Case Study on Implementation of TPM

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Abstract - This dissertation considers on implementation of TPM. This paper aims to study the results of TPM implementation in manufacturing industries. The correlation between various TPM implementation dimension and manufacturing performance improvement has been evaluated and verified by calculating overall equipment effectiveness (OEE). In our works, we cover the journey of implementation and any related issue that occurred in any company. The related issue is referred to benefits, challenges, limitations and the require elements to improve the TPM implementation plan. In addition it also will show the current state of TPM implementation at any company. During implementation of TPM in industry we used different tools such as 5s, employee empowerment, benchmarking, documentation etc. The study establishes that focused TPM implementation over a reasonable time period can contribute towards realization of significant manufacturing performance enhancements. It was found that improving overall equipment effectiveness is one of the main benefits in implementing TPM and it has been discussed in most of the literature. The tangible benefits that could be achieved through the successful implementation are discussed.

1. Introduction - Total Productive Maintenance (TPM) is a unique Japanese philosophy, which has been developed based on the productive maintenance concepts and methodologies. This concept was first introduced by M/s Nippon Denro Co. Ltd. of Japan, a supplier of M/s Toyota Motor Company, Japan in the year 1971. Total productive maintenance is an innovative approach to maintenance that optimizes equipment effectiveness, eliminates breakdowns and promotes autonomous maintenance by operators through day-to-day activities involving total workforce.

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. One approach to improve the performance of maintenance activities is to implement a Total Productive Maintenance (TPM) system. 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 is a production driven improvement methodology that enhance the equipment reliability and ensure effectual management of plant assets using employee involvement and empowerment, by linking maintenance, manufacturing and engineering functions. TPM brings maintenance into focus as a necessary and vitally important part of the business. 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.

Industry Forum’s TPM approach delivers significant results in three ways:

1. Program support material and knowledge, implementation approach and supporting materials to answer the ‘why’ and ‘how’ to implement.

2. Learning & Development – structured training and development programs to support implementation. All our training materials are developed with training frameworks for effective delivery.

3. Audit & Assessment – experienced in applying the reflective process of audits and assessments exploring opportunities and creating competitive gaps in a constructive way.

It is a system of maintaining and improving the integrity of production and quality systems through the machines, equipment, processes and employees that add business value to the organization. TPM focuses on keeping all equipment in top working condition to avoid breakdowns and delays in the manufacturing process. One of the main objectives of TPM is to increase the productivity of plant and equipment with a modest investment in maintenance. Total quality management (TQM) and total productive maintenance (TPM) are considered as the key operational activities of the quality management system. In order for TPM to
be effective, the full support of the total workforce is required. This should result in accomplishing the goal of TPM: "Enhance the volume of the production, employee morale and job satisfaction. TPM is an effective tool for the minimization of downtime of machines, production losses and material scraps.

1.1 Implementation of Total Productive Maintenance

Following are the steps involved by the implementation of TPM in an organization:

• Initial evaluation of TPM level
• Introductory Education and Propaganda (IEP) for TPM
• Formation of TPM committee
• Development of master plan for TPM implementation
• Stage by stage training to the employees and stakeholders on all eight pillars of TPM, Implementation preparation process,
• Establishing the TPM policies and goals and
• Development of a road map for TPM implementation

1.2 Issues and Challenges

The factory has been using Lean improvement techniques to improve the productivity, delivery and quality of the factory for several years but they recognized the need to reduce costs even further to ensure that they remained competitive against emerging market competition. The processing equipment operates in a high temperature and highly abrasive environment, so reliability and resilience is a key differentiator. There were additional challenges due to a range of technologies across the globe and also huge cultural differences, rates of acceptance and uptake by the workforce.

1.3 Objective

In our works, we cover the journey of implementation and any related issue that occurred in any company. The related issue is referred to benefits, challenges, limitations and the require elements to improve the TPM implementation plan. In addition it also will show the current state of TPM implementation at any company. To start implementation of TPM firstly top management need to understand that TPM needs to be part of a long term culture change program, not just an initiative for the maintenance department. A TPM structure to support the cultural change needs defined with clear responsibilities and ownership.

• To study of the existing and present maintenance system in Power Plant with effect of Japanese 5 S Concept of TPM.
• To study the problem faced by the employees with this system.
• To study the trends of breakdown of Machine in Power Plant.
• To improve productivity and quality.
• Need to change and remain competitive.
• Need to critically monitor and regulate work-in-process of manufacturing process.
• Regulating inventory levels and production lead-times for realizing optimal equipment available time.
• Ensuring more effective use of human resource through adequate training and multi-skilling.
• Refining preventive and predictive maintenance activities.

