IMPROVEMENT OF OPERATIONAL EFFICIENCY OF EQUIPMENT THROUGH TPM: A CASE STUDY

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ABSTRACT

The productivity improvement of workforce, under Indian conditions, is a far cry. Therefore, the left out area is that of equipment and that can be significantly improved through Total Productive Maintenance (TPM). The various researchers have established that TPM is an important tool to improve equipment efficiency and achieving the organizational goals. This approach is to contribute on quality as well cost fronts. TPM is essentially a tool of Lean manufacturing where in the waste need to be identified for elimination. The present study pertains to spot welding workstation which clearly reveals the inherent problems associated with the process function. The various types of wastes on this workstation are bad design of tooling, long changeover time, unplanned machine breakdowns, and machine conditions. Therefore, elimination of these wastes is necessary to improve the equipment operating efficiency (OEE). TPM methodology has been assessed on the spot welding workstation for improvement in present level of 61 % to 68% in first stage, 68% to 75% in second stage and up to or above 85% in the third stage.

1.0 INTRODUCTION

In most of the Indian Industries Low level of maintenance technology and skill at the plant causes the frequent equipment failures, more idling of the instrument, minor stops due to workforce, higher rate of quality defects in produced parts, unsafe working condition, and difficulty in commissioning of new equipment. So that most of the automotive parts manufacturing units go for TPM as a tool for continuous improvement in quality rate of the product and increasing their competitive advantage. Like Lean manufacturing, TPM is also highlighted areas of historically accepted or hidden wastes (Womack and Jones, 1996). Despite their different origins, progress of the organization will depends upon sensitizing the organization to recognize wasteful behaviors and practices; in effect, to create such a heightened sensitivity to these ‘wastes’ that each employee detects these issues as abnormal and takes
appropriate actions to eliminate them. Such an approach makes employees quite intolerant to other organizations that still maintain old business models and have not yet engaged in this form of waste elimination. In the case of TPM the root cause of this waste is a short-term perspective that tolerates poor reliability. The root cause of Lean wastes is optimizing parts of, rather than, the total value stream. TPM companies have always channeled improved effectiveness to increase customer value, but Lean Thinking helps to sharpen the definition of value. Lean Thinking has always sought reliable processes, but TPM Provides the route map to zero breakdowns and continuous improvement in equipment optimization.

In Indian context, TPM is an effective tool for control of waste and thereby enhancing efficiency and reliability. The main objective of TPM is to addressed the problem connected with equipment breakdown, defects/scrap, Large setup changeover time and reduced efficiency of equipments. TPM is indicative of three P’s as ‘Planned, Predictive and Preventive’. The starting point for introduction of TPM is application of 5S that is CANDO (Cleaning, arranging, neatening, discipline and order in workplace organization. TPM helps to achieve competitive advantage to organizations in terms of Productivity, Quality, Cost, Profit and Value addition to customers. Figure 1 represents the TPM process for efficiency and reliability improvement.

What is TPM?

1. Set a goal to maximise overall equipment efficiency (OEE).
2. Build an organization to prevents all type of losses for entire life of the production system
3. Involve all departments including development, sales and administration
4. Involve all personnel, including top personnel to first-line operators.
5. Practice zero loss activity through overlapping small group activities.

Figure 1 TPM process

The implementation of TPM is carried out through TPM-I and TPM-II as shown in Figure 2 below. TPM-I comprises of initial cleanup, countermeasure for contamination and initial standards where as TPM-II is general inspection, autonomous inspection, standardization and autonomous management as shown in Figure 3.
TPM is operator driven reliability as operator is first point for early warning. Since operator is with the machine during the operation of machine. Unfortunately, this is the most neglected area which is the cause of unnecessary waste. The operative equipment efficiency is the major of equipment performance. OEE is availability, quality performance and speed. As per ASQ studies conducted by the experts, following improvements in process productivity and reliability can be achieved. These results are quiet effective for improvement in overall performance.
Table 1 Improvement in various areas after implementing TPM

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Areas for improvement</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Productivity improvement</td>
<td>1.5 to 2 times</td>
</tr>
<tr>
<td>2</td>
<td>Reduction in No. of Sporadic Failures</td>
<td>1/10 to 1/250</td>
</tr>
<tr>
<td>3</td>
<td>Overall equipment effectiveness</td>
<td>1.5 to 2 times</td>
</tr>
<tr>
<td>4</td>
<td>Reduction in Product Defects</td>
<td>1/10</td>
</tr>
<tr>
<td>5</td>
<td>Reduction in Customer Claims</td>
<td>1/4</td>
</tr>
<tr>
<td>6</td>
<td>Reduction in Maintenance Cost</td>
<td>30%</td>
</tr>
<tr>
<td>7</td>
<td>Reduction in Product Inventories</td>
<td>0</td>
</tr>
<tr>
<td>8</td>
<td>Reduction in Accident, Elimination of Pollution</td>
<td>2</td>
</tr>
<tr>
<td>9</td>
<td>Increase in number of Employee Suggestions</td>
<td>5 to 10 times</td>
</tr>
</tbody>
</table>

A case study was undertaken in an organization which is engaged in manufacturing automotive components. The area selected for this case study purpose was the spot welding where the organization felt that the working efficiency is low and difficult to achieve desired results. A sampling survey was carried out and the result was the average utilization stands at 48% on an average. It was further observed that the setup change time was long because of unreliable tooling. The machine operator struggled to optimize the location of rod for purpose of welding as the center line never matched. Also, the various operational systems were in pathetic condition. The principles of OEE were applied to solve the existing problem and enhancing the operative efficiency.

1.1 Equipment Effectiveness Computation

\[ \text{OEE} = \text{Availability} \times \text{Performance Efficiency} \times \text{Quality Rate of the Product} \]

- **Availability** = \( \frac{\text{Operation time}}{\text{Loading time}} \)
  - \( \text{Operation time} = \text{Loading time} - \text{down time} \)
  - **Loading time** = Total time (in a shift) – planned down time
- **Performance Efficiency** = \( \frac{\text{Operating speed rate} \times \text{net operating rate}}{\text{Actual processing time} / \text{Operation time}} \)
  - \( \text{Operating speed rate} = \frac{\text{Theoretical cycle time}}{\text{Actual cycle time}} \)
  - **Net Operating rate** = \( \frac{\text{Actual processing time}}{\text{Operation time}} \)
  - **Actual processing time** = \( \frac{\text{processed amount} \times \text{actual cycle time}}{\text{actual cycle time}} \)

Note: All the PM prize winning companies in Japan have equipment effectiveness greater than 85%.

2.0 LITERATURE REVIEW

Seiichi Nakajima (1988), the father of TPM has pointed out that the origin of TPM traced back to 1951 when Preventive Maintenance was introduced in Japan, describes in his well-known book entitled TPM Development Program. He referred the time prior to 1950 as the “breakdown maintenance” period. The Japanese has developed TPM to support their lean manufacturing system based on Preventive Maintenance, Corrective Maintenance and Maintenance Prevention concepts and methodologies that was originated and developed in the U.S.A. He investigated about the Equipment Effectiveness (is a measure of the value added to production through
equipment). The process of O.E.E. finding is to increase equipment effectiveness so each piece of equipment can be operated to its full potential and maintained at that level. Nakajima describes in his book that TPM maximizes equipment effectiveness though two types of activity to insure that the equipment performs to design specifications, which is the true focus of TPM.

**Wireman (1988)**, examined the industry performance by using Preventive Maintenance. He suggested that the service life of the plant equipment can be prolonged by reconditioning the equipment before adverse condition lead to failure. In this concept the operator not empowered in maintaining minor activities rather he only operates the equipment.

**Kennedy (2005)**, it should be acknowledged that a TPM implementation is not a short-term fix program. It is a continuous journey based on changing the work-area, then the equipment so as to achieve a clean, neat, safe workplace through a "PULL" as opposed to a "PUSH" culture. Significant improvement can be evident within six months, however full implementation can take many years to allow for the full benefits of the new culture created by TPM.

**Deshmukh (2006)**, reviews the literature on maintenance management and suggest possible gaps from the point of view of researchers and practitioners. The paper systematically categorizes the published literature and then analyzes and reviews it methodically. This paper conclude that, in maintenance management the important issues range from various optimization models, maintenance techniques, scheduling, and information systems etc. Within each category, large gaps have been identified. A new shift in maintenance paradigm is also highlighted.

**Ahuja and Khambha (2008)**, presented the literature review on Total Productive Maintenance (TPM) that is an overview of TPM implementation practices, adopted by the manufacturing organizations. It also shows the appropriate enablers and success factors for eliminating barriers in successful TPM implementation. They systematically categorized the published literature and then analyzed and reviewed it methodically. The paper reveals the important issues in Total Productive Maintenance ranging from maintenance techniques, framework of TPM, overall equipment effectiveness (OEE), TPM implementation practices, barriers and success factors in TPM implementation, etc. They have highlighted the contributions of strategic TPM programmes towards improving the manufacturing competencies of the organizations. They also highlighted the approaches, suggested by various researchers and practitioners and critically evaluated the reasons behind failure of TPM programmes in the organizations.

### 3.0 CASE STUDY

The present study has been carried out in the spot welding workstations for the financial year of 2011-12. The machines are running on 2 shift basis (each shift consisting 8 hours). The optimum production cycle time is 0.20 min. per piece. The average quality acceptance level is 95% on each machine.

The setup change time 40 minutes with 1 setup change per shift. The welding workstation has the problem from major breakdowns with an average of 8 breakdowns in a month with an average of 60 minutes per breakdown consumption to repair that fault.
There were minor stops on the machine on an average 6 stops per shift and average duration of 4 minutes because of fixture fault. The machines are not working on 26 days a week rather these machines are running for a period of 24 days per month as two Saturdays are observed as holidays along with Sundays. The machine is also stopped for one day per quarter in a year for preventive maintenance.

3.1 OEE Calculation

- **Machine total available time per day** = 8*2*60 = 960 min/day

- **Planned down time** = Setup time for machine + Break time (coffee) + preventive mtn.
  = 80 + 100 + 10 = 190 min/day

- **Unplanned down time** = Break down time + minor stoppages
  = 40 + (6*2)*4 = 88 min/day

- **Loading time** = total time – planned down time
  = 960 – 190 = 770 min/day

- **Operation time** = loading time – unplanned down time
  = 770 - 88 = 682 min/day

- **Availability** = \[
\frac{\text{Operation time}}{\text{Loading time}} \times 100 = \frac{682}{770} \times 100 = 0.89\% \]

- **Quality rate** = \[
\frac{\text{Production Output} - \text{Defective products}}{\text{Production Output}} = \frac{2500 - 160}{2500} = 94\% \]

- **Performance efficiency**
  
  - Ideal Production Time = 0.2 min. per piece
  - Machine actual speed = 0.27 min. per piece
  - Processed amount = \( \frac{1}{0.23} \times 682 = 2500 \) pieces per day
  - Performance efficiency = \[
\frac{\text{Processed amount} \times \text{Ideal cycle time}}{\text{Operation time}} = \frac{2500 \times 0.2}{682} = 0.73 \times 100 = 73\% \]

- **OEE** = Availability* Quality rate* Performance efficiency
  = 0.89*0.94*0.73 = 0.61*100 = 61%

4.0 CONCLUSION

TPM is worker oriented reliability. All along, machine operator has not been taken care whereas, operator is the person associated with machine on day to day basis. TPM provides the basis for group performance as the workers across work culture are required to maintain a healthy
relationship for improving operative effectiveness of the equipment. TPM methodology implementation in Indian context results in low equipment breakdown, less idling and minor stops time, less quality defects, boost the productivity rate, trim the labor cost, shrinks inventory level, reduce accidents in plants, promote employee involvement on the workstation, save spare expenses and improve profits through increasing sale.

Even in the present case, the observe data confirms that the machine operator is not associated with machine performance. Therefore, the implementation of TPM will not only enhance the machine available time but also the due recognition to the operator. This TPM programme, apart from throughput time shall also increased the process reliability thereby de-generating the quantum of rejection. The gap between present performance of 61% to planned performance of +85% being quiet high and has been split in three phases: from 61% to 68% will be aimed to achieve in the financial year of 2012-13, 68% to 75% will be aimed to achieve in the financial year of 2013-14 and 75% to or more than 85% will be aimed to achieve in the financial year of 2014-15 respectively.

REFERENCES