc. These are combined with non-cutting operations like bending, extruding, forming, etc [9],[12].

C. DEFECTS IN MANUFACTURING DIES
Most of the die and tooling defects can be removed through operations known as die corrections. Some die defects are so critical in nature that they cannot be repaired and directly lead to die failure. In other cases, further repair is not possible after various die corrections have been done, resulting in the scrapping of the die. Many researchers have attempted to investigate or analyse individual die defects. Arif et al. conducted a more comprehensive study on die failure modes and mechanisms and presented a statistical analysis of the main die failure types and their sub-divisions. The focus in the current paper is not die failures but die corrections [12].

Five major categories of die defects are fracture, wear, deflection (plastic deformation), design/manufacturing, and hardness. The first three (fracture, wear, and deflection) relate to the structural and geometrical condition of the die after being used for some time and can be generally seen distinctly without the aid of a measurement device. The last two (design/manufacturing flaws and hardness problems) usually require an instrument for their detection [12].

Fracture defects appear as uneven crevices on the die surfaces and are caused by the large thermo-mechanical stresses combined with stress concentration locations in the profile. Rib cracks can lead to some minor deflections...
in the mandrel which are correctable in nature. Initiated cracks may propagate under fatigue loading over multiple extrusion cycles. The crack propagation mostly leads to ultimate brittle failure in the form of fracture of any feature of the die [9].

Fracture is also caused by the grain boundary severity of carbides in the steel die, by reducing the ductility and resistance to temperature variations. Gradually, the inhomogeneity and segregation increase in the die material. It also occurs as a consequence of poor tooling selection, resulting in insufficient support to the die. Cracks are usually seen on bearing, mandrel, and ribs that take load from the flowing metal. To prevent fracture defects, proper die hardness levels should be maintained by routine nitriding; mandrels should be designed so that they are free from high unbalanced mass variations and sharp edges, and ribs must be designed for minimum temperature increase and smoother flow [12].

FIGURE 16. Some fracture and wear defects: bearing crack leading to fracture (top left); crack on rib and mandrel leading to deflection (top right); rib crack (bottom left); severe bearing washout (bottom right).

Wear defects refer to the wear and tear of critical surfaces during service (such as the die bearing) and are typically of two types. Erosion is the deterioration or degradation of the surface, whereas washout appears as craters or linear depressions accumulated in certain regions. If the bearing washout is severe, the dimensions of the profile can change and lead the profile to go off geometry and beyond the tolerance limits. The causes of the wear defects include hard inclusions in the billet, improper setup parameters, loss of hardness, and high temperature rise due to friction. To reduce the wear problems, the die surfaces can be coated with a wear-resistant metal. This coating can reduce the uptake of hard inclusions, adhesion, thermal fatigue, and friction. Other benefits of coating include a higher oxidation temperature up to 750°C and high corrosion resistance. The polishing of dies before each cycle can facilitate the smooth metal flow over the ribs and bearing. Wear can also be minimized by ensuring the hardness levels of critical regions of the die and mandrel.

Deflection defects are caused by the plastic deformation of the die or its features due to thermal or mechanical stresses or a combination of both. Deflection in the mandrel can happen for two reasons. First, a plastic deformation can happen because of thermo-mechanical stresses occurring on the ribs and mandrel. Second, when a crack or fracture occurs on the rib, the mandrel gets bent to an angle from the central axis. This will result in flow-related product defects due to the bend in the cavity. The mandrel deflection can also lead to a dimensional change (angle and wall thickness) of the profile. A feature deflection can alter the dimensions of features in the extruded product, and sometimes this dimensional change (linear or angular) may exceed the designated tolerance limit, and the product will have to be scrapped. To reduce deflection defects, enough support and rigidity should be provided to the mandrel section through a proper selection of tooling. The rib regions should be polished for a smooth metal flow. To prevent feature deflection, additional tooling may be included, such as an insert-bolster attached to an insert-holder to match the aperture of the die backer. Another measure is to use an alternative custom backer, suitable for the die backer aperture.

Some die defects are due to flaws or miscalculations in designing the die geometry, to die material issues, or to manufacturing errors. These problems are therefore categorized as design/manufacturing defects. Sometimes, they cannot be detected until after at least a few trial or actual extrusion runs. Inaccurate angles can result in metal flow variations in different regions of the profile and may result in concave/convex product defects. The ribs control the flow of metal through the cavities of dies. The ribs may have excessive material (distended), and this will cause

FIGURE 16. Some fracture and wear defects: bearing crack leading to fracture (top left); crack on rib and mandrel leading to deflection (top right); rib crack (bottom left); severe bearing washout (bottom right).
obstruction to the metal flow in the cavities. Once the flow is obstructed, the pressure will rise and may cause flashing defects (the metal passes over the die) or blocked metal flow. Distended ribs can be easily corrected by machining off the excess material. This will reduce the pressure build-up [9].

The two types of hardness-related die problems are low-hardness and high-hardness. Low hardness makes the die softer than specified, resulting in dimensional and other errors in the extruded product. High hardness makes the die over-hard and brittle, increasing the chances of chip-off and other types of breakages. Routine grinding and polishing procedures may chip off the die bearing as tiny fragments because of its high brittleness. Once the bearing is chipped, it is usually not correctable. Common causes of these defects are either over-usage or improper re-hardening operations during die corrections. In such cases, a recalculation of the time required for periodic nitriding of the dies may be needed. The orientation of the dies while they are placed in the carbonitriding chamber must be checked for a uniform heat distribution. The preheating time of the dies should not be too long [12].

Defects that cannot be categorized into any of the above types are named other defects. These could be a combination of the major defects or defects due to setup errors or inefficient correction operations during die maintenance. If the die is not corrected properly, this can cause various flow-related problems, a temperature rise, and pressure build-ups at the die–billet interface. Correction beyond the tolerance limits can result in scrapping the die. The supervision of correction works by a co-worker or supervisor is usually practiced. Training workshops can be held from time to time to instruct the workers and improve their die correction knowledge and practical experience. The die inspection tools must be checked periodically for errors and recalibration requirements. One of the most common setup errors is the malfunctioning of the die preheating oven (also called die furnace). Usually, the dies are preheated at 450–500 °C for a time period of two hours. If any of these parameters are not maintained satisfactorily, thermo-mechanical stress variations may occur. Billet preheating is another factor which is done at 420–450 °C. The die furnace and billet furnace should be monitored and controlled appropriately. Another setup error is related to the choice of the right type of bolster, feeder plate, and die backer, which are essential for ensuring the rigidity of the die during extrusion and avoid cracks or fracture defects. A proper and rigid setting of the tool-stack should be ensured in the die slide. The performance of selected die sets and tool-stacks should be monitored from time to time, evaluating the appearance of crack defects on the die.

**D. OVERALL ANALYSIS**

It should be restressed here that this data regards die corrections and not die failures [9], [12]. This analysis was conducted for the full three-year period, on an annual basis. The major die defect classification is the same as described above: fracture (Fr), wear (Wr), deflection (Def), design/manufacturing (D/M), hardness (Hd), and other (Oth). The figure below presents the data in the form of a pie chart. For the combined three-year dataset, the majority of the die corrections (around 80%) were due to the defect types of fracture, wear, and other. The most frequent single category (32%) was other defects (defects happening during correction operations, mixed-mode defects, and setup damages), followed by wear (28%), fracture (19%), problems related to design or manufacturing (14%), and hardness and deflection (7%). The annual trend of die defects was almost the same as that for the three-year period, with minor differences [12].

![FIGURE 17. Peeling caused by hardness defect (left); correction error of excess chiselling (right)](image-url)
In the case of failed dies, the most frequent defect categories were fracture, wear, and plastic deformation (deflection). However, as observed above, the most common correctable die defects were other, wear, and fracture. The dies were brought to the die repair shop after every set of extrusion cycle, either for routine or specific repair. Small mistakes or inaccuracies in these correction operations led to further repair requirements, making “other repairs” the most common category. Fractures were not always repairable and led to complete die failure in many cases, so their frequency was less than that of wear corrections. Loss of hardness, leading to plastic deformation (deflection), was usually very difficult to correct, constituting only 7% of the correctable defects. The dies with significant deflection defects were usually scrapped (rather than repaired), as correction attempts using heating and realigning techniques mostly do not work [10], [12].

As explained in the previous section, errors during die repair are the most common cause of correctable die defects. The die bearing surface is obviously less strong than the ribs or ports. Severe wear on the bearing (washout) is therefore a bigger source of die defects than the wear of the ribs, ports, and other surfaces (erosion). The most common fracture category is “bearing cracks”, because of the lower strength of the bearing compared to other die features. Most of the thermal and mechanical fatigue occurs in the bearing and rib regions. As for the design/manufacturing defects, features such as choke, relief, clearance, and undercuts are important in maintaining proper metal flow through the die cavities and in generating the correct shape and dimensions of the extruded product. Distended ribs are very critical to prevent blockages and flashing defects in extrusion. Looking at both the annual and the three-year defects distribution, it can be clearly seen that correction defects, bearing washouts, and bearing cracks were the most prevalent three die defects. If quality control, operations, and die-shop engineers and operators in commercial extrusion plants focus on eliminating or reducing the causes of these three defects, then a large portion of repair or rejection of dies and tools can be avoided. A notable, and perhaps

E. CATEGORY-WISE BREAKDOWN
The above analysis indicates that the major defect categories were other, wear, fracture, and design or manufacturing. A further break-down of each of these defects into their component categories is presented in Figure 2.16 for a three-year period. For other defects, the major contributor was errors during die correction operations (CD-65%), followed by setup damages (SD-20%), and combination of multiple defects (MM-15%). Correctable wear defects (Figure 10b) were due to two problems: bearing washout (BW-87%) and erosion (E-13%). In the fracture category, 75% of the defects were bearing cracks (BC), 23% rib cracks (RC), and 2% mandrel cracks (MC). Design/manufacturing errors (Figure 10d) were mostly (>40%) caused by insufficient or excessive choke/relief (IC/R), improper clearance/undercut (IC/U-35%), and distended ribs (DR-24%). The distribution of these die defects and corrections on an annual basis was almost the same as that for the three-year period [12].

FIGURE 18. Overall breakdown of correctable die defects during three years (total and annual)

FIGURE 19. Breakdown of the most frequent defects in three years
The surprising finding is that the highest number of die-related problems is caused by errors in the die shop during correction operations. This finding needs to be corroborated with repair data from other medium-to-large size extrusion facilities. The regional extrusion plant from where this data was collected should exercise more care in hiring die-shop technicians and must initiate periodic re-training programs to increase the technical know-how and skills of the hired personnel. More attention should also be paid during routine inspection and repair of tools and equipment used in the die shop [10], [12].

### 3.1. DESIGNING OF DIES

This is the initial stage of the whole die-making process. Die design is an emerging field in which cost-effective methods are employed for the production of a diverse range of things [10]. But for maximizing the profits it is absolutely necessary for the die designers to work in collaboration with die casters at the initial stages. This helps in solving problems related to tooling and production. It also helps in maintaining balance so that costs can be reduced to the minimum.

A die is basically made in two sections: the fixed die half and the ejector dies half [10]. The fixed die half is the cover half and the latter makes the removal of castings possible. Certain modern dies also have slides, cores or other such sections so that holes, threads etc. can be produced in the casting. Two methods are used for this purpose: Hot chamber method or Cold chamber method. When the die machine is closed the two die halves are locked [9].

One of the first steps involved in designing a die is the selection of a suitable alloy. The characteristic properties of a particular alloy must be studied in detail keeping in mind the purpose for which the die is required. Mostly alloy tool steels are used for the purpose. Zinc proves economical for small casts. Aluminum is light weight and has strength at high temperatures. Magnesium is the lightest alloy and the easiest one to machine. Copper is strong and has tremendous wear resistance. Lead and Tin have high density and are used for making parts having very close dimensions [9].

The next thing is the cost of materials that are required [10]. We should not be more concerned about the cost per cubic pound or cost per cubic inch but should take a holistic view. For example, as metals are stronger, they are required in less quantity than plastics for a particular purpose.

Innovations are being done in die design, the casting process and in the alloys used. As a result, more and more markets are coming under its ambit and strong, varied and high precision products are being manufactured [11].

In manufacturing discrete parts using dies or moulds, the part design must be compatible with the process in order to assure the production of high-quality parts at low cost with short lead times. Thus, part and process designs are best considered simultaneously, which is often not the case in practice. This objective can only be achieved through good communication between the product and tool designer, who may be in different companies (OEM and supplier) and/or locations [11].
The use of different CAD systems by OEMs and suppliers further complicates communication within the supply chain. Figure 4.2, taken from, shows the proliferation of CAD systems in the top three tiers of the North American automobile industry. Because die and mould making firms tend to be third or fourth-tier suppliers, the “interoperability problem” of reliably transferring CAD data between firms is particularly acute in this industry [11].

The class of additive fabrication methods usually known as “rapid prototyping” (RP) or “solid freeform fabrication” (SFF) processes have evolved considerably over the past decade. Although they were originally marketed as aids to design visualization and prototyping, in recent years the most promising application of these technologies has been in the area of rapid tooling for net shape processes. An excellent review was given as a CIRP keynote paper at the 48th General Assembly [10].

All of the processes currently in use follow the same basic sequence of steps to construct a component. The process begins with a CAD solid model of either a piece part or tool insert, which is typically transferred to the RP machine in STL format [11]. This data structure reduces the solid model to a set of triangular facets that define the surfaces of the part. This STL file is then “sliced” by the machine controller software, turning what was originally a three-dimensional object into an ordered set of two-dimensional layers. The part is then reconstructed, one layer at a time.

In general, it is found that the Die (or a Mould) goes through a series of processes which are generally recommended and sequenced at random depending on the availability of the material, machine or the resource [12]. This poses a problem for sequential and timely processing of the Die/mould coupled with quality issues. Most of the machining operations are Computerized control including Wire-cut, EDM, VMC machining followed by CMM inspection and so on which has a huge influence over the cost of the Die. As a result, the overall cost of the Die is high.

The point to consider here is that even the Die itself needs a well-defined process while being transformed from a stock of material or while it is being assembled with the help of standard components [11]. The varied
elements of a die ranging from the standard Die set, the die-block, the punch plate with the punch holder, compression springs and the other elements necessary for assembling the die calls for a make-or-buy decision. While standard parts are preferred to be bought out, the components to be manufactured in-house necessitates an elaborate ‘Process Plan’ for yielding the most economic die with the prescribed specs for quality [12].

Process planning is responsible for the conversion of design data to work instructions through the specification of the process parameters to be used as well as those machines capable of performing these processes in order to convert the piece part from its initial state to final form. Doing all this with computer-aided assistance is called computer-aided process planning (CAPP) [11].

![Figure 23. Framework for Process Planning](image)

We also are referring to the use of CAID (Computer Aided Industrial Design) [12]. CAID is a subset of computer-aided design (CAD) software that can assist in creating the look-and-feel or industrial design aspects of a product in development [12].

CAID programs tend to provide designers with improved freedom of creativity compared to typical CAD tools. However, a typical workflow may follow a simple design methodology as follows: Creating sketches, using a stylus, generating curves directly from the sketch, generating surfaces directly from the curves [10].

The end result is generally a 3D model that represents the main intent of the designer had in mind for the physical product. Such models can then be saved in formats for more convenient exchange with others or manufacturing. CAID helps the designer focus on the technical aspect of the design methodology rather than the sketching and modelling aspects, contributing to the selection of a better product proposal in less time. When product pre-requisites and parameters have been more completely defined, output from the CAID software can be imported into a CAD program for pre-production testing, adjustment, and generation of technical drawings and manufacturing data such as CNC tool-paths [11].

![Figure 24. The progression of CAD towards the consumer](image)

CAID is far more conceptual and less technically focused than CAD. CAID programs tend to offer more tools that allow a designer to freely express themselves with more organic shapes and complex curves, whilst CAD software tends to be more focused on tools for the simple curves and straight lines more suitable for easy manufacturing [10].

CAD implementations have evolved dramatically since initial 3D offerings in the 1970s, which were typically limited to producing drawings similar to hand-drafted output. Advances in programming and computer hardware, notably solid modelling in the 1980s, have allowed more versatile applications of computers in design activities [11].

### 32. MANUFACTURING OF DIES
In this stage, the final designs of the die would be considered for the manufacturing of the product [9]. All the original designs our team had done will be used specifically for this purpose. All the other parameters regarding the functioning, the complexity of modification, the ease of access, the method of plastic moulding, etc. play an important role in the actual die production. That is why, all these parameters must be analysed before starting the actual die-making procedure [11].

Die and moulds manufacturing will continue to represent a very significant aspect of production technology. They must be manufactured with even shorter lead times to offer flexibility and rapid introduction of goods to market. Thus, the role of process modelling, especially in making complex dies or moulds, becomes very important for reducing time allocated for process development and try out [9].

High speed machining is well established while hard machining is being rapidly accepted. Optimized tool path generation, to maintain constant chip load in machining complex sculptured surfaces, is offered by research centres as well as some software suppliers. The wider use of these technologies will allow die makers to become even more competitive [10].

The trend for unattended machining is very strong, mainly in industrially developed high wage countries. This mode of manufacturing requires robust processes, advanced tool path generation, and best possible use of machine tools and cutters [12].

The cutting tool industry continues to develop new cutter geometries and coatings for obtaining better surface finish and long tool life. Obviously, this trend will continue. However, these new developments require that the users, i.e. die shops, keep training their personnel and keep up to date about new developments in the industry. The continuous development of cutting tools is now being assisted by using FEM based simulation of the cutting process. While these techniques are still at their infancy, there is no doubt that process simulation in machining will be accepted by the industry, as it is the case with process modelling of stamping, injection moulding and forging [12].

It is desired to machine the dies and moulds in one single set up. Thus, deep cavities usually machined by EDM are often manufactured by milling with long and thin cutters. While this trend will continue, still there will be many applications where EDM is still the only cost-effective method of manufacture.

The machine tool and software suppliers offer, overall, rather good products for die manufacturing. The cutting tools, including geometry, substrate material and coating, need continuous improvement in order to further improve the machining conditions [9].

The material which is most widely used for the dies is Mild Steel (AISI 1018 Mild/Low Carbon Steel). AISI 1018 mild/low carbon steel has excellent weldability and produces a uniform and harder case and it is considered as the best steel for carburized parts. AISI 1018 mild/low carbon steel offers a good balance of toughness, strength and ductility. Provided with higher mechanical properties, AISI 1018 hot rolled steel also includes improved machining characteristics and Brinell hardness.

Specific manufacturing controls are used for surface preparation, chemical composition, rolling and heating processes. All these processes develop a supreme quality product that are suited to fabrication processes such as welding, forging, drilling, machining, cold drawing and heat treating.

A. OVERCOMING THE DEFECTS INVOLVED IN MANUFACTURING

We have stated the several defects which may occur during the manufacturing of dies and how often do they occur with respect to the timeline. We have also stated the detailed analysis of all the major as well as the most recurring defects occurring within the dies by showing the past data in the form of Pie Charts. Now, we will see how these defects could be overcome [12].

There are three ways by which a need for die corrections is identified. First, the new dies go through trial runs before being used for the actual production. If there are problems during these trial runs or if the extruded product from these trial runs is defective, die corrections may be needed. Second, the dies are inspected after every production run. Routine correction operations, such as die cleaning etc., are always required. Some other
Die corrections are done periodically, such as die re-hardening. Third, a poor product quality during actual production runs may suggest certain die corrections [12].

As mentioned earlier, a proper condition of dies and tooling is crucial for good product quality and plant productivity. Die failures leading to rejection result in production interruptions (down-time and up-time), and the replacement of the scrapped dies further adds to the cost and time. Hence, die corrections play a crucial role in maintaining productivity and profitability by making defective dies re-usable and avoiding (or delaying) a final rejection.

A die shop is the station where the dies are routinely inspected and repaired. Broadly speaking, die corrections are of two types: pre-service corrections and post-service corrections. Pre-service corrections are the ones carried out on new dies after the initial trial runs, before putting them in regular service. These corrections are mainly focused on adjusting the geometry or feed design, in case minor adjustments are needed. In some extrusion plants, it is customary to nitride (surface hardening) all the new dies before regular use. Post-service corrections are done every time the die is dismounted after being used for extrusion. They are mainly focused on correcting the flow, damage and wear, fractures, deflections, and loss of hardness. From another perspective, die correction operations can also be categorized into common corrections and task-specific corrections, described in detail below.

The die-shop technicians who perform die correction operations are called die correctors. They manage the die resources and are usually responsible for preparing the die assembly, performing trial runs, repairing, and maintaining the dies and related tooling. These workers must possess a high level of technical skills and knowledge. One die defect may be corrected in more than one way. Some corrections can be costly and time-consuming, while improperly selected corrections can reduce the die life. Another issue is that several die corrections may be required to rectify a single problem. Thus, a proper selection and execution of optimum corrective operations are very important.

Some major principles should be generally followed in carrying out any die correction operation. Corrections should be usually carried out at the back end of the die. Working at the front end can reduce the die life. A particular die should be corrected by one specific corrector, as he/she is familiar with the die and leaves a kind of mark or handwriting. All corrections must leave sufficient room for corrections in the future. Most of the corrections are done by removing some die material, so the selection and the extent of the operation should be determined appropriately to avoid a permanent damage of the die. Even though corrections are done, it should be kept in mind that problems can recur later. All correction details and design changes must be properly documented [9], [12].

B. COMMON DIE CORRECTOR OPERATIONS
As the name suggests, common die corrections are the operations done on all dies on a routine basis. The first in this category is cleaning and polishing of the dies. For instance, dies in aluminium extrusion are prone to aluminium oxide build-ups on the undercuts or clearances near the bearing. Sometimes, these oxides can be found sticking inside the welding chambers and ports, or even on the die face. These build-ups are blockages that can also cause product defects like die lines and pickups, so they should be eliminated after every production run. After being used, the dies are cooled sufficiently and then immersed in a tank of caustic soda solution at 60–80 °C for about eight hours. Without proper cooling, the hot dies might crack when put in the caustic tank. Caustic soda reacts with the oxide build-ups on the die and dissolves them. These dissolved residues are then removed by thorough washing. Care must be taken to ensure the complete removal of the residues, as they can cause product defects.

After washing, a gel is applied on the die and it is polished with an emery cloth of 600–320 grade. While polishing, the emery cloth and file are aligned perfectly square with the bearing surface. If this is not done carefully, rolling or tipping may occur, and the bearing edges may get rounded off, resulting in an undesired choke or relief.

Another routine die correction is nitriding or carbo-nitriding, a type of surface-hardening or case-hardening operation. This is required for new dies if they are not fully hardened by the manufacturers. The dies are also carbo-nitrided after cleaning and polishing. This hardening is also performed after a pre-specified amount of extrusion.
through the die, to ensure proper hardness levels. Once
the dies are cleaned, polished, and nitrided, the bearing
surfaces and other critical portions are protected before
storing the die, using lubricating compounds such as spray
paint, medium-weight oil, graphite spray, etc [12].

C. SPECIFIC DIE CORRECTOR OPERATIONS
These die corrections need to be carried out for specific
problems observed by the quality control or die-shop
personnel. Problems in the extruded product could be due
to die-related issues, wear and tear etc. of the die and
tooling itself. Described below are all the major die
correction operations generally carried out. Table 4.2 lists
the die defects and product defects for which each
corrective operation is carried out. Later, a brief
frequency-based statistical analysis of die defects is also
presented, based on three-year defect data from an actual
medium-to-large size commercial extrusion plant. It
should be pointed out here that die corrections can be
performed only a finite number of times. After repeated
die corrections of the same type, the die has to be
scraped because of issues regarding its strength,
dimensions, etc.

The bearings of dies and mandrels need to be
shortened when there is a requirement to increase the
flow at certain regions of the profile. This “shortening of
the bearings” is done by milling and grinding for
corrections and hand/machine polishing for small
corrections, resulting in a decrease of the frictional area of
the bearing land. Product defects such as speed
difference, concavity/convexity, angle-out, etc. can be
rectified using this operation. An increased metal flow can
also require a further fine tuning by filing the choke or
relief.

The operation of “choking” is performed when there is
a requirement to reduce the metal flow at certain portions
and is mostly done on hollow dies. It is the process of
giving an angle to the bearing or increasing the angle of
the bearing on the inner web, to decrease the metal flow.
Angle openings are very minute, and so this operation is
usually done by hand-filing and not by grinding. Once the
cap-bearing is choked, the same choke angle should be
given to the mandrel bearing. Since it is meticulous, this
operation is avoided whenever possible and is performed
only by highly skilled workers when necessary. However, it
occurs after shortening. Hence, choking is usually
employed when there is incorrect shortening, or
shortening can no longer be done [12].

The ridges in hollow dies may become blunt because of
die wash, mostly resulting from over-usage or out-of-limit
service. These ridges can be sharpened by “chiselling” the
edges. This is a temporary method of fixing and cannot be
generally repeated. Also, once it is done, the corrected
feature will not be maintained for a long time. Die
problems such as erosion, rib design defects, and
correction defects can be rectified with this operation.

“Undercutting” is mostly employed for the correction of
mandrels in hollow dies. Apart from blockages etc. due to
usage, there may not be sufficient metal flow because of a
design or manufacturing error. The flow speed and volume
will increase when blockages are relieved and chambers
are widened, as shown in Figure 4.5. Undercutting can
help prevent the product defects known as ripping and
flashing, in addition to speed difference and other flow-
related problems. Shallow grooves are sometimes created
on the die face by grinding to further control the metal
flow.

Pockets in the die can be carved out to increase the
metal flow. This “increasing of the clearance” will be done
after each carving, allowing more metal to flow. This is
usually done when the undercut is not sufficient [9], [12].

The depth of the chamber near the bridge can be
increased by milling or other machining techniques, as and
where required to regulate the flow. This “increasing of
depth” is usually done on the mandrels of dies for hollow
profiles.

“Machining/skimming” is mostly employed on the
bearings, port-holes, and ribs, for all kinds of wear and
washouts and dimensional inaccuracies. Sometimes, this is
done intentionally to adjust the metal flow in porthole
dies, to improve the product quality. Because of the high
hardness of H13 or similar steels, diamond tip tools are
mostly used. The die corrector’s skills are critical in doing a
good machining. After this operation, the die will have a
unique design, slightly different from the manufactured one.
FIGURE 25. Some die correction operations: undercutting (top left); milling (top right); welding (bottom left); grinding (bottom right).

The ribs and mandrels are always prone to plastic deformations after excessive use or large stresses, especially at high temperatures. These deflections are usually not correctable but can be repaired through “heating and realigning” in some cases. These corrections do not guarantee perfection and efficient functioning but make the die usable to some extent. Feature deflections related to profiles such as projections and cavities are also corrected (realigned) using this operation.

Also known as punching, “peening” involves the use of a punch and a hammer or peen. It is usually employed in the case of minor wear or deflection at the bearing edges of hollow dies, mandrels, and die surfaces. These edges and corners are peened with a hammer and a punch to impart slight adjustments. The dies can be heated (250–300 °C) and peened to prevent minute cracks, possible in cold working. However, this is generally avoided, as wrong punching pressures may destroy the design. The die surface or edges may gradually develop cracks or tiny fissures during service. These defective regions or spots can be repaired by “welding” and machining. Gas Tungsten Arc Welding (GTAW) is the method commonly used. Welding should preferably be done after annealing the die (550–650°C) to minimize cracks from thermal stresses. Another application is to weld a feature (such as tongue) back on the die when the feature is broken off or deflected. The new feature is made of the same material as the die and machined as per the drawings. Then, it is grafted on the die by welding.

Surface “grinding” can be used to rectify wear and geometrical deflections of the cavities. It can also be used to modify undercuts and clearances, etc. It can also be a secondary correction operation after other procedures (such as welding) [12].

Routine “nitriding” (or carbo-nitriding) has been described above. Here, it is discussed as a task-specific corrective operation. As a consequence of certain working conditions or after repeated usage, some damage or degrading of the top nitrided layer may occur. Low hardness (softening) may also be reported resulting from the thermo-mechanical conditions, especially in the bearing region. Such dies are re-nitrided to ensure sufficient hardness at critical regions. The Rockwell hardness of H13 steel dies after carbo-nitriding should be around 63–64 HRC. In addition to resolving low hardness problems, this process can protect and strengthen the newly welded portions after correcting deflection and fracture defects [9].

Die and product defects and related die corrections have been explained in the previous section. To achieve higher productivity and reduced rework and rejection, it is important to identify more frequent die-related problems and reduce and eliminate their occurrence. This section presents a brief frequency-based statistical analysis of actual correctable die defects. The data were collected from a regional aluminum extrusion facility, representing a typical medium-to-large size plant. This information is based on the number of dies sent for correction over a period of three years. All dies were made from H13 tool steel, and the aluminum alloy billets used were either Al-6061 or Al-6063.

D. CONSIDERATIONS TO OBTAIN THE DESIRED DIMENSIONS IN A MOULDED PRODUCT

The cavity dimensions of a mold for forming an injection-molded product can be expressed by the following equation.

Formula 7: \( L = M(1+S-E) \)

Whereas:
L: Mold cavity dimensions

M: Product dimensions

S: Mold shrinkage

E: Dimensional change resulting from environmental and usage conditions (temperature, water absorption, creep and other variables)

Causes for dimensional change in S and E are described below.

Linear mold shrinkage SL (what is ordinarily referred to as mold shrinkage) and volume mold shrinkage SV are defined by the following equations.

\[
SL = \frac{L_0 - L}{L_0} \times 100
\]

\[
SV = \frac{V_0 - V}{V_0} \times 100
\]

Whereas:
L0: Mold cavity dimensions
L: Product dimensions after leaving the molded product at room temperature for 24 hours after molding
V0: Mold cavity volume
V: Product volume after leaving the molded product at room temperature for 24 hours after molding

Assuming shrinkage occurs in a uniform and isotropic manner:

\[
L = \sqrt[3]{V}, \quad L_0 = \sqrt[3]{V_0}
\]

\[
SL = \frac{L_0 - L}{L_0} \times 100 = \left[ 1 - \left( \frac{V}{V_0} \right)^{\frac{1}{3}} \right] \times 100
\]

Ordinarily, however, shrinkage does not occur uniformly and isotopically, so it does not work.
W = S/V: Shape coefficient (1/m)
S: Exposed surface area (m²)
V: Volume (m³)
D: Diffusion constant(m²/S)

FIGURE 27. Equilibrium water absorption for each nylon grade (23°C)

33. CONCLUSION
The current die manufacturing procedures are very costly, with an average die costing for about 2 lakh rupees. Hence, the main motivation of this paper and for our group was to analyze this procedure and search for errors and cost reduction. Hence, this paper provides a detailed analysis towards designing a die which would use maximum area of die to increase the productivity, optimizing the cost of manufacturing the die, designing the runners which would provide stable flow of molten plastic, avoiding the problems like flashes and runout and choosing the appropriate material for semi-automatic injection moulding method. Therefore, in order for all this to take place, we have systematically arranged the flow of this paper and explained meticulously the same in respective modules: studying and analyzing the basic concepts regarding plastic moulding and manufacturing dies, and going through each and every detail regarding the procedures which must be conducted for the same. Also, comprehensive study is given to the materials which must be chosen for their respective roles in their respective domain.

REFERENCES


AKSHAT M. AKUT was born in Dhule, Maharashtra, India, in 1998. He received the Secondary School Certificate from Guru Nanak English High School, Kalyan, Maharashtra, in 2014 and the High School Graduate degree from Hill Spring International Junior College, Kalyan, in 2016. He will also shortly receive the Bachelor of Engineering degree in Mechanical Engineering from Savitribai Phule Pune University (SPPU), Pune, in 2020.

From 2016 to 2020, he was affiliated with NBN Sinhgad School of Engineering for the BE program in Mechanical Engineering, where he was a part of eight projects, out of which he was the project leader in four of them, including a research project and an industrial project. He has given a total of nine seminars with presentations at the Department of Mechanical Engineering at NBN Sinhgad School of Engineering, and even one at a state-level conference with proceedings where his presentation was ranked in the top 5. He has also worked as a project lead intern at Viram Plastics, a small-scale industry in the plastic moulding domain, for a sponsored industrial project.

Mr. Akut was a recipient of a prize for excellence in the Annual 10th Grade Maharashtra State Board English Examination by Guru Nanak English High School, in 2014. He also has professional memberships with major organizations like Space Development Nexus and Inter-University Centre for Astronomy and Astrophysics, as he got the privilege of being a selected attendee amongst the few candidates for their national as well as international programs like internships, workshops, trainings, conferences, etc.

TANMAY N. SALKE was born in Pune, Maharashtra, India in 1998. He received the Secondary School Certificate from Pride English School, Pune, Maharashtra, in 2014 and the High School Graduate degree from Muktangan Junior College, Pune, in 2016. He is currently pursuing the B.E. degree in mechanical engineering at NBN Sinhgad School of Engineering, Pune affiliated to Savitribai Phule Pune University.

Mr. Salke has worked in various science promotional activities since last 9 years. He has also conducted aeromodelling workshops with his team. He also worked in Nirmitee Bhaishal Mukta Vidyapeeth, which is a company helping academically failed students by giving them jobs they can do. His specialization is in CAD designing, and works in plastic domain. He is currently an entrepreneur and owns Futureline Scientific Products, which is a company manufacturing science toy products. His primary aim is to promote science and practical knowledge in children for better skill development.

AJINKYA P. BARBADE was born in Pune, Maharashtra, India in 1998. He received the Secondary School Certificate from Sainik School, Satara, Maharashtra, in 2014 and the High School Graduate degree from the same school in 2016. He is currently pursuing the B.E. degree in mechanical engineering at NBN Sinhgad School of Engineering, Pune affiliated to Savitribai Phule Pune University.

In 2019, Mr. Barbade successfully completed his internship and certifications in Ansys workbench and Hypermesh softwares, from Eleation company, Pune. His seminar reports and mini-projects includes sterling engine and counter of rpm of moor using Aurdino and digital display screen. His interests comprise of Digital Manufacturing, designing and creating innovative solutions. He also had served NGO named Bhumi for 2yrs.

OMKAR U. MULAY was born in Pune, Maharashtra, India in 1998. He received the Secondary School Certificate from the Sinhgad Spring Dale School, Pune, Maharashtra, in 2014 and the High School Graduate degree from Abasaheb Garware College, Pune, in 2016. He is currently pursuing the B.E. degree in mechanical engineering at NBN Sinhgad School of Engineering, Pune affiliated to Savitribai Phule Pune University.
An Overview of Computer Aided Process Planning and its Applications in Digital Manufacturing

Akshat M. Akut

1Department of Mechanical Engineering, NBN Sinhgad School of Engineering, Ambegaon, Pune, Maharashtra, India, 411041

ABSTRACT Computer aided process planning (CAPP) is the application of the computer to assist process planners in the planning functions. It is considered as a very important parameter amongst both computer-aided design (CAD) and computer aided manufacturing (CAM). Nowadays, CAPP is extensively used in several major manufacturing enterprises. In this article, an attempt is made to provide a comprehensive overview on CAPP based on those several parameters. The aim of this paper is to provide a detailed survey with graphical representation for easy understanding of the past, present, and future of CAPP and also the vital role it plays in Digital Manufacturing and how it can be integrated with CAPP and how precise it can prove as an application towards Digital Manufacturing. This paper includes a brief introduction to CAPP, its approaches, a detailed survey and its role in Digital Manufacturing.


3. INTRODUCTION

The importance of CAPP in a manufacturing facility cannot be underestimated. One of the reasons for this is that it provides a link between design and manufacturing and reduces the time and cost and improves the quality [7]. The CAPP area has been greatly developed in the last three decades [1].

The use of computer technology for process planning was initiated four decades before. Since then, there has been a large amount of research work carried out in the area of computer-aided process planning (CAPP). One of the reasons for this is the role of CAPP in reducing throughout time and improving quality. CAPP is the application of the computer to assist process planners in the planning functions. It is considered as the key technology for computer integrated manufacturing (CIM) [1]. It consists of the determination of processes and parameters required to convert a block into a finished part/product. The process planning activities include interpretation of design data, selection, and sequencing of operations to manufacture the part/product, selection of machine and cutting tools determination of cutting parameters, choice of jigs and fixtures, and the calculation of machining time and costs [10].

It can also be called as the use of computer technology to aid in the process planning of a part/product. In manufacturing, CAPP is the link between CAD and CAM. In that, it provides for the planning of the processes to be used in producing a designed part. It is the linkage between the CAD and CAM module. Process planning is concerned with determining the sequence of individual manufacturing operations needed to produce a given part/product. The resulting operation sequence is documented on a form typically referred to as a route sheet (also called as a process sheet/method sheet) containing a listing of the production operations and associated machine tools for a work part or assembly [1]. Process planning in manufacturing also refers to the planning of use of blanks, spare parts, packaging material, user instructions, etc.
modified for a new part and print the plan. Other
capabilities were table-driven cost and standard
estimating systems for sales representatives to create
customer quotations and estimate delivery time [10].

There are two basic approaches to CAPP: variant and
generative [1], [10]. From these two basic approaches, the
variant approach continues to be used by some
manufacturing companies. Nowadays, the trend is toward a
generative approach [2].

A. VARIANT APPROACH
Also called as retrieval approach, it uses a group
technology (GT) code to select a generic process plan from
the existing master process plans developed for each part
family and the edits to suit the requirements of the part.
The variant approach is commonly implemented with the
GT coding system [10]. Here, the parts are segmented into
groups based on similarity, and each group has a master
plan. The advantage of this approach is the ease of
maintenance, but the lack of an on-time calculation of
manufacturing processes and quality of the process plan
still depends on the knowledge of a process planner and it
still requires manual inputs for the establishment of the
mass data into manufacturing processes [1].

B. GENERATIVE APPROACH
In this approach, a process plan for each component is
created from scratch without human intervention. These
systems are designed to automatically synthesize process
information to develop a process plan for the part [2].
These systems contain a logic to use manufacturing
database and suitable part description schemes to generate
a process plan for a particular part. Generative approach
eliminates disadvantages of the variant approach and
bridges the gap between the computer-aided design (CAD)
and computer-aided manufacturing (CAM) [3]. The
bottleneck of this approach is the difficulty in obtaining the
useable features and the difficulty in representing,
managing and utilizing human expertise [1].

C. METHODOLOGIES IN COMPUTER AIDED PROCESS
PLANNING
There are ten established methods or technologies of
computer-aided process planning [1]. They are as follows:
feature-based technologies, knowledge-based systems,
artificial neural networks, generic algorithms (GAs), fuzzy
set theory and fuzzy logic, Petri nets (PNs), agent-based
technologies, internet-based technologies [5], standard for
exchange of product data (STEP) compliant method,
functional blocks to overcome the issues of machining
operation, tool and machine selection and sequencing,
feature extraction, reorganization, interpretation and
representation, knowledge integration, representation,
acquisition and sharing, setup planning, integration of
product and manufacturing data, intelligent tool path
generation, optimization problems. Intelligent decision
making and sharing of knowledge, integration of process
planning and scheduling [9].
Feature technology plays a key role in process planning with two approaches: feature recognition and design by features. This approach has been adopted by many process planning systems, due to its ability to facilitate the representation of various types of part data in a significant form to drive automated CAPP [9]. Knowledge-based technology allows the capturing of knowledge from experts and is able to simulate the problem-solving skills of a human expert in a particular field. Neural networks have an ability to recognize transitional and complex features without feeding any previous knowledge into the system and they also have the ability to derive rules or knowledge through training with examples and can allow exceptions and irregularities in the knowledge. Generic algorithms are generally good at finding acceptably good solutions to problems quickly. They do not need gradient information or smooth functions, and they have to be carefully structured and coded. Agent-based approach offers some unique functionality for distributed product design and manufacturing [1].

The fact that process planning for a complex part can be broken down into smaller planning problems makes these problems manageable by a number of intelligent agents working in cycle. Fuzzy logic and Petri nets technologies are used in CAPP by combining with other technologies to offer better solutions. Internet-based technology enables engineers to achieve the dynamic tool and machining selection, thus aiding the existing CAPP system to generate realistic and economical process plans [9]. Is also allows process planners in any industry to react to any unexpected changes and to support the data exchange between different systems used in different companies. STEP-compliant in CAPP leads to the likelihood of using standard data throughout the entire process chain in the manufacturing atmosphere, hence increasing the system’s capability of integrating with other systems in the complete CIM environment. The functional blocks approach plays an active role in CAPP in response to shop floor uncertainty because functional block (FB)-embedded algorithms can make decision adaptively to changes at run time and can be integrated with dynamic scheduling and STEP-numerical control (NC) system [10].

CAPP has vast no. of applications in the production sector as well as the design sector. It plays an important role in planning the different processes involved in that particular sector. It has been employed for various casting industries [3] as well as major polymer moulding manufacturing industries also [4].

35. LITERATURE REVIEW

The idea of developing a process plans using computers was presented by Niebel in 1965. In 1984, Harold presents the first review article on CAPP in which scholars discussed about the approaches and strategies for structuring manufacturing methods and data development for the development of a generative type-automated planning system. That article also outlines the anticipated development of a “common language of geometry” to relate a part to the process and development of CAD/CAM systems that incorporated CAPP [2]. In 1988, Ham and Lu presents an assessment of CAPP status and appropriately stated that the direction of future research lies on the integration of design, manufacturing, and the use of artificial intelligence (AI) technologies. In the following year, the most significant survey of that time was accomplished by Atling and Zhang, which indicated that the difficulty in the integration of CAD with CAPP is due to the lack of common methods to represent geometric entities [10]. In this survey, the author also recognized AI technologies as a crucial technology in the development of an effective process planning system and also pointed out the importance of the learning systems and identified an ideal approach to integrate all the information involved in production of a part into a single database.

The authors also highlighted the issue of interfacing between CAPP and CAM and other computerized production systems such as NC tool path, MRP, production simulation, etc [10]. In the same year, a survey of the 128 systems of CAPP was in print by Goudaand Taraman, which highlights the four types of CAPP systems: variant, semi-generative, generative, and expert process planning system. In the year 1993, a survey was conducted by El Mararghy in which the issues of quality and evolving standards are addressed. That survey also included the major development thrust in CAPP, evolving trends, challenges, integration of design, and production planning. In the same year, Eversheim and Schneewinf suggest that the future of CAPP development is an extension to assembly planning, function integration with NC programming, use of AI methods in decision making, and use of database sharing for data integration with CAD. In year 1995, an overview of the techniques and the role of process planning was discussed by Kamrani et al. That article also highlights the critical issues and the
characteristics associated with evaluation and selection of a CAPP system. In the following year, a comprehensive review on CAPP was published by Leung, in which the author observed that solid modelling in CAPP systems is not as adequate as anticipated, hence the revitalization of variant process planning systems [1].

The scholars believed that it is logical that future process planning systems be built on intelligent system architectures with AI techniques. In 1997, an 8-year survey (1990–1997) was in print by Cay and Chassapis, which provides an overview of manufacturing features and feature recognition techniques with CAPP research [3]. In the following year, a review was presented by Marrie et al., which covers the literature from 1989 to 1996. In that article, the advantages and disadvantages of the systems were discussed with the generative approach highlighted [2]. After a 10-year gap, Xu et al. presented an article which provides a comprehensive review on CAPP technologies developed for machining since the 1990s, but mostly after 2000. In that article, the researchers provided an up-to-date review of the CAPP research works, a critical analysis of journals that published CAPP research works, and an understanding of the future direction in the field [1].

In year 2008, Hu et al. presented XML-based implementation of manufacturing route sheet documents to solve the operation sequencing problem for web-based process planning. This method is an extension of the artificial immune system approach and inherits its characteristics from Maslow’s hierarchy of needs theory related to psychology. In the same year, Alvares et al. presented an integrated web-based CAD/CAPP/CAM system for the remote design and manufacture of feature-based cylindrical parts [3]. In this system, the information about features was manipulated through a relational database system. A GUI was implemented in Java and HTML. Later in year 2009, Agrawal et al. addressed the DPP problem in the e-manufacturing environment. In that article, the authors presented a multiagent system consisting of three autonomous agents: global manager, design, and optimization. These agents are capable of communicating to each other through XML. In year 2013, an Internet-based CAD/CAPP/CAM prototype system for the remote manufacturing of mechanical components was developed. In the same year, Wang developed a process planning and machine availability monitoring system based on the Internet [5].

36. DIGITAL MANUFACTURING

Rapid development of science and technology sets the following main requirement to high-performance and high efficiency production: it has to be ready and able to stop manufacturing its previous, well-established product at any time and without losses, and within a short period of time switch to manufacturing a batch of any size of new product type. This and many other problems can be solved by introducing digital technologies followed by creation of a single digital platform, where all components of an information system are integrated with each other, with further perspective of implementing “digital manufacturing” [6]. In most cases, the term "digital manufacturing" means an information (electronic) model of hi-tech production embracing main trends in advanced manufacturing technologies, as well as new materials and information and communication resources. This model includes information about all processes taking place in manufacturing, as well as all volume of information about product, which can be classified by stages of its life cycle.

Development of an information model is necessary to create single information environment of an enterprise [5]. With the expansion of production volume and product mix and increase production rates, the need for management information increases dramatically. Increasing requirements for information. Created at the enterprises of the system are already inadequate. In the new conditions it raises the question of the organization of complex information systems including all documentation, codes and media, covering a range of indicators required for management enterprise. A new quality of integrated information systems and their components (informational
space) is that they must work in close integration with production management systems. In most cases, engineering enterprises employ traditional technologies, such as computer-aided design (CAD), computer-aided manufacturing (CAM) and computer-aided engineering (CAE) [8]. However, enterprises are not yet ready to introduce such latest digital technologies as real-time big data analysis, electronic data exchange, cloud manufacturing. Also, most employed technologies come from different vendors, and can only be partially integrated with each other, or even are not compatible at all [6].

Digital tools aid process-planning services in overcoming lack of information, creating conditions for effective planning, implementing multi-function tools in technological area, as well as manufacturing operation management. We treat digital technologies as being able to aid engineering enterprises in reaching excellence in process planning. However, this requires structured approach, including initiative priority determination, data digitizing and creation of digital workflow model [6].

The basic concept that became the standard for foreign developers and manufacturers of high-tech products, is a cross-cutting modelling as properties (in the early stages of design), and processes for the preparation of production and product release. This ensures achievement of the required production (cost, time, exit products to market) and operational parameters. The complex solution of this problem may be reached by introduction of digital technologies which allow modelling of alternative scenarios at all stages of product life cycle: designing, process planning, manufacturing, operation and aftermarket servicing. The generic diagram of digital manufacturing according to the modern concept of PLM (Product Lifecycle Management) is shown. It is necessary to notice that this concept is not fully implemented at engineering enterprises. This process is somewhat similar to automated process planning [7].

The main causes of difficulties in implementation of this concept are reviewed below. Each stage of life cycle should ensure a digital link with neighboring ones according to provided workflows. The continuity of electronic interaction sets invariance continuity requirements for model of transferred data, including data transferred between different facilities: design offices, manufacturing plants, operators, etc. In particular, the engineering documentation in model provided by design office has to be understandable by personnel of manufacturing plant, as well as cooperating enterprises. The problem complexity increases if the manufacturing plant receives documentation from several design offices which use different data models [7]. In this case, the enterprise has to develop its own internal data model (invariance compared to external sources) and ensure unequivocal conversion of source data from different source models into its own internal one [8]. Application of digital manufacturing principles to technological developmental work on electronic design documentation in ideal conditions can provide a range of advantages compared to traditional process [6]:

1) Reduction of number of cycles in preparation of electronic technical document set: electronic technological models, design and technical specifications, process planning sheets, technological...
routes, structured assembly sets (assembly units), etc.;
2) Increase of electronic technical documentation quality thanks to automation of large volumes of routine technical operations;
3) Ability to organize parallel developmental work on documentation by more than one group of engineers.

Based on the developed design and technological documentation is made design of production areas and workshops for the manufacture of products. Design of manufacturing sites and workshops best to implement simulation modelling. After creating models of the entire fleet of technological equipment is required to insert them into the production casing. After that is determined by the physical connection, routing blanks, etc. and directly is itself a simulation. Further, if necessary, the project can be completed with additional objects to complete creating a visual layout of production in the industrial building [4]. Additional objects can be permanent fencing of robotic systems, stacker, large alternate, conveyors, pumping stations, magnetic separators for the regeneration of the coolant, automated warehouses and other facilities.

Designed a simulation 3D model of the object is a complete copy of the projected plant (production area, lines), in which you can make changes at various stages of project management of technical re-equipment and creation of digital production. These changes will automatically adjust the work conducted. Development of design and technical specification, technical documentation, including technological processes and CNC programs for machining centers should be performed and kept in the same single data structure of the PDM system environment [8].

It is obvious that a single-platform PLM environment provides the required workflows most efficiently, without data losses. Nowadays single-platform solutions integrating a wide range of functional systems are only being developed. The problem of data integration is extremely multidimensional and diverse. The complexity and nature of methods used for its solution largely depend on integration level which is necessary to provide, properties of each data source and all the range of sources as a whole, as well as required integration methods. Data integration systems can provide such integration at physical, logical and semantic levels. Data integration at physical lever, in theory, is the simplest problem and is reduced to data conversion from different sources into the required single format of their physical representation. This paper discusses mainly the two other cases [6].

Data integration at logical level provides ability to access data contained indifferent sources in terms of the single global diagram that describes their collective behavior taking structural and, possibly, behavioral (when using object models) data properties into account [4]. Semantic properties of data are not considered. Support of single data representation with consideration of their semantic properties within the context of single domain ontology provides data integration at semantic level. Data sources may have different properties sufficient for data integration method selection - they can support data representation in terms of one or another data model, they can also be static or dynamic, etc. A multitude of sources of integrated data can be uniform or non-uniform.
in terms of parameters corresponding to the integration level used.

Regarding the data integration methods, two approaches are possible: virtual or actual (materialized) representation of integrated data. When the first approach is used, the access mechanism is created, which, when the user request is processed, releases data in required representation directly from data sources [4]. The full materialized representation of integrated data in terms of the single user interface is not supported here. The virtual approach is used most often for frequently refreshed data sources. In the second approach, on the other hand, full materialized representation of integrated data separated from sources and coexisting with them is formed. This data representation is employed in user request processing. This approach is used, for example, in data repositories [5].

Understanding of real necessity of digital manufacturing implementation allowed the enterprise management to perform a range of large-scale projects aimed at creation and effective employment of information system, most important parts of which are ERP (Enterprise Resource Planning), and CAPP (Computer Aided process planning). During its introduction, a couple of problems with integration of these systems appeared, since these systems belong to different developers [5]. The following problems, among others, are worth mentioning:

1) ERP is a resource management system, and result of its operation is directly connected with reaching of enterprise's global goal: high-quality, timely and cost-effective product manufacturing. Thus, ERP is an upper level system relative to others. Consequently, this system should have right to set the rules for others, regardless of differences in ideology, information structure, and, lastly, without taking real abilities of systems into account.

2) Operation of ERP is based on the so called "normative reference information" database, which by definition has to be actual at any time. Of course, ERP has its own mechanism for forming of this data, as well as it keeping in required condition, but they are hard to use in real processes of design.

By operation of these systems, the aforementioned normative-reference information database is formed, and this is the area where CAD and CAPP systems are responsible. In this sense, the ERP is dependent on results of operation of another system. The situation became even worse because the project of introduction of CAD and CAPP systems has independent value for engineering services of this enterprise [7]. Operation of an ERP system requires much more information than CAD and CAPP. This specific information contains manufacturing data and it is excessive, non-required for forming of design and technical documentation. Examples of such information are additional parameters of range, which characterize it as accounting objects; data about production cycle (such as intershop transfer times of part batch), etc. For integrated operation of systems, the problem of which of them should generate such information, and who should be responsible for it, is very sensitive [4], [6].

Operation of this department for introduction of CAD and CAPP during the transition period is vital. After the transition period is finished, the purpose of this department is also changed. As percentage of operational processes using automated system for technological preparation of manufacturing increases, an archive of electronic documentation is formed in the system, and, correspondingly, necessity of its qualified usage appears [7]. It is assumed that all loads regarding operation of electronic archive will be taken by this department, which, by that time, is guaranteed to be have required expertise and experience.

Management of design and technological production preparation at the enterprise was integrated into the common information system of this enterprise, which, first, solved its own problem, and second, created basis and premise for successful implementation of ERP introduction [6].

37. CONCLUSION

CAPP plays an important role in manufacturing enterprises, and it eliminates the gap between CAD and CAM integration. Therefore, the need of CAPP is always there for such integration systems. From this survey, it has been found that most of the CAPP work carried out on machining manufacturing resolve the problem issues of operation, tool and machine selection and sequencing, feature extraction, reorganization, interpretation and representation, knowledge integration, representation, acquisition and sharing, setup planning, energy consumption, linear and nonlinear planning, integration of product and manufacturing data, intelligent tool path generation, optimization problems, intelligent decision making and sharing of knowledge, integration of process
planning and scheduling, etc. The aim of this paper is to provide a detailed survey with graphical representation for easy understanding of the past, present, and future of CAPP and also the vital role it plays in Digital Manufacturing and how it can be integrated with CAPP efficiently because of its wide applications in the domain. From this survey and graphical representations, it has been identified that the STEP-compliant, knowledge-based, generic algorithm, feature-based, neural network, and Internet-based methods had been used in the majority of CAPP works as compared to fuzzy set theory/logic, Petri nets, and agent-based methods and also when it comes to the application regarding digital manufacturing.

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AKSHAT M. AKUT was born in Dhule, Maharashtra, India, in 1998. He received the Secondary School Certificate from Guru Nanak English High School, Kalyan, Maharashtra, in 2014 and the High School Graduate degree from Hill Spring International Junior College, Kalyan, in 2016. He will also shortly receive the Bachelor of Engineering degree in Mechanical Engineering from Savitribai Phule Pune University (SPPU), Pune, in 2020.

From 2016 to 2020, he was affiliated with NBN Sinhgad School of Engineering for the BE program in Mechanical Engineering, where he was a part of eight projects, out of which he was the project leader in four of them, including a research project and an industrial project. He has given a total of nine seminars with presentations at the Department of Mechanical Engineering at NBN Sinhgad School of Engineering, and even one at a state-level conference with proceedings where his presentation was ranked in the top 5. He has also worked as a project lead intern at Viram Plastics, a small-scale industry in the plastic moulding domain, for a sponsored industrial project.

Mr. Akut was a recipient of a prize for excellence in the Annual 10th Grade Maharashtra State Board English Examination by Guru Nanak English High School, in 2014. He also has professional memberships with major organizations like Space Development Nexus and Inter-University Centre for Astronomy and Astrophysics, as he got the privilege of being a selected attendee amongst the few candidates for their national as well as international programs like internships, workshops, trainings, conferences, etc.
Development & Fabrication of Air Brake System by Using Exhaust Gas

Vinayak Newale¹, Omkar Gawade², and Shivam Chauhan³

ABSTRACT
The aim of this project is to develop an air brake system based on exhaust gas, called an "air brakesystem". The main aim is to reduce the workloads of the engine drive to operate the air compressor, because here the compressor is not operated by the engine drive. Here we are placing a turbine in the path of exhaust from the engine. The turbine is connected to a dynamo by means of coupling, which is used to generate power. Depending upon the airflow, the turbine will start rotating, and then the dynamo will also start to rotate. A dynamo is a device which is used to convert the kinetic energy into electrical energy. The generated power can be stored in the battery and then this electric power has loaded to the DC compressor. The air compressor compresses the atmospheric air and it stored in the air tank and the air tank has pressure relief valve to control the pressure in the tank. The air tank supplies the compressed pneumatic power to the pneumatic actuator through solenoid valve to apply brake. The pneumatic actuator is a double acting cylinder which converts pneumatic pressure into linearmotion

INDEX TERMS DC Compressor, Dynamo, Pressure Relief Valve

1. INTRODUCTION

Braking System - A brake is a mechanical device that inhibits motion by absorbing energy from a moving system. It is used for slowing or stopping a moving vehicle, wheel, axle, or to prevent its motion, most often accomplished by means of friction. Most brakes commonly use friction between two surfaces pressed together to convert the kinetic energy of the moving object into heat, though other methods of energy conversion may be employed. For example, regenerative braking converts much of the energy to electrical energy. Other methods convert kinetic energy into potential energy in such stored forms as pressurized air or pressurized oil. Eddy current brakes use magnetic fields to convert kinetic energy into electric current in the brake disc, fin, or rail, which is converted into heat. Still other braking methods even transform kinetic energy into different forms, for example by transferring the energy to a rotating flywheel. Brakes are generally applied to rotating axles or wheels, but may also take other forms such as the surface of a moving fluid (flaps deployed into water or air). Some vehicles use a combination of braking mechanisms, such as drag racing cars with both wheel brakes and a parachute, or airplanes with both wheel brakes and drag flaps raised into the air during landing.

Friction brakes on automobiles store braking heat in the drum brake or disc brake while braking then conduct it to the air gradually. When traveling downhill some vehicles can use their engines to brake. When the brake pedal of a modern vehicle with hydraulic brakes is pushed against the master cylinder, ultimately a piston pushes the brake pad against the brake disc which slows the wheel down. On the brake drum it is similar as the cylinder pushes the brake shoes against the drum which also slows the wheel down.

2. Literature Review

In recent years the scientific and public awareness on environmental and energy issues has brought in major interests to the research of advanced technologies particularly in highly efficient internal combustion engines. Viewing from the socio-economic perspective, as the level of energy consumption is directly proportional to the economic development and total number of populations in a country, the growing rate of population in the world today indicates that the energy demand is likely to increase. Substantial thermal energy is available from the exhaust gas in modern automotive engines. Two-thirds of the...
energy from combustion in a vehicle is lost as waste heat, of which 40% is in the form of hot exhaust gas. The latest developments and technologies on waste heat recovery of exhaust gas from internal combustion engines (ICE). These include thermoelectric generators (TEG), Organic Rankine cycle (ORC), six-stroke cycle IC engine and new developments on turbocharger technology. Being one of the promising new devices for an automotive waste heat recovery, thermoelectric generators (TEG) will become one of the most important and outstanding devices in the future. A thermoelectric power generator is a solid-state device that provides direct energy conversion from thermal energy (heat) due to a temperature gradient into electrical energy based on See back.

3. Methodology

The Two stroke petrol engine is connected to the wheels in which exhaust gas braking is attached. Pressure tank is used to store the exhaust gas under required pressure. The braking speed is varied by adjusting the valve is called flow control valve. Solenoid valve is used to operate the pneumatic cylinder which actuates the brake lever of the wheels. The flow chart of the experiment is given in the figure below.

4. Working Principle

A Two stroke engine powered by petrol is used to produce exhaust gas. Here we are placing a turbine in the path of exhaust from the silencer. The turbine is connected to a dynamo, which is used to generate power. Depending upon the airflow the turbine will start rotating thus rotating the dynamo. A dynamo is a device which is used to convert the kinetic energy into electrical energy. The generated electric power is stored in a battery after rectification. Thus, the stored electrical power is use to run the DC compressor the compressor compresses the atmospheric air and it is stored in an air tank. When the brake is applied the 5/2 solenoid valve is activated and it allows the air to actuates the pneumatic cylinder thus the brake is applied.

5. Components and Functions

The generation of electricity using the flow or velocity of vehicle exhaust gas of the following components to fulfill the requirements of complete operation of the machine.

1. Dynamo
2. Turbine
3. Battery
4. Engine

1. Dynamo
Dynamo is an electrical generator. This dynamo produces direct current with the use of a commutator. Dynamo was the first generator capable of generating power in the industries. The dynamo uses rotating coils of wire and magnetic fields to convert mechanical rotation into a pulsing direct electric current.

2. Turbine
A steam turbine is a mechanical device that extracts thermal energy from pressurized steam and converts it into rotary motion.
3. Battery
In our project we are using secondary type battery. It is rechargeable type. A battery is one or more electrochemical cells, which store chemical energy and make it available as electric current. There are two types of batteries, primary (disposable) and secondary (rechargeable), both of which convert chemical energy to electrical energy.

4. Engine

[6] Richardson, Jr., Hubert: “Scroll Compressor With Orbiting Scroll Member Biased By Oil Pressure,” U.S. engine or machine designed to energy into useful mechanical motion. Heat engines, including internal combustion engines and external combustion engines (such as steam engines) burn a fuel to create heat, which then creates motion. The term internal combustion engine usually refers to an engine in which combustion is intermittent, such as the more familiar four-stroke and two-stroke piston engines.

6. FutureScope

As we could not afford the engine of heavy vehicles, we have used a two-wheeler engine. By implementing this project on heavy vehicles which have powerful engines we will be able to produce more power from the engine exhaust gases. Low cost dynamo, battery and the turbine had to be purchased due to the low budget. By using high voltage battery, high voltage producing dynamo and by using proper turbine we can considerably increase the power production required for the air braking system.

7. Conclusion

By doing this project we were able to understand the importance of Coordination between the various departments in a manufacturing unit. This brake system offers ample scope for improvement By providing intermittent force at the brake plate. One of the major aims to achieve is that when the operator sees a brake force, that he needs to know immediately strike him, implying that the designs simple and easily understandable. Such was the case with AIR brake system. AIR Brake system are hailed as the greatest mechanical contrivance.

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Shivam Chauhan student of Smt. KashibaiNavaleSinhgad Institute of Technology & Sci. Kusgaon (BK), Lonavala, Pune, Maharashtra, India, 410401. Pursuing his degree in Mechanical Engineering from Pune University. Completed his HSC from Vikas The Concept School, Hyderabad, India.
Rotocasting :- A Review
IV. Keval S. Jawale
Dept. of Mechanical Engineering, Pimpri Chinchwad College Of Engineering and Research, Ravet, Pune, Maharashtra, India, 412101

ABSTRACT
Rotocasting is becoming a highly sophisticated manufacturing method for plastic parts. A lot of advanced processes, advanced features and different complicated moulds are becoming available at regular intervals. Because of this many designers and industrialists are creating complicated and innovative moulds. Rotocasting is a technique of obtaining hollow plastic parts. This is achieved by rotating the mould cylinder. By adding many other features the efficiency of this process can be increased. Also the time can be reduced. All the factors considered during rotocasting are discussed in this review paper.

1). INTRODUCTION
Rotocasting is also known as Rotational moulding or Roto moulding. Rotocasting provides a means of producing polyethylene articles of a size and shape that cannot be manufactured economically in any other way. It is particularly suited for relatively large, hollow, seamless parts. Such parts include large industrial chemical or agricultural tanks, shipping containers, marine floats, traffic bollards, canoes and small boats, rocking horses, pedal cars – indeed almost any hollow, enclosed or open-ended shape. It is a low pressure, high temperature manufacturing method for producing Hollow, one-piece plastic parts. Currently rotational moulding is a very competitive alternative to blow moulding, thermoforming and injection moulding for the manufacture of hollow plastic products. This is because it offers designers the opportunity to achieve the economic production of stress-free articles, with uniform wall thickness and complex shapes. Rotational Molding involves a heated hollow mold which is filled with a charge or some material. It is then slowly rotated around two axis causing the softened material to disperse and stick to the walls of the mold. In order to maintain even thickness throughout the part, the mold continues to rotate at all times during the heating phase and to avoid sagging or deformation also during the cooling phase. The process was applied to plastics in the 1940s but in the early years was little used because it was a slow process restricted to a small number of plastics. Over the past two decades, improvements in process control and developments with plastic powders have resulted in a significant increase in usage. The distribution of rotomolding

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V. 2). The Rotational Moulding Processes
Basically there are 4 steps in rotocasting:
a. Charging the mould.
b. Heating the mould.
c. Cooling the mould.
d. Demoulding.

A. Charging the mould:
A hollow metal mould (at room temperature) is charged with some quantity of powdered (or liquid) plastic, which is equal to the desired part weight.

VI. Fig1:- Powder poured in mould
It can be seen that the mould has been clamped into position and the mould begins to rotate in a heated environment. This is often a hot air convection oven, but the mould could be heated by a variety of methods that include electricity, infrared, hot oil or open flames.

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Pimpri Chinchwad College Of Engineering and Research, Ravet

...
3). Rotation axis and Prototype

The speed of mould rotation is very slow. Rotocasting is different than centrifugal casting in which speed is high. All the parts of the mould should dip in the plastic and if the speed is high, for complicated moulds the plastic will not reach each part of mould. By altering the speeds of rotation about the perpendicular axes of rotation it is possible to control the wall thickness of the end product. Areas that need to be thick should enter the powder pool more regularly than other parts of the mould surface. The ratio of the speeds about the two axes can be set to different values, depending on the shape of the plastic part. The speed ratio is the speed of the major (arm) axis divided by the speed of the minor (plate) axis. Computer simulation programs such as Roto Sim can be used to determine the correct speed ratio before the mould is set up on the moulding machine.

4). Properties of Rotocasting

The properties to be considered while performing rotocasting are as follows:

a. Stiffness/Rigidity:

Increasing the density leads directly to increased stiffness. Slow cooling will promote a higher moulding density and hence increased stiffness. Additional rigidity can very often be obtained by incorporating ribs in the design of the article.

b. Toughness:

The toughness of rotational moulded polyethylene articles, as measured by low temperature impact properties and environmental stress crack resistance (ESCR), depends on the choice of the polyethylene used, the rotational moulding cycle, and the design of the moulding.

c. Shrinkage:

It is a very complex phenomenon and depends on number of variables as follows:

1. The grade of powder used: Shrinkage is greater for polyethylenes of higher density.
2. The melt temperature: The higher the temperature the greater the shrinkage.
3. The thickness of the moulding: Shrinkage increases with the thickness of themoulding.
4. The shape of the moulding: Uniform shrinkage in all dimensions can be expected only with symmetrical shapes, e.g. tubes and spheres.

d. Distortion or Warping:

The most important factors affecting distortion are the rate and uniformity of cooling. Rapid cooling can cause severe distortion in most mouldings because the temperature gradient between the inner and outer layers of the moulded wall section leads to non-uniform cooling rates.

5). Materials used in Rotocasting
There are two main classes of plastics. About 80% of the millions of tons of plastics used in the world every year are
“thermoplastic” and the remaining 20% are
“thermosetting”. Thermosetting polymers are those that undergo an irreversible change during moulding - as happens to an egg when it is boiled. Thermoplastics, on the other hand, can go through a continual cycle of softening when they are heated and solidifying when they are cooled like candle wax. The vast majority of the plastics used in rotational moulding are thermoplastics, but some moulders use materials with thermosetting characteristics – for example, crosslinked polyethylene. More than 80% of all the material used is from the polyethylene family:
- cross-linked polyethylene (PEX),
- low-density polyethylene (LDPE),
- linear low-density polyethylene (LLDPE),
- high-density polyethylene (HDPE)
- Other compounds are PVC plastisols, nylons, and polypropylene.

6). Different types of Rotocasting Machines

1) Rock and roll machine:-
This machine is mainly to produce long narrow parts. This is a two arm rotational moulding machine.
2) Clamshell machine:-
This is a single arm rotational moulding machine. More than one mould can be attached to the single arm.
3) Vertical or up and over rotational machine:-
Vertical rotational molding machines are energy efficient due to their compact heating and cooling chambers.
4) Shuttle machine:-
Most shuttle machines have two arms that move the molds back and forth between the heating chamber and cooling station.
5) Swing arm machine:-
The swing-arm machine can have up to four arms, with a bi-axial movement. Each arm is independent from each other as it is not necessary to operate all arms at the same time.
6) Carousel machine:-
This is one of the most common bi-axial machines in the industry. It can have up to 4 arms and six stations and it comes in a wide range of sizes. The machine comes in two different models, fixed and independent. A fixed-arm carousel consists of 3 fixed arms that must move together. One arm will be in the heating chamber while the other is in the cooling chamber and the other in the loading/reloading area.

XI. Fig 12:- Multi arm Rotocasting

Machine 7). APPLICATION

Rotocasting or centrifugal casting is used to produce hollow objects for application in aerospace, industries, marine, and power transmission. Ferrous metals such as low alloy steel, stainless steel, and iron, or non-ferrous alloys such as aluminum, bronze, copper, magnesium, and nickel can be casted using this process. Some of the asymmetrical component that are produced are cylinders or disks, bearings, bushings, coils, cylinder liners, nozzles, pipes, tubes, pressure vessels, pulleys, rings, and wheels.

XII. Fig 13:- Boat using Rotocasting

Fig 14:- Slide using Rotocasting

8). CONCLUSION
This paper is an review of rotocasting. This paper has covered all the important concepts about rotocasting, the processes in rotocasting, the materials used in rotocasting, the properties to be taken into consideration during rotocasting, different types of machines and the application. So in short this paper gives a brief discussion about rotocasting. The efficiency can be increased or the time can be decreased by various factors taken into consideration.

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Keval S. Jawale, the student of Pimpri Chinchwad College Of Engineering And Research, Pune, Maharashtra, India, 410401. Pursuing his bachelor’s degree in Mechanical Engineering from Pune University.
Atomiser Device

Piyush A. Dalke¹, Dr. G.P. Deshmukh², Tanaya Zope³, Prasad Zope⁴, Aniket Darge⁵, Pratik Patil⁶

¹Research Scholar, Department of Mechanical Engineering, Chhatrapati Shivaji Maharaj University Panvel, Navi Mumbai, Maharashtra, India, 410206
²Professor, Department of Mechanical Engineering, A. C. Patil College of Engineering, Kharghar, Navi Mumbai, Maharashtra, India, 410210
³Student, Department of Mechanical Engineering, A. C. Patil College of Engineering, Kharghar, Navi Mumbai, Maharashtra, India, 410210
⁴Student, Department of Mechanical Engineering, A. C. Patil College of Engineering, Kharghar, Navi Mumbai, Maharashtra, India, 410210
⁵Student, Department of Mechanical Engineering, A. C. Patil College of Engineering, Kharghar, Navi Mumbai, Maharashtra, India, 410210
⁶Student, Department of Mechanical Engineering, A. C. Patil College of Engineering, Kharghar, Navi Mumbai, Maharashtra, India, 410210

ABSTRACT

The population of India is increasing rapidly. In order to fulfill their diet and needs, the production of foods must be increased. But this must be affordable to everyone. In India farming is done by traditional ways. Besides, there has been larger development of industry and service sector as compared to that of agriculture sector. The mechanization of agriculture in India to some extent has been developed. The pesticide sprayer is one among them and it is done by traditional farm workers by carrying backpack type sprayer, which requires human effort or by using electric pump. To improve the agriculture system and to reduce the human effort and problems associated with the backpack sprayer new equipment is fabricated which will be beneficial to farmers. Our contribution on our project is advancing the spraying methods which are friendly to use and operate and which can be used in different spraying stages of farming as per process requirement. It can be operated in small farming land with standard spacing decreasing the labour cost and human effort.

INDEX TERMS Infrared sensor, Pesticide sprayer

1. INTRODUCTION

Agriculture plays a vital role in Indian economy. Around 65% of population in every state is depending on agriculture. Although its contribution to GDP is now around one sixth, it provides 56% of Indian work force. Their marginal and small farmers are around 81% and land operated is 44 %. As far as Indian scenario concerned, more than 75 % farmers are belonging to small and marginal land carrying and cotton provides about 80 % employment to Indian workforce. So any improvement in the productivity related task helps to increase Indian farmer's status and economy. The current backpack sprayer has lot of limitations and requires more energy to operate. The percentage distribution of farm holding lands for marginal farmers is 3 %, for small farmers 22.6 %, for small and marginal farmers 61.7 %, for semi-medium farmers 19.8 %, for medium farmers 14 % and for large farmers 4.5 % in year 1960. The maximum percentage of farm distribution belonged to small and marginal category. The invention of a sprayer brings revolution in the agriculture or horticulture sector, this enables farmers to maximize the agricultural output. They are used for garden spraying, weed and pest control, liquid fertilizing plant leaf polishing. There are many advantages of using sprayers such as they are easy to operate, maintain and handle, facilitates uniform spread of the chemicals, capable of throwing chemicals at the desired level, precision nozzle tip for adjustable stream and capable of throwing foggy spray, light or heavy spray depending on the requirement. The objective of the application of pesticide sprayer is to keep the pest under check. The pest population have kept suppressed to minimum biological activities to avoid economic loss of crop yields. Thorough killing of proper eradication of pest is neither practical nor necessary. The objective of pesticide sprayer application besides keeping pest population under check should also be to avoid pollution and damage to the non-targets.

2. STATEMENT OF PROBLEM

The Indian farmers (small, marginal, small and marginal, semi-medium) are currently using lever operated backpack sprayer. A backpack sprayer consists of tank 10-20 litres capacity carried by two adjustable straps. Constant pumping is required to operate this which results in muscular disorder. Also, the backpack sprayer can’t maintain pressure which results in drifts/dribbling. Developing adequate pressure is laborious and time consuming. Pumping to operating pressure is also time consuming. Moreover, very small area is covered while spraying. So, more time is required to spray the entire land. Back pain problems may arise during middle age due to carrying of 10-20 litres tank on back.

3. OBJECTIVES

A. Easy in construction.
B. More economical.
C. Easy to clean and maintain.
D. It does not create air pollution & noise.
E. Does not require fuel for working; hence cost is reduced.
F. Easy to handle.

4. METHODOLOGY

A. STUDY OF THE PROBLEMS STATEMENT

The problems associated with the manual operated spraying machine are rectified and a new machine is
designed to overcome those problems.

B. SOLIDMODEL
The model is designed by using CAD software.

C. SELECTION OF MOTOR CALCULATION
Selection of the motor is a major problem because it depends on the torque required and weight to be pulled; by using formulas, the motor has been selected. The battery selection also places an important role. The required power is delivered to the system by the battery.

D. SELECTION OF MATERIAL
The choice of materials for a vehicle is the first and most important factor for automotive design. In this we used Mild Steel bar alloy as a base material for chassis as it will provide maximum strength and minimum deflection compared to other chassis material. Analysed design of chassis is selected which has robust design and best suitable for agricultural works.

E. FABRICATION
The selected materials are fabricated by using permanent joints as well as temporary joints. All the components are fitted and connected in an electronic circuit.

F. DEMONSTRATION AND TROUBLESHOOTING
It is aimed more at an agricultural land by spraying long distance. The studies demonstrated that each stage has the potential to be the most cost effective solution to perform well in agricultural land and there are two failure modes which the system may experience. These two conditions which may require troubleshooting are zero power output (no power) and low voltage issue.

5. DESIGN OF ATOMISER DEVICE

6. MAIN COMPONENTS

A. FRAME
The frame is used to support all the body parts. It is also called as the chassis. The frame material is mild steel. The main functions of the frame are: To support the chassis components and body and to deal with static and dynamic loads, without undue deflection or distortion.

B. SENSOR
An infrared sensor is an electronic device, which emits in order to sense some aspects of the surroundings. An infrared sensor can measure the heat of an object as well as detects the motion. These types of sensors measures only infrared radiation, rather than emitting it; that is called as a passive infrared sensor. Usually in the infrared spectrum, all the objects radiate some form of thermal radiations.

C. PUMP
Any spray liquid must be atomized before it leaves the spray nozzle. The pump facilitates the necessary pressure for this purpose.

D. MOTOR
A DC motor is any of a class of rotary electrical motors that converts direct current electrical energy into mechanical energy. The most common types rely on the forces produced by magnetic fields. Nearly all types of DC motors have some internal mechanism, either electromechanical or electronic; to periodically change the direction of current in part of the motor.

E. TANK
A sprayer may have either a built-in tank or a separate tank to carry the spray liquid. The tank needs to be large enough to avoid frequent refilling but not cumbersome to carry. The tank is equipped with a large opening with a built-in strainer and cap to fill in the liquid. Small openings pose difficulty in filling and cleaning the tank.

**F. BATTERY**

Battery is another significant part of our design. These devices store DC energy from the PV panel in chemical form and when needed converts the stored chemical energy to electrical energy.

**G. NOZZLE**

The function of spray nozzle is conversion of pressurized spray liquid into droplets for application on the target. Nozzles are identified by:
1. Droplets size
2. Delivery
3. Type of nozzle

Nozzles are comprised of a spray tip, a filter/strainer, a nozzle body and a cap. The nozzle tip is the prime component of nozzle. It determines the flow and distribution of the spray. There are many different types of tips, each designed for a certain type of spray application. Selecting the correct type and size of spray nozzle is essential for each application. The nozzle determines the amount of spray applied to an area, the uniformity of the application, the coverage of the sprayed surface, and the amount of drift. Although nozzles have been developed practically for every kind of spray application, only a few types - extended range flat-fans, flood jets, etc. are commonly used in the application of crop protection products.

**H. WHEEL**

HC05 module is an easy to use Bluetooth SPP (Serial Port Protocol) module, designed for transparent wireless serial connection setup. The HC05 Bluetooth module can be used in a master or slave configuration, making it a great solution for wireless communication. This serial port Bluetooth module is fully qualified Bluetooth V2.0+EDR (Enhanced Data Rate) 3Mbps Modulation with complete 2.4GHz radio transceiver and baseband.

7) **POWER AND MOTOR CALCULATION**

**A. Based on power,**

\[ \text{Power} = \text{Force} \times \text{Velocity} \]

Here, Force = Operating Voltage = 12 Volts Velocity = Load Current = 0.3 Amperes

\[ \text{Power} = 3.6 \times 10^{-3} = 3.6 \text{Watts} \]

**B. Based on motor,**

\[ M = \text{Weight in kilograms} \times g \]

Gravity in m/s^2
Four wheels with 4 inch diameter are used. Wheel width is changed to allow for a wider tire to be used and to poke the wheel out to the fender of the vehicle. Having the ability to run a wider tire allows for more of the vehicle's power to be put to the ground because there is a larger surface area making contact with the road.

1. **HC05 BLUETOOTH MODULE**

Power = M x g x V
3.6 = M x 9.81 x 0.159
M = 2.308 kilograms (each motor)

8) **ADVANTAGES**
A. Easy to operate.
B. Easy to assemble & disassemble.
C. Easy maintenance.
D. Safety of operator is observed.
E. Relief to operator from back pain.

9) **APPLICATIONS**
A. It is used for particular crops such as tomato.
B. It can be used in small domestic farms.

10) **FUTURE SCOPE**
1) Additional energy can be used such as solar power.
2) We can use cameras for remote access with the help of smartphone.
3) We can use higher range up to 100 meters for remote control.
4) We can make automated changes in height and width.

11) **CONCLUSION**
It is an upgraded design of manually operated sprayer which will be helpful for small land farmers. It consumes less time and saves money as compared with conventional spraying. This machine does not require any fuel or power so maintenance is less. This model removes problem of back pain, vibrations and noise. This alone pump can be used for multiple crops. The model has been provided with multiple nozzles along with sensor, which has a required spray over the crops.

The proposed system is very efficient and can be used in agricultural field very effectively. This technology is most suitable for Energy Alternate Device for power sprayers. This system is user friendly and also environment friendly as it does not produce any pollution. Also this robot can be used at very remote places where fuel and power are not available. Moreover the same technique and technology can also be extended for all types of powersprayers.

**ACKNOWLEDGMENT**
This project is a synergistic product of many minds and has been accumulated over the last few weeks. This has been a special project brought to fruition through the efforts of some people. Many people contributed enthusiastically to this project, which really came together in the last few weeks before deadline. For their continuous guidance and valuable advice, I would like to take this opportunity to thank all of them.
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I would like to place on record my deep sense of gratitude to my parents for financial wisdom and inspiration that they have guided and helped me from day one.

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MR. PIYUSH A. DALKE is a young faculty working as Assistant Professor at JSPM’s/TSSSM’s Padmabhooshan Vasantdada Patil Institute of Technology Pune completed his BE Mechanical in 2015 and his M-Tech in CAD/CAM in 2017. He is also pursuing his PhD from CSMU Panvel, Navi Mumbai University. He has teaching experience of 05 year with 15 national and international patents filed and published. He has also published 04 books with national publisher and 01 book with international publisher. His area of expertise is subjectlike Engineering Graphics, System Mechanical Engineering, Production Technology, Manufacturing Process etc. His areas of research interests are Nano-fluid, Hybrid Engine, Plastic, IOT, Clean air, Agriculture, Smart environment- friendly innovation and owns a Email:patilpiyush101@gmail.com

DR. G. P. DESHMUKH has been working as a Professor and Head of Mechanical Engineering Department in A. C. Patil college of Engineering, Navi Mumbai from last 27 years. I have completed BE, ME and PhD from Amravati University. Published more than 10 research papers in reputed international journals and conferences and working as a reviewer.
In Ti6Al4V material is, in exacting super alloy, used extensively in the most application such as aerospace, chemical, marine ship racing cars etc. However, the characteristics of this material make it difficult to machine due to poor thermal conductivity and work hardening. The drilling process is classified as procedure that produces continuous elevated temperatures due to effect in surface finishing. With emerging new and efficient minimum quantity of lubrication system delivery systems, the industry has shown drift from flood and dry lubrication towards minimum quantity of lubrication system. Having this in mind, to further improve the cutting fluids, hybrid Nano composite of AL2O3 & Multiwall carbon Nano tubes was developed in situ with mechanical alloying vegetable oil hybrid Nano fluids were prepared by dispersing the synthesized Nano composite powder in vegetable oil. A unit’s minimum quantity lubrication system combined with a compressor is used to source Nano fluid mist to the drilling zone, when machined under dry, MQL- vegetable oil and MQL- Nano fluid conditions. The results were compared while machining with dry and Veg-MQL lubricating conditions. A 41 % reduction in surface roughness (drill diameter) was obtained when compared to dry machining process.

INDEX TERMS Minimum quantity lubrication technique, Nano fluids containing multiwall carbon nanotubes and Al2O3Nano meter size

1. INTRODUCTION

In the background of cooling and lubrication by cutting fluids, the notion of “the additional, the better” is giving way to stricter environmental regulations and research findings in recent years in the effectiveness of minimum quantity lubrication in lieu of flood lubrication. In Minimum Quantity Lubrication (MQL), a minute amount of the cutting fluid with an approximate flow rate is mixed with compressed air and delivered as aerosol to the tool/work piece interface. The lubricating function is attained by the cutting fluid, while the cooling function is mainly ensured by the high flow-rate of the compressed air. Due to evaporation of the small amount of the cutting fluid in MQL upon interaction with the hot tool–interface spot, the residues of the cutting fluid on the work piece and surfaces is minimal. The low consumption of the cutting fluid in MQL can yield reduced waste disposal and treatment, better occupational care and enhanced environmental compatibility. Considering that the cutting fluid cost is reported to be higher in the automotive industry than that of the drilling cutting tool cost, the low consumption rate in MQL presents an enormous cost-saving potential. In addition to economic efficacy and environmental compatibility, the MQL has been reported to encounter exceed flood lubrication presentation in terms of tool life and surface quality of the work piece. Specifically, in drilling of Ti6Al4V with oxide-coated HSS drill bits using a vegetable oil in flood lubrication and MQL, no significant tool life difference, measured by the number of holes beforehand reaching the end of life criterion, was observed. Moreover, the average trust force was lower. The application of MQL technique in developing machining processes, such as high-speed drilling and orbital drilling, has exposed hopeful results for hard-to-machine material, such as hardened steel, aerospace alloys, carbon–fiber reinforced plastic, and titanium–CRFP laminates, in terms of work piece surface quality and reduced surface. Orbital drilling represents a promising alternative drilling process with advantages over conventional drilling, such as reduced tool inventory, reduced axial force and risk for delamination in composite laminates, better cooling of the tool and hole edges, and the ability to repair misaligned and damaged holes. The incorporation of MQL in orbital drilling also reduces operational costs through the minimal use of the fluid and lack of residues.

2. LITERATURERESURVEY
Recent journals and various publications suggest that many experiments and investigations have been performed on the various methods adopted for achieving less costly and eco-friendly. These investigations have led to a better material/production system.

Khan [12] studied the effects of minimum quantity lubrication (MQL) by vegetable oil-based cutting fluid on the turning performance of low alloy steel AISI 9310 as compared to completely dry and wet machining in terms of chip tool interface temperature, chip formation mode, tool wear and surface roughness. MQL machining proved to be much superior compared to dry and wet machining in reducing the tool wear and enhancing surface finish. In addition to this the MQL also offers environment friendliness.

Choudhury and Chinchanikar [13] investigated the machining performance of CVD coated multi-layer TiCN/Al2O3/TiN carbide tool during turning of hardened AISI 4340 alloy steel at different levels of hardness i.e. 35HRc and 45 HRc. A modified Taylor tool life equation was developed considering the effect of cutting parameters. The correlation coefficients found close to 0.9, showed that the developed models were reliable and could be used effectively for predicting the responses for the given tool and work material pair and within the domain of the cutting parameters. It was found that, feed value of 0.15 mm/rev, depth of cut of 1 mm and cutting speed of 235 (35 HRC) and 144 m/min (45 HRC) are the optimum cutting parameters for minimum cutting forces, surface roughness and better tool life.

Sahoo and Sahoo [14] carried out experiments to study the growth of flank wear, surface roughness and chip morphology (shape and color) with respect to machining time for multilayer TiN and ZrCN coated and uncoated carbide inserts in hard turning of AISI 4340 steel at different levels of hardness i.e. 35HRc and 45 HRc. A modified Taylor tool life equation was developed considering the effect of cutting parameters. The correlation coefficients found close to 0.9, showed that the developed models were reliable and could be used effectively for predicting the responses for the given tool and work material pair and within the domain of the cutting parameters. It was found that, feed value of 0.15 mm/rev, depth of cut of 1 mm and cutting speed of 235 (35 HRC) and 144 m/min (45 HRC) are the optimum cutting parameters for minimum cutting forces, surface roughness and better tool life.

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Ghani et al. [16] studied the wear mechanism of TiN-coated carbide and uncoated cermet’s tools at various combinations of cutting speed, feed rate, and depth of cut for end milling of hardened AISI H13 (50 HRc) tool steel. In the high cutting speed regime the rate of wear growth of the insert was assessed by progressive flank wear using optical microscope. The wear mechanism at the end of tool life was investigated in detail using scanning electron microscope(SEM).

H. Hegab [17] Flood cooling is a type of cooling used in industry to reduce the high temperature generated during machining. New environmental cooling and lubrication systems are highly required to improve the cutting quality characteristics and achieve a sustainable machining system. Multi walled carbon nanotubes (MWCNTs) and Al2O3 Nano particles are among the Nano additives that have superior thermal, mechanical and tribological properties.

Milon D. Selvam [18] in this work, used vegetable oil was used for preparing emulsified cutting fluids; this would ultimately reduce the cost contribution of cutting fluid on the total manufacturing cost and would eliminate the pollution caused by the oil waste fed on the environment. It was so evident that the machined components with palm oil based emulsion exhibited better surface quality and the surface quality of the components machined with peanut oil based emulsion gives a less deviation of 0.0251 m from the results obtained under palm oil based emulsion. Similarly, for mineral based Servocut 'S' emulsion, it was a 0.0087 m deviation from the results obtained under palm oil based emulsion. This might be due to the base oil properties and characteristics.

Safian Sharif [19] Cooling and lubrication are very important in metal cutting process due to the reduction of negative effect.
resulting from interaction of cutting tool and work piece. Machinability factors such as tool wear, surface roughness, cutting force and chip morphology are usually affected without efficient cooling strategy. Researchers have reported the introduction of nanoparticles in base cutting fluid into MQL lubrication technique and its improvement of lubrication and cooling. The efficiency of Nano fluid in metal cutting operation can be attributed to the enhanced thermal conductivity and heat transfer coefficient that are key to its superior performance over other lubricants/cooling method. The effect of increase of volume concentration as it affects the thermal conductivity of Nano fluid and its subsequent performance in application were evaluate.

Kishor Kumar [20] Cutting fluids play a vital part in turning process. Basically, these cutting fluids are made up of mineral oil (MO) and performance enhancing additives that are produced chemically. However, MO has adverse environmental effects and causes health hazards. Therefore, MO is gradually replaced by green cutting fluid (GCF). Indigenously developed environmental friendly vegetable based GCF with minimum quantity cutting fluid (MQCF) application technique can serve as a viable solution to make current work a cleaner process. In this present study, vegetable-based GCF was synthesized and characterized. Emulsion stability and anti-corrosion properties of GCF were investigated. MQCF machining process parameters such as cutting fluid emulsion composition, nozzle stand-off distance and nozzle spray angle were experimentally optimized to extract better output.

3. CONCLUSION

Performance of carbide inserts is improved by the use of the MQL technique with Al2O3 and MWCNT Nano fluids. The enhancement of thermal conductivity and lubricating characteristic of the base fluid is observed due to the presence of Al2O3 and MWCNT nanoparticles. We study MQL parameters, including the fluid types, nanoparticle types, nanoparticle concentration, and drilling parameter, is investigated in terms of cutting forces and surface roughness. The obtained results will provide the important direction for selecting the control factors of the further studies.

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27. Hadad


About the Authors:

Mr. Piyush A. Dalkeis a young faculty working as Assistant Professor at JSPM’s/TSSM’s Padmabhooshan Vasantdada Patil Institute of Technology Pune completed his BE Mechanical in 2015 and his M-Tech in CAD/CAM in 2017. He is also pursuing his PhD from CSMU Panvel, Navi Mumbai University. He has teaching experience of 05 year with 15 national and international patents filed and published. He has also published 04 books with national publisher and 01 bookwith international publisher. His area of expertise is subject like Engineering Graphics, System Mechanical Engineering, Production Technology, Manufacturing Process etc. His areas of research interests are Nano-fluid, Hybrid Engine, Plastic, IOT, Clean air, Agriculture, Smart environment-friendly innovation and owns a Email: patilpiyush101@gmail.com

Dr. B.N.Tripathi author received the B.E degree from NIT Kurukshetra. M.Tech degree from MDU Rohtak, Haryana. Received the PhD degree from IIT Dhanbad, Jharkhand. Author has about 18 years’ experience in teaching of mechanical engineering subject. At present working in CSMU, Panvel, Navi Mumbai. Author published about 12 papers in reputed international journal

Dr.G.P. Deshmukh have been working as a Professor and Head of Mechanical Engineering Department in A.C Patil college of Engineering Navi Mumbai from last 27 years. I have completed BE, ME and PhD from Amravati University. Published more than 10 research papers in reputed international journals and conferences and working as a reviewer in two international journals, also filed and published five patents at nationaland international level.
Design And Optimization Of Hydraulic Cylinder Mounting Bracket

Komal Sawant¹, Sainand Jadhav ²

M.E. Student, Department of Mechanical Engineering, NBN Sinhgad School Of Engineering, Pune, India¹
Professor, Department of Mechanical Engineering, NBN Sinhgad School Of Engineering, Pune, India²

ABSTRACT- In present study weight optimization, vibrational analysis is considered as a major factor to design an optimized model for the existing design of hydraulic cylinder mounting bracket. So, experimental and numerical analysis of existing hydraulic cylinder mounting bracket is to be performed to study the effect of deformation, mode shapes, weight optimization and to obtain optimized model using ANSYS software (Topology optimization). Static structural and free vibrational analysis are to be performed to determine best optimized model results with existing design. From the static structural analysis, total deformation, von mises are to be calculated and natural frequencies are to be obtained from modal analysis. Results and conclusions will be drawn. Suitable future scope will be suggested.

Keywords—FEA, UTM, Topology optimization, Hydraulic bracket

I. INTRODUCTION

Current advancements in the water power industry have reformed our capacity to mechanize forms in the horticultural, development, and assembling areas. To accomplish these advances, computerized machines must have pressure driven systems that can give exact and dependable movement control. Water driven systems can control both the rotational and straight movement used in these procedures. Water powered engines are utilized to actualize rotational movement, while direct control is performed by pressure driven chambers. Water driven chambers are accessible in an assortment of styles and can be mounted from multiple points of view. They are effective and dependable, and albeit little of their fundamental structure has changed altogether in ages, they are as yet pertinent to the ventures to which they provide food. Albeit a few chambers are made with a by and large poor form quality, for example, with cast iron tops and heads, greater chambers are normally built with produced steel. Water powered chambers get their capacity from pressurized water powered liquid, which is regularly oil. The water driven chamber comprises of a chamber barrel, in which a cylinder associated with a cylinder bar moves to and fro. The barrel is shut toward one side by the chamber base (likewise called the top) and the opposite end by the chamber head (additionally called the organ) where the cylinder bar comes out of the chamber. The cylinder has sliding rings and seals. The cylinder separates within the chamber into two chambers, the base chamber (top end) and the cylinder bar side chamber (bar end/head end). ribs, trunnions, clevises, and drags are basic chamber mounting alternatives. The cylinder bar likewise has mounting connections to interface the chamber to the item or machine segment that it is pushing or pulling. A water driven chamber is the actuator or "engine" side of this framework. The cylinder pushes the oil in the other chamber back to the supply. On the off chance that we accept that the oil enters from top end, during expansion stroke, and the oil pressure in the pole end/head end is around zero, the power F on the cylinder bar rises to the weight P in the chamber times the cylinder zone A. The welded chamber is essentially a barrel with a top welded to the base, and afterward with the mounting treatment welded to that top, commonly a cross cylinder or double tangs to imitate a clevis. The
cylinder and pole are introduced into the chamber, and afterward a strung head is slid over the pole and torqued onto the barrel.

Fig. 1: Hydraulic cylinder bracket

II. LITERATURE REVIEW

Priyanka S. Dahalea et al. [1] In this paper it presents experimental and Finite Element examination of a run of the mill motor mounting bracket. It likewise introduced the Modal Analysis in FEA to decide the frequency band and check the bracket for security. The exploratory examination for co-connection to build up variety of rate and in this manner decide the idea of Boundary conditions to be utilized in FEA for progressively precise investigation. The Automobile motor case framework may encounter undesirable vibrations brought about by impedance between the street and the motor. Motor bracket has been planned as a structure to help motor. Because of vibrations of motor the openings on the motor Bracket get extended which prompts the failure of bracket. The outcomes got for the static basic and modular investigation have demonstrated that the subsequent limit condition for example one fixed and one pressure support are increasingly precise with less level of deviation 18.6 % with exploratory outcomes, which can be utilized for additional investigation for wellbeing of Engine mounting bracket.

Mohammed Khaja Nizamuddinet al. [2] This paper manages the topology optimization of motor mounting bracket of 'Chevrolet beat' utilizing the instruments CATIA V5R20 for demonstrating and Hyper works for limited component investigation. The utilization of motor mounts is the best answer for dampening the impact of vibrations and transmitting powers between the motor and the car body structure. The principle goal of the work is to limit the heaviness of the motor mounting bracket by thinking about the structure and material format. For various material format and various structures, the anxieties and loads are registered and contrasted with show up at the best model under recommended conditions. It is seen that the most extreme worry for all plans didn't surpass a definitive rigidity for the relating materials. In light of the examination of the weight decrease accomplished in the three streamlined structures, it tends to be reasoned that the most elevated weight decrease has been acquired in plan.

Pooja Morea et al. [3] This paper centers around the deduction of move capacity of radiator brackets to communicate their dynamic vibration attributes. The way to deal with determine the equivalent involves limited component demonstrating of the radiator bracket, model approval, parameter recognizable proof dependent on affectability study and structure of tests to infer the exchange work. Extreme vibration brings about auxiliary harm. The structure itself has certain inside properties and it is essential to comprehend its attributes. In this paper, move work for the initial two bending frequencies of the bracket is created with parameters that would essentially influence the major frequency as information sources. The initial two bending frequencies acquired from diagnostic technique are contrasted and that from the limited component models and found to have great understanding. The exchange capacities to acquire the initial two twisting frequencies of radiator mounting bracket are
inferred dependent on parametric examination and plan of investigations. The seven basic parameters influencing the elements of the bracket are radiator mass, motor mass, number of jolts, generally speaking thickness of bracket, bracket length, tie bar length and nearness or nonattendance of AVMs among radiator and bracket.

Lan, Jet al. [4], In this paper, rope-wheel type is contemplated. Rope-wheel glass lifter as a rule comprises of slider, manage rail, direct wheel, engine, the upper and lower wire ropes, and so forth. Two distinct techniques are applied to the topology improvement of guide rail and a weighted trade off programming approach for illuminating multi-target topology enhancement of numerous stacking cases and normal frequencies is proposed in this paper. Initially, the plan area is resolved by the mechanical structure and working conditions. Furthermore, the single objective continuum structure topology streamlining mathematic models of guide rail are fabricated and the investigation of multi-firmness topology improvement of various volume part are done appropriately. Thirdly, a weighted trade off programming approach is proposed to take care of multi-targets advancement issues and multi-target topology improvement are performed dependent on this strategy in which volume portion is set as 0.4, 0.5 and 0.6. The estimations of advanced consistence are lower than that of the single objective topology improvement and the initial three request frequencies of multi-target topology enhancement are higher than that of single objective.

Sreekanth Dondapatib et.al[5] In the current work, experimental examination on the failure of a suppressor mounting bracket connected to business vehicle is finished. Splits are distinguished at the welded area of suppressor mount which shows that weld joint has preferred quality over the suppressor/bracket body. To comprehend the conceivable underlying drivers of the failure, fishbone chart was utilized, which helped in deciding the significant reasons for the failure by a graphical portrayal. Further, the three parameter Weibull dispersion was likewise evolved to decide the Mean Time to Failure (MTTF) life which was seen as 15,172 km. Also, elastic testing of sheet metal was performed on the sheets which was utilized in the assembling of Muffler. Besides, a Thermo-Mechanical coupled examination was completed utilizing business code, ANSYS 16.0, which adjusts Finite Element Analysis (FEA) definition. The warm loads on suppressor were imported to basic investigation alongside a static heap of 4 g quickening were forced on the suppressor body to reenact the impacts of high effect loads.

III. PROBLEM STATEMENT
Optimization of weight has been very critical aspects of any design. It has substantial impact on vehicle performance, and in spin minimizes the emissions. For Experimental and numerical analysis of existing hydraulic cylinder mounting bracket to study the effect of deformation, mode shapes, weight optimization and to obtain optimized model using ANSYS software.

IV. OBJECTIVES

● To develop optimized hydraulic cylinder mounting bracket for existing model in CATIA software.
● To perform static and vibration analysis (modal analysis) of hydraulic cylinder mounting bracket using ANSYS 19 software. To determine mode shape, natural frequency, deformation, von misses, stresses and strain.
● To perform stain gauge test on UTM for extracting of stain in hydraulic cylinder mounting bracket.
● Validation of experimental and numerical analysis.

V. METHODOLOGY
Step 1:-Initially research paper are studied to find out research gap for project then necessary parameters are
studied in detail. After going through these papers, we learnt about optimization of hydraulic cylinder bracket mounting.

Step 2: Research gap is studied to understand new objectives for project.

Step 3: After deciding the components, the 3D Model and drafting will be done with the help of software.

Step 4: The components will be manufactured and then testing will be performed on UTM using strain guage.

Step 5: The testing will be carried out and then the result and conclusion will be drawn.

**CATIA MODEL**

![CATIA model of hydraulic cylinder bracket](Image)

**Fig 1 CATIA model of hydraulic cylinder bracket**

**Material Properties**

<table>
<thead>
<tr>
<th>Material Properties of S.S</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Property</strong></td>
</tr>
<tr>
<td>Material Field Value</td>
</tr>
<tr>
<td>Density</td>
</tr>
<tr>
<td>Isotropic Modulus</td>
</tr>
<tr>
<td>Yield Modulus</td>
</tr>
<tr>
<td>Poisson's Ratio</td>
</tr>
<tr>
<td>Bulge Modulus</td>
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<tr>
<td>Shear Modulus</td>
</tr>
</tbody>
</table>

**Table 1 Material properties of S.S**

**FEA ANALYSIS OF HYDRAULIC BRACKET IN ANSYS**

**Geometry**

![Geometry](Image)

**Fig. 3 Geometry of actual hydraulic cylinder bracket**

**Mesh**

ANSYS Meshing is a general-purpose, intelligent, automated high-performance product. It produces the most appropriate mesh for accurate, efficient Multiphysics solutions. A mesh well suited for a specific analysis can be generated with a single mouse click for all parts in a model. Full controls over the options used to generate the mesh are available for the expert user who wants to fine-tune it.
The power of parallel processing is automatically used to reduce the time you have to wait for mesh generation.

![Meshing of actual hydraulic cylinder bracket](image1)

**Fig. 4** Meshing of actual hydraulic cylinder bracket

After meshing of hydraulic cylinder bracket are 100911 and elements 67969.

![Boundary condition of actual hydraulic cylinder bracket](image2)

**Fig. 5** Boundary condition of actual hydraulic cylinder bracket

In present investigation existing hydraulic cylinder bracket of standard size of bore size 63 mm is selected. So, in boundary condition following in and out for 3.5 MPa operating pressure FEA analysis have been performed to determine stress, deformation and topology optimization.

### Deformation Results

![Deformation result of actual hydraulic cylinder bracket](image3)

**Fig. 6** Deformation result of actual hydraulic cylinder bracket.

Maximum deformation under static condition of actual hydraulic cylinder bracket was 0.01025 mm.

### Equivalent stress
Fig. 7 Equivalent stress result of actual hydraulic cylinder bracket

Maximum Equivalent stress of actual hydraulic cylinder bracket was 116.28 MPa

MODAL ANALYSIS

To perform modal analysis fixed support is applied at inner side of cylinder bracket to determine mode shape with natural frequency

At mode 1

Natural frequency of actual hydraulic cylinder bracket at mode shape 1 was 2700 Hz

At mode 5

Table 2- Tabular representation of the mode shapes with respective frequency

Static analysis Under inword boundary condition
TOPOLOGY OPTIMIZATION OF HYDRAULIC CYLINDER BRACKET

Topology optimization may be a mathematical approach that optimizes material layout within a given design area, for a given set of loads and boundary conditions such that the resulting layout meets a prescribed set of performance targets.

FEA ANALYSIS OF NEW OPTIMIZED HYDRAULIC BRACKET IN ANSYS

on surface 6 mm holes along with on cylindrical surface 12 mm holes are produced to optimize the existing design.

Geometry
Fig 16  CATIA model of optimize hydraulic cylinder bracket

**Deformation Results**

Maximum deformation under static condition of optimize hydraulic cylinder bracket was 0.01144 mm

**Equivalent stress**

Fig. 18 Equivalent stress results of optimize hydraulic cylinder bracket

Maximum Equivalent stress of optimize hydraulic cylinder bracket was 129.23 MPa

**Experimental Test**

A Universal Testing Machine (UTM) is employed to check both the tensile and compressive strength of materials. Universal Testing Machines are named intrinsically because they will perform many various sorts of tests on an equally diverse range of materials, components, and structures. Universal Testing Machines can accommodate many sorts of materials, starting from hard samples, like metals and concrete, to flexible samples, like rubber and textiles. This diversity makes the Universal Testing Machine equally applicable to virtually any manufacturing industry. The UTM may be a versatile and valuable piece of testing equipment which will evaluate materials properties like tensile strength, elasticity, compression, yield strength, elastic and plastic deformation, bend compression, and strain hardening. Different models of Universal Testing Machines have different load capacities, some as low as 5kN and others as high as 2,000kN.
## Specification of UTM

<table>
<thead>
<tr>
<th></th>
<th>Max Capacity</th>
<th>400KN</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>Measuring range</td>
<td>0-400KN</td>
</tr>
<tr>
<td>3</td>
<td>Least Count</td>
<td>0.04KN</td>
</tr>
<tr>
<td>4</td>
<td>Clearance for Tensile Test</td>
<td>50-700 mm</td>
</tr>
<tr>
<td>5</td>
<td>Clearance for Compression Test</td>
<td>0-700 mm</td>
</tr>
<tr>
<td>6</td>
<td>Clearance Between column</td>
<td>500 mm</td>
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<tr>
<td>7</td>
<td>Ram stroke</td>
<td>200 mm</td>
</tr>
<tr>
<td>8</td>
<td>Power supply</td>
<td>3 Phase, 440Volts, 50 cycle. A.C</td>
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<tr>
<td>9</td>
<td>Overall dimension of machine (L<em>W</em>H)</td>
<td>2100<em>800</em>2060</td>
</tr>
<tr>
<td>10</td>
<td>Weight</td>
<td>2300Kg</td>
</tr>
</tbody>
</table>

### Test Procedure

The load pointer is set at zero by adjusting the initial setting knob. The dial gauge is fixed and the optimize hydraulic cylinder bracket for measuring elongation of small amounts. Measuring the diameter of the optimize hydraulic cylinder bracket by vernier caliper at least at three places and determine the mean value also mark the gauge length. Now the optimize hydraulic cylinder bracket is gripped between upper and middle cross head jaws of the m/c. Set the automatic graph recording system. Start the m/c and take the reading.

### CONCLUSION

In present study existing hydraulic cylinder mounting bracket is studied under static and modal analysis technique to determine stress, deformation and natural frequency. In topology optimization technique area indicated in red region assist to remove the material from that area and reanalysis is to performed to check the sustainability of element under existing boundary condition. After topology optimization of hydraulic cylinder bracket equivalent stresses are within the yield limit.

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A review paper on Automatic Emergency Braking System

Anushka Zazane1, Prajakta Waghmare2, Vivek Mahajan3, Kunal Patil4, Gulab Siraskar5

1 B.E. Student 2 B.E. Student 3 B.E. Student 4 B.E. Student 5 Assistant Professor

DEPARTMENT OF MECHANICAL ENGINEERING, PIMPRI CHINCHWAD COLLEGE OF ENGINEERING & RESEARCH, RAVET-PUNE, MAHARASHTRA, INDIA

I. Abstract

In recent times in India, vehicle accidents are the major problem and is increasing as number of vehicles on the road increases. Due to these road accidents human life gets more insecure in spite of taking preventive measures. Automatic Emergency Braking System is specially designed mechanism as a smart solution to these problems and used as intelligent and innovative techniques to actively enhance safety of vehicles and importantly for preventing road accidents. This system mainly aims in using combination of electronically and mechanically developed structure to avoid unnecessary collisions. Automatic braking system uses ultrasonic sensor which senses the vehicle which comes in front of our system that may cause the destruction as accidents. The sensor transmits the signal to Electronic Control unit for applying brakes automatically before crashing down. This system warns the driver through alarm or automatically applies the brakes to avoid the happening crash by studying the current distance between the host vehicle and the obstacle with the critical braking distance. This braking system provides pre-crash safety for vehicles.[1][3]

II. INTRODUCTION

Driving is an essential practise in recent times. Now-a-days to travel from one place to another a person needs vehicle which in turns is increasing the number of vehicles on road because of which number of road accidents are also increasing in similar ratio. These accidents generally cause a lot of damage, serious injuries also deaths.

According to latest Traffic departmental survey made in Indian subcontinent in alone 2018, the country reported 151 thousand fatalities due to road accidents, which on average 1214 road crashes occur every day [4] Each year, about three to five percent of the country's GDP was invested in road accidents. Most of the times the study reveals that the accidents happen due to failure in braking systems, like sometimes driver presses the brake pedal during driving but due to system error brake cannot be applied; or unconscious driving of driver can also be one of the considerable reasons. Etc. Sometimes the accidents may also occur due to improper visibility of driver caused by changes in the atmosphere in surroundings ,for example in areas such as lonavala or hill stations where there is dense foggy outside the driver during driving has to struggle a lot as the driver has incomplete vision that is so not clear for safe driving. So as a solution to these upcoming dangerous problems a smart technology is studied and experimented to develop known as “Automatic Emergency Braking System.”

This project is designed to develop a new system that can solve this problem where drivers may not brake manually but the vehicles can stop automatically due to obstacles. The main target for this project is, cars can run automatic braking due to obstacles when the sensor senses the obstacles [2]. The braking circuit function is to brake the car automatically after received signal from the sensor and avoid further crashes. The system keeps track of any vehicles in its front. It will continuously keep the track of the distance between the two vehicles. When two come dangerously close the combination of electric and mechanical components will work out together and the system activates the brakes and it will stop the vehicle. The National Highway Traffic Safety Administration shows the strong belief in these intelligently working technologies and also signifies that these technologies have high potentials to improve and make suitable advancements for better vehicle safety in future.[1]

III. OBJECTIVES
The sole aim of this project is to:

1. To reduce number of road accidents that tend to increase death rate risks.
2. To increase the response time of the vehicle upon braking action [1].
3. To ensure safety of vehicles, human life.
4. To reduce production costs in comparison of artificial intelligence used in higher class vehicles.

IV. COMPONENTS

1. Ultrasonic sensor:

The Ultrasonic sensor is a type of device that works on the principle of SONAR and RADAR system. This system is used to determine the distance between the obstacle and the host vehicle. This sensor generates the high-frequency sound (ultrasound) waves. When this ultrasound is generated transmitted from the sensor hits the obstacle in front it reflects back as echo which is sensed by the receiver. Maximum range of used product is presently 20 meters (about 70 feet).

2. Relay circuit board:

Relays are electronic instruments that are used to control high voltage circuits with the help of low voltage signals. They are also used to control high current circuits with help of low current signals. Also used as protective relays. Because of this function all the faults during transmission and reception can be detected and isolated.

3. Pneumatic cylinder:

A pneumatic cylinder is a cylindrical shaped metal made component which is more or less as a machine that guides a piston inside it in a straight-line reciprocating motion in a cylinder. In this cylinder the air converts heat energy into mechanical energy through expansion in engine cylinder, and the gas receives piston compression in the compressor cylinder to increase the pressure in the cylinder.

4. 5/2 Direction control valve (DC 24V):

A 5/2 direction control valve is another type of important mechanical control device. It has 5 ports equally spaced and 2 distinct switching positions. It is also used to isolate and simultaneously bypass a passage way for the fluid which for example should retract or extend a double acting cylinder. There are variety of ways to have this valve actuated. A solenoid valve is commonly actuated as, a lever can be manually twist or pinch to operate, an internal or external hydraulic or pneumatic pilot to move the shaft inside, sometimes with spring control systems. This device plays a vital role in actuating the pneumatic cylinder in the system as the adapter gives suitable input to this valve for carrying out the function.

5. Brake pedal assembly:

Brake pedal- The brake pedal is a flat platform that the user presses with its foot in order to stop the vehicle or slower down its speed during driving. When the driver puts his foot on the brake pedal, the system automatically applies the optimum pressure required to avoid hitting the car in front.

Brake pedal assembly- it is a foot pedal that moves a piston in the master brake cylinder. In hydraulic braking system brake pedal moves a piston in the master cylinder; brake fluid then applies great force to the brake pads or shoes.

6. Pneumatic pipe:

It is a transport system that is used in pneumatic assemblies. These are the tube links that are sending and receiving to different stations. The air compressor pump at the receiving station can suck or blow the air. When it sucks the air, it pulls canisters along the tube towards it; and when it blows, it pushes the canisters in opposite direction.

7. 24V DC adapter (AC-DC):

An adapter or is a device that converts attributes of one device or system to those of an otherwise incompatible device or system.

V Schematic Diagram of Working mechanism
V. METHODOLOGY

The “Automatic Emergency Braking systems” are the systems that are to be incorporated in two wheelers or on four wheelers that supports to provide the control of vehicle by means of master controller of digital driving system. Accident prevention is one of the most important areas of research today. Our paper is designed to stop/control accidents caused by loss of control, drunken driving and rash driving, by means of circuitry aided by a relay kit. In our work, braking distance and the distance of the hurdle are taken into consideration [2]. By using this distance between the obstacle and the host vehicle all the components are being actuated and their proper functioning in order leads to desired braking of vehicle.

The ultrasonic sensor works upon ultrasonic sound waves which has transmitter to transmit the sound waves and receiver to receive the reflected sound waves from the obstacle. Once the hurdle or obstacle comes in front range of the sensor; the sensor immediately receives the signal of reflected waves coming from the the obstacle to the receiver. Once the receiver is activated it sends the signal to further components. As ultrasonic sensor has two outputs, one of which is connected to light and further to the alarm that sounds loudly used to make the driver alert and another output of the sensor is connected to the DC adapter 230V.

In the further flow of operation of breaking the DC adapter is used to actuate the 5/2 directional control valve as it is being simultaneously being activated by sensor. As the 5/2DCV gets operated by changing its switching positions internally the compressed air from the air compressor flows directly into pneumatic cylinder for cylinder actuation. This 5/2 DCV has two inlet ports from which one connected to adapter and one to air compressor (6 bar pressure). And three outlet ports from which one is connected to pneumatic cylinder and other two are blocked.

Once the pneumatic cylinder is actuated it automatically operates the hydraulic lever if the driver does not operate in certain specific time limit before crashing. This braking system provide pre-rash safety for vehicle and passengers. As well as this system improve the reaction time of vehicle braking to keep safe distance between two vehicles. By using this arrangement, we control the speed of vehicle in lesser distance.\[1][2] [Fig. 2][7].

B. Fig. 3 Warning provided by pre-safe brakes in typical rear end collision situations [8].

VI. CALCULATIONS.

Actual Calculations: -
1. Weight of vehicle = 1500 Kg
2. Frictional coeff. Of wheel & road = 0.6
3. Coeff. Of friction for disk and caliper = 1.5
4. Wheel Base = 2 mtrs.
5. C.G. of vehicle from ground = 0.508 mtrs.
6. Diameter of tyre = 0.5 mtrs.
7. Inner diameter of disc = 100mm
8. Outer diameter of disc = 200m.

Load Distribution:
- 40% of TL on front two wheels.
- 60% of TL on rear two wheels.

Load on each front wheel = 300 Kg
Load on each rear wheel = 450 Kg

Static Weight Transfer or static load on wheel:
\[ F_S = uR_n = 0.6 \times 300 \times 9.81 \]
Thus, \( F_S = 1765.81 \text{N} \) ................................ (Constant)

Dynamic Weight Transfer (For \( a=0.5g \))
\[ F_D = \frac{(450 \times 0.5 \times 9.81 \times 0.508 / 2)}{2} \]
Therefore, \( F_D = 280.32 \text{N} \)

Total load = \( F_S + F_D = 1765.81 + 280.32 = 2046.12 \text{N} \)

<table>
<thead>
<tr>
<th>Sr.No.</th>
<th>Acceleration</th>
<th>Dynamic wt. transfer</th>
<th>Total load</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.59</td>
<td>280.32N</td>
<td>2046.12N</td>
</tr>
<tr>
<td>2</td>
<td>1.29</td>
<td>672.76N</td>
<td>2438.57N</td>
</tr>
<tr>
<td>3</td>
<td>2.09</td>
<td>1121N</td>
<td>2886.81N</td>
</tr>
<tr>
<td>4</td>
<td>3.79</td>
<td>2076N</td>
<td>3841.81N</td>
</tr>
</tbody>
</table>

Leverage Ratio:
\[ \text{Leverage Ratio} = \frac{X}{Y} = \frac{6.2}{1} \]
\[ = 6.2 \]

Maximum pedal force= 400N (for any type of vehicle)
Pedal Force (for 8 Kg) = 8*9.81
Pedal Force = 78.48N ~ 80N (Also considered for model calculations)

Master Cylinder Input Force = Pedal Force
\[ \text{Master Cylinder Pressure} = \frac{\text{F}_{\text{MC}}}{A_{\text{MC}}} \]
Where \( A_{\text{MC}} \) is area of master cylinder = (22/7)
\[ r^2 = 160 \ldots \ldots \ldots (r = 7 \text{cm}) \]
Thus, \( P_{\text{MC}} = \frac{486.57}{160} \)
\[ = 3.04106 \text{MPa} \]

Clamping Force:
\[ F_N = (\text{Torque/}u^*R_e^*n) \]
Where, \( u = \text{Coeff. Between pads and disc} \)

C. Model Calculations:

Leverage Ratio:
\[ \text{Leverage Ratio} = \frac{X}{Y} = \frac{6.2}{1} = 6.2 \]
Maximum pedal force= 400N (for any type of vehicle)
Pedal Force (for 8 Kg) = 8*9.81
Pedal Force = 78.48N ~ 80N (Also considered for model calculations)

Master Cylinder Input Force = Pedal Force
\[ \text{Master Cylinder Pressure} = \frac{\text{F}_{\text{MC}}}{A_{\text{MC}}} \]
\[ = 486.57 \text{N} \]
Master cylinder pressure = (Force/Area)
Where, Area of cylinder = (22/7) * \( r^2 \)
\[ = (22/7) \times 6^2 = 113 \text{cm}^2 \]
Pressure = 1.15MPa
Dynamo Torque = 250
N- m \( u = 1.5 \)
\[ R_e = \frac{75}{n} \]
\[ n = 2 \]
Thus, $F_N = 1111.11N$

Braking Force = 
$F_B = 2uF_N$
Thus, $F_B = 3333.33N$

Braking Torque = 
$T_B = F_BRe$
$T_B = 249.99N\cdot m$

For Pneumatic Cylinder: -

Input Pressure = 6 Bar

$\text{Force required (FMC)(Model) = 486.57N}\,$ As, 

$\text{Pressure = (FMC / A)}$ 

Thus, $A = 0.000810\, m^2$

Then, $A = [(22/7)/4] * D^2$

$D = 0.02812m \approx 28.12mm \approx 30\, mm\,$ Stroke 

length = 100 mm ….. (By Festo catalogue)

**VII. RESULT TABLE**

For Actual calculations:

<table>
<thead>
<tr>
<th>Braking Force $F_s$</th>
<th>Braking Torque $T_B$</th>
<th>Acceleration</th>
</tr>
</thead>
<tbody>
<tr>
<td>6820.3</td>
<td>511.52</td>
<td>0.5g</td>
</tr>
<tr>
<td>8128.5</td>
<td>8609.63</td>
<td>1.2g</td>
</tr>
<tr>
<td>9623.31</td>
<td>721.74</td>
<td>2.0g</td>
</tr>
</tbody>
</table>

For model calculation: -

Braking Force = $F_B = 3333.33N$

Braking Torque = $T_B = 249.99N\cdot m$

**VIII. ADVANTAGES**

1. Safety of modern cars and humans increases.
2. Road accidents can be reduced and risk of deaths can be decreased.
3. These systems provide more safety to passengers and are also able to give faster response.

**IX. CONCLUSION**

This Automatic Emergency Braking Systems are reliable can be easily incorporated in any type of vehicle. This braking system if implemented can avert lots of accidents and can save invaluable human lives and property. Our Intelligent braking system provides a glimpse into the future of automotive safety and how much more advanced these individual systems can be for avoiding accidents and protecting vehicle occupants when they are integrated into one system. The future of automotive safety is more than just developing new technology.

It is shifting the approach to safety. Also, the use of this system is by considering minimum and essential components in this system which in terms reduces the overall costing of the system. This system will reduce the accidents happen on the roadways. Is also reduces the braking distance of the vehicle.

**D. REFERENCES**


automatic stopping,“Expert


MISS. ANUSHKA ZAZANE, MISS PRAJAKTA WAGHMARE², MR. VIVEK MAHAJAN³, MR. KUNAL PATIL⁴, MR. GULAB SIRASKAR⁵

PIMPRI CHINCHWAD COLLEGE OF ENGINEERING & RESEARCH, RAVET-PUNE, MAHARASHTRA, INDIA
Review of Matrix Applications in Solving Coupled Differential Equations

S. S. Borgaonkar

1Dept. of First Year Engineering, Pimpri Chinchwad College Of Engineering and Research, Ravet, Pune, Maharashtra, India, 412101

ABSTRACT In this paper, we review and important application of matrices in solving coupled differential equations. Coupled differential equations are a commonplace in analysis of oscillatory phenomenon like vibrations. Though one can solve such problems without the use of matrices, the use of matrices in such problems helps ease out the process of solving those problems and also give us an insight into the working of the techniques. Let us review these methods.

INDEX TERMS diagonalisation, matrix, coupled, differential equations, orthonormality

38. INTRODUCTION

Mathematics, which always seems, and is perceived as abstract, looks abstract because it has developed a language for itself where a lot of information is put together in a very concise manner. Thus statement such as – “calculating the area contained within a curve given by a certain equation” – are simply written as something which is called an integral which looks like “\( \int_{a}^{b} f(x) \)”. Thus, this notation represent the complete statement given above in quotation marks. A very simplistic case for the above integral would be the area of a square, namely, the statement – “the area of a square such that each side is 1 is” – is replaced by the simple notation – “\( x^2 \)”. Another example would be – “the velocity of an object – say a car – at an instant \( t_0 \)” is represented by the expression “\( f'(x) \)” One might perceive these expression as abstract symbols, but, they have precise and profound meaning to each of them.

One such mathematical construct, is the “matrix”. A matrix, as everyone in science or engineering has studied, is an arrangement of numbers. This arrangement is termed as “rows” or “columns”. One could have equal number of rows or columns, or unequal number of them. One then defines various operations on this matrix, and related constructs required for such operations. One defines addition and multiplication of matrices, one defines an identity matrix, an inverse matrix, and some special types of matrices, such as Hermitian and Unitary matrix. We will not state here all the definitions, but will remind the reader these definitions and concepts as and when required for the purpose of understanding of the subject matter of the current discussion.

Matrices, which seem abstract are useful in many ways to solve everyday problems such as solving differential equations, especially coupled differential equations, solving simultaneous equations, solving problems which include rotations, etc. In this paper, we are going to discuss the application of matrices for solving coupled differential equations.

1. COUPLED DIFFERENTIAL EQUATIONS

In physics and engineering, one often encounters differential equations, which are coupled. Coupled differential equations essentially means that the derivative of one dependent variable depends on the value of the other dependent variable. Let us illustrate this by the following differential equations.

\[
\frac{dy_1}{dx} = y_2 \quad (1)  \\
\frac{dy_2}{dx} = y_1 + y_3 \quad (2) \\
\frac{dy_3}{dx} = y_2 \quad (3)
\]

One can take any linear expression one chooses to solve. Non linear equations are not straightforward to solve and each equation has to be investigated individually. Hence, here we constrain ourselves to linear equations. The dependence on the right hand side of the above equations can be of one’s choosing depending on the problem at hand.

One can see that these are coupled equations, simply because, one dependent variable, \( y_i \) depends on other variable \( y_j \), or as in case of eqn. (2), on the sum of two such
variables. One can solve these by separating the variables, and converting these to second order in those variables, but as the variables keeps on increasing, it becomes more and more difficult to do that. Matrices helps us solve such equations using certain properties which are unique only to matrices. Let us write down these equations in a more concise form, which will further help us to write them in the matrix form.

\[ \dot{y}_1 = y_2 \]  \hspace{1cm} (4)

\[ \dot{y}_2 = y_1 + y_3 \]  \hspace{1cm} (5)

\[ \dot{y}_3 = y_2 \]  \hspace{1cm} (6)

We will now make two column vectors as follows:

\[ \vec{Y} = \begin{pmatrix} y_1 \\ y_2 \\ y_3 \end{pmatrix} \]  \hspace{1cm} (7)

\[ \vec{\dot{Y}} = \begin{pmatrix} \dot{y}_1 \\ \dot{y}_2 \\ \dot{y}_3 \end{pmatrix} \]  \hspace{1cm} (8)

Thus we have defined two column vectors, one for the variables, and one for the derivative of the variables. The individual entries in the column vectors are the components of the respective vectors. One has to note that the basis used to write these vectors is the usual basis, namely the column vectors, which are as follows:

\[ \vec{1} = \begin{pmatrix} 1 \\ 0 \\ 0 \end{pmatrix} \]  \hspace{1cm} (9)

\[ \vec{2} = \begin{pmatrix} 0 \\ 1 \\ 0 \end{pmatrix} \]  \hspace{1cm} (10)

\[ \vec{3} = \begin{pmatrix} 0 \\ 0 \\ 1 \end{pmatrix} \]

Using this, then, one can write the individual components as the inner product of the basis vectors and the vector described by eqn. (7) and eqn. (8). Let us explicitly write these components for future reference.

\[ y_1 = \vec{Y} \cdot \vec{1} \]

\[ y_2 = \vec{Y} \cdot \vec{2} \]  \hspace{1cm} (10)

\[ y_3 = \vec{Y} \cdot \vec{3} \]

And the components in the derivative vector are:

\[ \dot{y}_1 = \vec{\dot{Y}} \cdot \vec{1} \]

\[ \dot{y}_2 = \vec{\dot{Y}} \cdot \vec{2} \]  \hspace{1cm} (11)

\[ \dot{y}_3 = \vec{\dot{Y}} \cdot \vec{3} \]

Using these definitions and statements of components, then, the eqn. (7) can be rewritten as:

\[ \vec{Y} = (\vec{Y} \cdot \vec{1}) \vec{1} + (\vec{Y} \cdot \vec{2}) \vec{2} + (\vec{Y} \cdot \vec{3}) \vec{3} \]  \hspace{1cm} (12)

Remember that this equation and equations (10) and (11) are possible only because the vectors \( \vec{1}, \vec{2} \) and \( \vec{3} \) are mutually orthogonal. In addition to this, to simplify the calculations, it is always good to normalize the basis, which these vectors already are. Thus in the above equation, the basis vectors chosen are orthonormal. Armed with these definitions, now, let us write eqn. (4), (5) and (6) into the following single matrix equation.
\[
\begin{pmatrix}
\dot{y}_1 \\
\dot{y}_2 \\
\dot{y}_3 
\end{pmatrix} = \begin{pmatrix}
0 & 1 & 0 \\
1 & 0 & 1 \\
0 & 1 & 0 
\end{pmatrix} \begin{pmatrix}
y_1 \\
y_2 \\
y_3 
\end{pmatrix} \quad (13)
\]

The physical meaning of this equation is that, given a vector \( \vec{Y} \), is acted upon by an operator, in this case it happens to be the differential operator, which is written in the matrix form, say \(- D\), where

\[
D = \begin{pmatrix}
0 & 1 & 0 \\
1 & 0 & 1 \\
0 & 1 & 0 
\end{pmatrix} \quad (14)
\]

Hermitian matrix, the eigenvectors are mutually orthogonal. We have further normalized the vectors and hence we have again a set of orthonormal basis vectors. The equations above express these new basis vectors in terms of the old basis vectors. It will be useful to write these explicitly in terms of the old basis vectors.

The above eigenvectors are the new basis. Note that because the matrix to be diagonalised is a symmetric and a

\[
\vec{I} = \frac{1}{2} \left( \begin{array}{c} 1 + (\sqrt{2})^2 + 3 \\ 1 
\end{array} \right) \quad (17)
\]

\[
\vec{II} = \frac{1}{\sqrt{2}} \left( \begin{array}{c} 1 - 3 \\ 1 
\end{array} \right) \quad (18)
\]

\[
\vec{III} = \frac{1}{2} \left( \begin{array}{c} 1 - (\sqrt{2})^2 + 3 \\ 1 
\end{array} \right) \quad (19)
\]

Let us now rewrite the eqn. (13) in the new basis.

\[
(\begin{pmatrix}
\dot{y}_1 \\
\dot{y}_{II} \\
\dot{y}_{III} 
\end{pmatrix}) = \begin{pmatrix}
\frac{\sqrt{2}}{2} & 0 & 0 \\
0 & 0 & 0 \\
0 & 0 & -\frac{\sqrt{2}}{2} 
\end{pmatrix} \begin{pmatrix}
y_1 \\
y_{II} \\
y_{III} 
\end{pmatrix} \quad (20)
\]

where the individual components of the column matrices can be expressed as dot products of the vectors \( \vec{Y} \) and \( \vec{\dot{Y}} \) in the new bases. These projections are as follows:

\[
y_I = \vec{Y} \cdot \vec{I} \quad (21)
\]

\[
y_{II} = \vec{Y} \cdot \vec{II} 
\]

\[
y_{III} = \vec{Y} \cdot \vec{III} 
\]

\[
\begin{align*}
\vec{I} &= \frac{1}{2} \left( \begin{array}{c} \frac{1}{2} \\ \frac{1}{2} \end{array} \right) \\
\vec{II} &= \frac{1}{\sqrt{2}} \left( \begin{array}{c} \frac{1}{2} \\ \frac{1}{2} \end{array} \right) \\
\vec{III} &= \frac{1}{2} \left( \begin{array}{c} \frac{1}{2} \\ \frac{1}{2} \end{array} \right)
\end{align*} \quad (16)
\]

and,

\[
\lambda_I = \sqrt{2}, \quad \lambda_{II} = 0, \quad \lambda_{III} = -\sqrt{2}, \quad (15)
\]

and the corresponding eigenvectors, which are the new basis vectors, are

\[
\begin{align*}
I &= \begin{pmatrix}
\frac{1}{2} \\
\frac{1}{2} 
\end{pmatrix} \\
II &= \begin{pmatrix}
\frac{1}{\sqrt{2}} \\
0 
\end{pmatrix} \\
III &= \begin{pmatrix}
\frac{1}{2} \\
0 
\end{pmatrix}
\end{align*} \quad (16)
\]
\[ \dot{y}_i = \dot{\vec{Y}} \cdot \vec{I} \]

\[ \dot{y}_{II} = \dot{\vec{Y}} \cdot \vec{II} \] \hspace{1cm} (22)

\[ \dot{y}_{III} = \dot{\vec{Y}} \cdot \vec{III} \]

The vectors \( \vec{Y} \) and \( \dot{\vec{Y}} \) are written as:

\[ \vec{Y} = \begin{pmatrix} y_i \\ y_{II} \\ y_{III} \end{pmatrix} \] \hspace{1cm} (23)

\[ \dot{\vec{Y}} = \begin{pmatrix} \dot{y}_i \\ \dot{y}_{II} \\ \dot{y}_{III} \end{pmatrix} \] \hspace{1cm} (24)

Let us now rewrite eqn. (25) similar to eqn. (12).

\[ \vec{Y} = (\vec{Y} \cdot \vec{I}) \vec{I} + (\vec{Y} \cdot \vec{II}) \vec{II} + (\vec{Y} \cdot \vec{III}) \vec{III} \] \hspace{1cm} (25)

Let us now explicitly retrieve our differential equations from the diagonalized matrix equation eqn. (28).

\[ \dot{y}_i = \sqrt{2} y_i \]

\[ \dot{y}_{II} = 0 \] \hspace{1cm} (26)

\[ \dot{y}_{III} = -\sqrt{2} y_{III} \]

The solution to these differential equations, based on standard integration, is

\[ y_i = y_i(0) \left( e^{\sqrt{2}x} \right) \]

\[ y_{II} = y_{II}(0) \]

\[ y_{III} = y_{III}(0) e^{-\sqrt{2}x} \] \hspace{1cm} (27)

\[ y_{II}(0) = y_{II}(0) e^{-\sqrt{2}x} \] \hspace{1cm} (28)

Here, the quantities \( y_i(0), y_{II}(0) \) and \( y_{III}(0) \) are constants of integration, which can be determined by the initial conditions. Also note that, since these are determined from initial conditions, one can write these as:

\[ y_i(0) = \vec{Y}(0) \cdot \vec{I} \]

\[ y_{II}(0) = \vec{Y}(0) \cdot \vec{II} \]

\[ y_{III}(0) = \vec{Y}(0) \cdot \vec{III} \] \hspace{1cm} (29)

Using these values of the solutions, and substitute them in eqn. (37)

\[ \vec{Y} = \begin{pmatrix} y_i(x) \vec{I} + y_{II}(x) \vec{II} + y_{III}(x) \vec{III} \\ \end{pmatrix} \]

\[ = \begin{pmatrix} y_i(0) e^{\sqrt{2}x} \vec{I} + y_{II}(0) \vec{II} + y_{III}(0) e^{-\sqrt{2}x} \vec{III} \\ \end{pmatrix} \]

\[ = \begin{pmatrix} (\vec{Y}(0) \cdot \vec{I}) e^{\sqrt{2}x} + (\vec{Y}(0) \cdot \vec{II}) \vec{II} + (\vec{Y}(0) \cdot \vec{III}) \vec{III} e^{-\sqrt{2}x} \\ \end{pmatrix} \]

Let us now substitute the basis vectors \( \vec{I}, \vec{II} \) and \( \vec{III} \) in terms of the old basis vectors \( \vec{1}, \vec{2} \) and \( \vec{3} \) from eqn. (17), (18) and (19). Hence the vector \( \vec{Y} \) becomes

\[ \vec{Y} = \frac{1}{2} \left( \vec{1} + (\sqrt{2}) \vec{2} + \vec{3} \right) \]

\[ \times \left( \vec{Y}(0) \cdot \vec{I} + (\sqrt{2}) \vec{II} + \vec{III} \right) \times e^{\sqrt{2}x} \]
Collecting the coefficient terms of vectors $\hat{1}$, $\hat{2}$ and $\hat{3}$, we get the vector as follows:

\[
\vec{y}(x) = \frac{1}{4} \left( y_1(0) + \sqrt{2} y_2(0) + y_3(0) \right) e^{\sqrt{2}x} \hat{1} + \frac{1}{2} \left(y_1(0) - y_3(0)\right) \hat{2} + \frac{1}{2} \left(2y_1(0) \cosh \sqrt{2}x + 4y_2(0) \cosh \sqrt{2}x + 2y_3(0) \sinh \sqrt{2}x\right) \hat{2} + \frac{1}{4} \left(2y_1(0) \cosh \sqrt{2}x + 2\sqrt{2}y_2(0) \sinh \sqrt{2}x + 2y_3(0) \cosh \sqrt{2}x\right) \hat{3} + \frac{1}{2} \left(y_1(0) - y_3(0)\right) \hat{3}
\]

The coefficients of the vector $\vec{y}(x)$ are nothing but our required functions $y_1(x)$, $y_2(x)$ and $y_3(x)$. Let us put these down one by one.

\[y_1(x) = \frac{1}{2} \begin{bmatrix} 1 + \cosh \sqrt{2}x \\ \sqrt{2} \sinh \sqrt{2}x \\ -1 - \cosh \sqrt{2}x \end{bmatrix} y_1(0)\]

\[y_2(x) = \frac{1}{2} \begin{bmatrix} \sqrt{2} \sinh \sqrt{2}x \\ \cosh \sqrt{2}x y_2(0) \end{bmatrix} y_2(0)\]

\[y_3(x) = \frac{1}{2} \begin{bmatrix} -\left(1 - \cosh \sqrt{2}x\right) y_1(0) \\ \sqrt{2} \sinh \sqrt{2}x y_2(0) \end{bmatrix} y_3(0)\]

The above are then the solutions of the coupled differential equations which we started out in the beginning. These type of differential equations are mainly found in oscillatory phenomenon, which can be encountered in structural elastic analysis. Usually, oscillatory phenomenon which have oscillatory functions as solutions, then involve trigonometric functions rather than hyperbolic functions which appear above. Nevertheless the treatment remains the same, namely,
diagonalising, and then separating the degrees of freedom of the problem. One can then revert back to the original variables by substitution as seen above.

One might still think, what is the virtue of the above method over conventional separation and substitution of matrix. Now a matrix is diagonalizable only if it can be inverted. One can then conclude that, a matrix that does not have an inverse, also is not diagonalizable, and one can conclude from this whether the system of differential equations can or cannot be solved. This highlights the advantage of solving problems using matrices.

3. CONCLUSION

In the above discussion, the application of matrices to the specific case of coupled differential equations is discussed. It should be noted that, though specific values have been taken, one can apply this method to other cases, but with the caution that the resulting operator matrix should be invertible. If such is not the case, other methods or specific boundary conditions should be investigated.

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REFERENCES


SANDEEP S. BORGAONKAR was born in Pune, MH, India, in 1984. He received his B.Sc. and M.Sc. degrees in Physics from Savitribai Phule Pune University (formerly University of Pune) in 2005 and 2007 respectively.

He has been in the field of teaching since 2012. He has been an Assistant Professor in Applied Physics at the Pimpri Chinchwad College of Engineering and Research. He is also pursuing his Ph.D. at the Department of Physics, Savitribai Phule Pune University. His research interests include quantum entanglement, applications of the same in relative evolution, quantum reference frames and quantum coherences.
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Prof. Siraskar Gulab
Prof. Salunke Mahendra

Team members
Prof. Vele Nandkumar
Prof. Chougule Sukhadip
Prof. Chavan Priyanka
Prof. Deshmukh Aniket
Prof. Supe Gajanan
Prof. Bobade Sudarshan
Prof. Napte Kiran
Prof. Kale Ompriya
Prof. Choudhari Dnyaneshwar
Prof. Parbat Rahul

Patron
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Dr. Chougule Arachana,
Dr. Mankar Sham,
Dr. Sawarkar Sameer

Prof. Dr. Harish Tiwari (Principal PCCO&R) and PCET Trust

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