2. Company Profile (Adani):-

Adani, a global conglomerate with a presence in multiple businesses across the globe, has entered the power sector to drive a ‘power full’ India. Our comprehension of the criticality in meeting the power requirement and its crucial role in ensuring the energy security of India, spurred us to build India’s largest and among the world’s top 5 single location thermal power plant at Mundra. Along with thermal power generation, Adani power has made a paradigm shift by venturing into solar power generation in Gujarat. It is Adani’s endeavor to empower one and all with clean, green power that is accessible and affordable for a faster and higher socio-economic development. Adani Power Limited has commissioned the first supercritical 660 MW unit in India.

Adani Power: Empowering the Nation

Adani, a global conglomerate with a presence in multiple businesses across the globe, has entered the power sector to drive a ‘power full’ India.

The company is implementing 16500 MW at different stages of construction. Its mission is to achieve 20000 MW by 2020. The company produces electricity using only coal. 100 MW of
solar power station is also under advanced stage of implementation at Surendranagar in Gujarat out of which 40 MW is already commissioned. The company has gone to long term PPAs of about 7200 MW of its 9280 MW with government of Gujarat, Maharashtra, Haryana and Rajasthan.

Adani comprehension of the criticality in meeting the power requirement and its crucial role in ensuring the energy security of India, spurred us to build India’s largest and among the world’s top 5 single location thermal power plant at Mundra. Along with thermal power generation, Adani power has made a paradigm shift by venturing into solar power generation in Gujarat. It is Adani’s endeavor to empower one and all with clean, green power that is accessible and affordable for a faster and higher socio-economic development. Adani Power Limited has commissioned the first supercritical 660 MW unit in India. Mundra is also the world’s first supercritical technology based thermal power project to have received ‘Clean Development Mechanism (CDM) Project’ certification from United Nations Framework Convention on Climate Change (UNFCCC).

Adani power has the fastest turnaround time of projects in the industry. To complete the value chain in power supply, adani has forayed into power transmission. Group’s first line to be commissioned was 400 KV, 430 km long double circuit line from Mundra to Dehgem. Further the group achieved a landmark with completion of about 1000 km long 500km Bi-pole HVDC line connecting Mundra in Gujarat to Mohimdevgarh in Haryana. This became the first HVDC line by a private player in India and connects western grid to northern grid. Today adani power has approximately 5500 circuit Kms of transmission lines connecting its Tiroda project in Maharashtra with Maharashtra grid. The advantageous edge Adani has is the national and international coal mining rights with its promoter Company Adani Enterprises Limited which ensures fuel security. Vertical integration within the Adani group shall provide synergies to the power business and catapult it to electrifying heights of success. Power Business of Adani Group has witnessed several achievements as well as challenges since its inception and yet the journey continues on the chosen path. Team Power believes in Passion, Speed and Quality in every endeavor of the organization. The team has established benchmarks in various areas and is continuously in pursuit of excellence. Words like First, Largest, Top, etc. have become its identity.

The recent times have been very eventful. Many lessons have been learnt, initiatives taken and benchmarks established. The current scenario in power sector and our long term plans present several challenges for our Nation to generate continues electricity and trying to fulfill the requirement of our Country.

Adani believe that challenges are a part of professional life and provide with the opportunity to excel. Adani foresee a brighter and exciting times ahead when many more milestone shall be crossed by Team Power. Adani believe in his people’s strength, which has been evident on many occasions. It’s the people, in the organization who make miracles happen and they shall continue to empower the organization to make it the best in the business.

### Table 2.1   Capacity of Adani Power Plant

<table>
<thead>
<tr>
<th>Stage</th>
<th>Unit Number</th>
<th>Installed Capacity (MW)</th>
<th>Date of Commissioning</th>
<th>Status</th>
</tr>
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<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>660</td>
<td>2012 September</td>
<td>Running</td>
</tr>
<tr>
<td>1</td>
<td>2</td>
<td>660</td>
<td>2013 March</td>
<td>Running</td>
</tr>
<tr>
<td>1</td>
<td>3</td>
<td>660</td>
<td>2013 June</td>
<td>Running</td>
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<tr>
<td>1</td>
<td>4</td>
<td>660</td>
<td>2014 April</td>
<td>Running</td>
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<td>1</td>
<td>5</td>
<td>660</td>
<td>2014 October</td>
<td>Running</td>
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</table>

### Loss Category

<table>
<thead>
<tr>
<th>No.</th>
<th>Loss</th>
<th>Category</th>
<th>Status</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>Failure losses - