The Implementation and Evaluation of Total Productive Maintenance – A Case Study of mid-sized Indian Enterprise

Ravikant V. Paropate¹, Dr. Rajeshkumar U. Sambole²

1 Assistant Professor (Mechanical Engineering), Jawaharlal Darda Institute of Engineering and Technology, Yavatmal, India.
2 Associate Professor (Mechanical Engineering), Jawaharlal Darda Institute of Engineering and Technology, Yavatmal, India.

Abstract

A total productive maintenance (TPM) is a fundamental component of world-class manufacturing which has been recognized as one of the significant operation strategy to regain the production losses due to equipment inefficiency. TPM is the methodology aims to improve the accessibility of the existing equipment and in consequence curtail the further capital investment. The case study has been carried out at cotton spinning plant to identify the extensive deficiency associated with equipment effectiveness. The paper intents on analyzing the practical problems accomplishing TPM program and improved the effectiveness for critical machine by significant value.

Keywords: TPM, Stages, Cotton Spinning Plant, OEE.

1. INTRODUCTION

Total Productive Maintenance is the equipment and process improvement strategy that links many of the elements of a good maintenance program to achieve higher levels of equipment effectiveness (Williamson, 2000). One approach to improve the performance of maintenance activities is to implement a Total Productive Maintenance (TPM) system (Hermann, 2000). Total Productive Maintenance (TPM) is a maintenance program which involves a newly defined concept for maintaining plants and equipment. The goal of the TPM program is to markedly increase production while, at the same time, increasing employee morale and job satisfaction. TPM brings maintenance into focus as a necessary and vitally important part of the business. It is no longer regarded as a non-profit activity. Down time for maintenance is scheduled as a part of the manufacturing day and, in some cases, as an integral part of the manufacturing process. The goal is to hold emergency and unscheduled maintenance to a minimum (Venkatesh J, 2009). At many companies where maintenance is viewed as an operational expense to be minimized and not as an investment in increased process reliability, the maintenance practices decrease their competitiveness by reducing throughput, increasing inventory, and leading to poor due-date performance (Patterson, et al, 1996).

2. LITERATURE SURVEY

According to Roberts (1997), the TPM program closely resembles the popular Total Quality Management (TQM) program. In addition, there is no strong evidence indicating that the mean of estimated learning index from the companies in Taiwan is different from that in Japan. Also, small plants as well as large plants can implement TPM and have the same maintenance performance. The approach of this research can help a company when it starts implementing the TPM program. The company can use this multiple linear equation to obtain the estimated learning index where the award year can be treated as the expected TPM award year. Then the expected OEE can be easily obtained and used to monitor the maintenance progress. TPM has been proven to be successful for helping to increase the productivity and overall equipment effectiveness (Hongyi S. et al, 2003). Kathleen E. et al, (2001) spotlighted on comparison of the TPM and Maintenance program which concludes that TPM can be a strong contributor to the strength of the organization which has the ability to improve Maintenance programs. World Class Manufacturing programs, such as JIT, TQM, and TPM, should not be evaluated in isolation. They are closely related and in combination can help foster better Maintenance programs. ChoyDS (2003), focus on implementation of TPM for a dramatic organizational change that can affect organization structure, work-floor management system, employee responsibilities, performance measurement, incentive systems, skill development and the use of information technology. Eti, M. C. et al, (2004) spotlighted that TPM is predicated by the challenge of seeking to do things better – hence dealing effectively with change (often requiring rapid alteration) needs to become a way of life within manufacturing organizations. The willingness of employees within an organization an organization to accept “change” for the better is an essential prerequisite for successfully implementing TPM. Their degree of eagerness to embrace “change” determines the rate of progress towards that goal. TPM can only succeed in an organization that is committed to provide the necessary training and time to monitor the success or failure of the ensuing improvement initiatives. Kennedy (2005), it should be acknowledged that a TPM implementation is not a short-term fix program. Chan, et al. (2005) studied TPM accomplishment in electronic manufacturing company and result shows that there is 83% improvement in equipment productivity improvement as well the equipment stoppage rate was rescued from 517 to 89 times. This improvement enhances the equipment in both effectiveness and quality in product
produced. There is emerging need for TPM implementation in the Indian Industry and need to develop TPM implementation practice and procedures. The successful implementation of TPM in the industry is a function of ability of an industry to approach and practice TPM; support and improvement, providing empowerment and incentives, promoting cross functionality and team work (Ahuja et al., 2007). The goal of TPM is to bring competitive advantages to organizations, improve quality of the products, and reduce the cost production of the line (Tsarouhas, P. 2007). Graisa, M. et al, (2011) have done an investigation on Libyan cement industry and found that lack of training (operational and maintenance), lack of incentives for improvements, and the lack of personal development system are the current production challenges being faced. Hence, they suggested model framework for the Libyan cement factories so that improvements can be made. In addition to, Ziaashkiani, A., et al, (2011) have mapped the dynamics of overall equipment effectiveness to enhance asset management practices. Having drawn out the dynamic mapping of the maintenance function, they discussed about the production pressure and maintenance performance, effect of cost on delaying long-term investments, and conflicts between maintenance and production, to name a few. This study focused on accomplishing TPM for the critical machine for a section of medium scale spinning plant in India.

3. PROBLEM DEFINITIONS IN COTTON SPINNING PLANT
Cotton Spinning plant under consideration includes the regular production of two types of Yarn; consist of regular yarn and lowing yarn. This plant consists of several sections. In this various section the cottons is collected, cleaned, impurities are removed from raw cotton, then through several section it get converted into yarn. Production is the most important factor if is manufactured with specific quantity and the required quality with given time span then only it meets the customer satisfaction. Considering the above thing one section is considered as critical section. By study and finding various reasons which affect the A, P, Q of OEE for particular section, on a production line Pilot machine which one is responsible for the production is selected. From the calculation, it is observed that the OEE of C-1, C-2, C-3, C-4, C-5 are 0.6898, 0.7678, 0.7420, 0.7848 and 0.7792 respectively. Various factors which will affect the A, P, Q factors are recorded. From the above analysis, the Critical section is selected of the implementation of the total productive maintenance, as the carding machine converts the cotton into the main for i.e. slaver, which is used on another machines as the input to next machine for production of yarn.

In the critical section, there are total five machine, for which the Availability (A), Quality Rates (Q), Performance Efficiency (P), Overall Equipment Effectiveness (OEE) is calculated from the data of one month out of which that the values for the availability (A), quality rates (Q), performance efficiency (P) is minimum which affects the value of Overall Equipment Effectiveness (OEE) which is also minimum from the other machines. The above observation indicates that from above of the Card Machine nos. i.e. C-1, C-2, C-3, C-4, C-5, specifically machine no. C-1 is the Pilot machine, on which A, P, Q factors are minimum.

4. IMPLEMENTATION METHODOLOGY
a. Pillar 1- Applying 5s Tool
   The 5S methodology relies on the creation and keeping well organized, clean, high effective and high quality workplace (J. Michalska et al, 2007). The 5S implementation is made to keep the workplace neat and clean, so that the problem identification is easy for the operator. It also seems to maintain the one specific place for the one object. The proper storage bins should be there for the tool and keys of machine door required at the working condition.

b. Pillar 2- JISHU HOZEN (Autonomous Maintenance)
   This pillar is geared towards developing operators to be able to take care of small maintenance tasks, thus freeing up the skilled maintenance people to spend time on more value added activity and technical repairs. The operators are responsible for upkeep of their equipment to prevent it from deteriorating. Its basic is that “I operate I maintain”. These abnormalities to failure are eliminated by using the technique such as Abnormality Sheet, CLITA, One Point Lesson (OPL’s), See Through technique which are discussed as follows.

   i. Abnormality Sheet
      For the selected Machine, various abnormalities to cause machine failure are observed and are enlisted so that the solution and reasons for the failure is search out to run machine efficiently. The frequently observed problems of regular nature are also noted, which will help the problem solving while creating the sheet.

   ii. CLITA
      The CLITA tool is employed to carry out JH activity during daily start of shift. At the beginning of the each shift, CLITA operations i.e. cleaning, inspection, retightening & lubrication have allotted specific time of approximately 5 to 10 minutes intentionally to this tool. Following instructions must be written on the machine.

      a. All the component of machine must be labeled with some identification numbers.

      b. As per the daily checking requirement, number of component should label with the operation e.g. if the component should be daily checked with the visual inspection then it is painted with the CLITA symbol of Visual Inspection.
c. Supply details, operations list, preventive maintenance done as well due date, specifications limits must note neatly on machine for avoiding any confusion.
d. Workplace of the machine is painted with yellow color as well the space for operating; observing the components of machine must be marked for safety of operator.

iii. One Point Lesson (OPL)
This form is a tool that helps to effectively and efficiently communicate TPM training concepts to participants and employees. The One Point Lesson form is structured to motivate the trainer to establish all important activities onto one simple and easy to use.

c. Pillar 3 - KAIZEN
Kaizen is a Japanese word that has become common in many western companies. The word indicates a process of continuous improvement of the standard way of work [17] J. C. Chen. [18] J. Farris states that the Kaizen Event is a complex phenomenon organizational and has the potential to affect both systems, the technical system (work are performance) and social systems (participation employees and of work areas employees). Coming all (operator, Supervisor, Manager, Maintenance people) together for various problem through brainstorming session suggestion for the correction and future steps are decided to overcome the same problem.

d. Pillar 4 - Planned Maintenance
It is aimed to have trouble free machines and equipment producing defect free product for total customer satisfaction. This breaks maintenance down into four “families” or group, Viz., preventive maintenance, breakdown maintenance, corrective maintenance and maintenance prevention (Melesse Workneh W alkjira, Ajit Pal Singh 2012)[18]. Planned maintenance aims to have trouble free machines and equipment’s produce defect free products to satisfy customer’s requirement (Paneerselvam 2010)[17].

e. PILLAR 5 - Quality Maintenance
It is aimed towards eliminating non-conformances in a systematic manner. Quality maintenance aims towards achieving zero defects, tracking and addressing equipment problems and root causes as well Setting 3M (machine/man/material) conditions (Ahuja et. al., 2008)

f. PILLAR 6 - Training
This should ensure that all maintenance staff (i) possess the necessary technical skills to understand and maintain the plant and equipment, (ii) are able to communicate intelligently with other departments within the organization about pertinent matters, and (iii) be able to work in teams or as a group (M.C. Eti et. al., 2006). TPM discipline, while technical, is more cultural. Everyone in the organization must receive sufficient information on TPM. Therefore training programs/seminars should be arranged weekly/monthly for all levels of organization (Mora, 2002).

g. PILLAR 7 - Office TPM
Office TPM should be initiated after activating four other pillars of TPM. Office TPM improves synergy between various business functions, remove procedural hassles, focus on addressing cost-related issues as well apply 5S in office and working areas (Ahuja et. al., 2008)

h. PILLAR 8 - Safety, Health and Environment
The way maintenance is performed will influence the availability of plant as well as the safety of its operation. These, in turn, will determine the profitability of the enterprise (Visser J.K., 1998). This pillar focus to ensure safe working environment; provide appropriate work environment; eliminate incidents of injuries and accidents and provide standard operating procedures (Ahuja et. al., 2008)

Pilot machine, on which A, P, Q factors are minimum.

5. DISCUSSION AND RESULT
After the suggestion of Total Productive Maintenance Implementation in Spinning plant at the Carding section on the Card No. 01. It is Predicted that the Availability, Performance Efficiency and Quality rates are improved which will directly affects the OEE of the equipment. Following are the prediction taken through the detail study of all the factors which affects the A, P, Q factors results in the changes of OEE.

Table 1. Predicted time loss

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Suggested Kaizen</th>
<th>Present Condition Time in min. (31 Days)</th>
<th>Predicted Time in min. (31 Days)</th>
<th>Present Condition Time in min. (01 Days)</th>
<th>Predicted Time in min. (01 Days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Filter Fault</td>
<td>1487</td>
<td>744.0208</td>
<td>15.98</td>
<td>8</td>
</tr>
<tr>
<td>2</td>
<td>Cotton suction Fault</td>
<td>260</td>
<td>139.5074</td>
<td>2.79</td>
<td>1.5</td>
</tr>
<tr>
<td>3</td>
<td>Storage Machine Empty Fault</td>
<td>356</td>
<td>186.0076</td>
<td>9.82</td>
<td>2</td>
</tr>
</tbody>
</table>
On the present condition, the form the Machine Card No. 1 the availability improvement is carried out through the suggested model, the change is shown below and the calculation is shown in Table 2.

### Table 2 Predicted Impacts on Availability

<table>
<thead>
<tr>
<th>Topic</th>
<th>Impact</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Filter Kaizen for checking of Circular fan</td>
<td>0.70414</td>
<td>70.414</td>
</tr>
<tr>
<td>Storage Machine Empty Condition Kaizen</td>
<td>0.17866</td>
<td>17.866</td>
</tr>
<tr>
<td>Cotton suction Mechanical Fault</td>
<td>0.13677</td>
<td>13.677</td>
</tr>
</tbody>
</table>

Effect on the Quality Rate affects by minimizing the quality cotton by reducing the number of stoppages, as the each stoppage about 200 grams of flat finished cotton is wasted and from the filter room the compact wastage is obtained for the recycling. Following are the predicted improvement in the quality rate from the machine, due to reducing the number of stoppages to minimize the flat finished waste from machine.

### Table 3 Predicted impact on quality rates

<table>
<thead>
<tr>
<th>Quality rates improvement</th>
<th>Impact</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Filter checking kaizen</td>
<td>0.26401</td>
<td>26.401</td>
</tr>
<tr>
<td>Cotton suction kaizen</td>
<td>0.24699</td>
<td>24.699</td>
</tr>
<tr>
<td>Mechanical drive kaizen</td>
<td>0.0341</td>
<td>3.41</td>
</tr>
<tr>
<td>Initial cleaning</td>
<td>0.08146</td>
<td>8.146</td>
</tr>
<tr>
<td>Safety circuit</td>
<td>0.08223</td>
<td>8.223</td>
</tr>
</tbody>
</table>

Performance efficiency is affected by the maximizing production within the given production time. The Carding machine equipped with automated working system as the problem and stoppages is identified by sensors the working speed is decreased, so here the performance is decreased. Through the suggestion the factor predicted improvement in Performance efficiency are as follows.

### Table 4 Predicted impact on Performance Efficiency

<table>
<thead>
<tr>
<th>Performance Efficiency Improvement</th>
<th>Impact</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Storage Machine Empty Condition Kaizen</td>
<td>0.16703</td>
<td>16.703</td>
</tr>
<tr>
<td>Filter Checking Kaizen</td>
<td>0.21436</td>
<td>21.436</td>
</tr>
<tr>
<td>Setting Time Minimized through CLITA</td>
<td>0.22494</td>
<td>22.494</td>
</tr>
<tr>
<td>Cleaning Impact</td>
<td>0.11726</td>
<td>11.726</td>
</tr>
</tbody>
</table>

Following are impact on the Overall Equipment Effectiveness which is predicted as follows:

![Figure 1. Predicted Change in the OEE of Card No.1 After Implementing TPM](image)

Following is the Change predicted after implementation of Total Productive Maintenance on a machine Card no.01 from carding section.
6. CONCLUSION

Total productive maintenance is successfully gives the improvement in the availability, performance efficiency and the quality rate, results in improvement of the overall equipment effectiveness of the equipment.

At the Spinning plant, implementation of total Productive maintenance is suggested for the carding machine. In the present condition values for availability, quality rates, performance efficiency and overall equipment effectiveness are 89.6832%, 79.29%, 96.4783% & 68.9866% respectively and the values after TPM implementation are 91.96%, 79.758%, 97.177% & 71.465% respectively. The overall equipment effectiveness is calculated by considering the values of production quantity, breakdown time, productive time, wastage and recycles cotton quantity using Microsoft Excel.

Through the suggested implementation of Total Productive Maintenance on carding machine from carding section the availability, quality rates, performance efficiency and the respective overall equipment effectiveness changes are predicted as 2.2768%, 0.6989%, 2.4784% respectively, these values shows the improvement and successful implementation of TPM on carding machine. Pilot machine, on which A, P, Q factors are minimum.

References

[8] Industrial Maintenance Management-Sushil Kumar, Shrivastava, (S Chand & Company Ltd.).

Table No. 5.- Predicted Changes in the A,P,Q and OEE.

<table>
<thead>
<tr>
<th>Machine No.</th>
<th>Availability (A)</th>
<th>Quality Rates (Q)</th>
<th>Performance efficiency (P)</th>
<th>Overall Equipment Effectiveness (OEE)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>X</td>
<td>Deviation</td>
<td>X</td>
<td>Deviation</td>
</tr>
<tr>
<td>C-1</td>
<td>0.89683</td>
<td>0.016214</td>
<td>0.7929</td>
<td>0.694783</td>
</tr>
<tr>
<td></td>
<td>0.070304</td>
<td></td>
<td>0.103367</td>
<td></td>
</tr>
<tr>
<td></td>
<td>0.689866</td>
<td></td>
<td>0.13915</td>
<td></td>
</tr>
<tr>
<td>new C-1</td>
<td>0.9196</td>
<td>0.097393</td>
<td>0.79757</td>
<td>0.971772</td>
</tr>
<tr>
<td>increase</td>
<td>0.02276</td>
<td>-0.00882</td>
<td>0.00467</td>
<td>0.006989</td>
</tr>
<tr>
<td>in %</td>
<td>2.2768</td>
<td>-0.8821</td>
<td>0.4678</td>
<td>0.6989</td>
</tr>
</tbody>
</table>

Pilot machine, on which A, P, Q factors are minimum.

AUTHOR

Ravikant V. Paropate is Assistant Professor in Department of Mechanical Engineering, Jawaharlal Darda Institute of Engineering and Technology, Yavatmal, India. He holds a Bachelor’s degree in Mechanical Engineering and Master degree in Production Engineering. He has 3 years of teaching experience and published over 08 papers in international journals and conferences. His research interests include Quality Management, Total Productive Maintenance.

Dr. Rajeshkumar U. Sambhe is Associate Professor (Mechanical Engineering) at Jawaharlal Darda Institute of Engineering and Technology, Yavatmal, India. He is completed his Doctoral studies from Government College of Engineering Amravati and awarded Ph.D. from Sant Gadge Baba Amravati University, Amravati. He holds his Bachelor Degree in Mechanical Engineering with University Merit and Master Degree in Production Technology with total 16 years experience. He has published 15 papers in international journals and conferences including paper International Journal of Productivity and Quality Management and International Journal of Business Excellence.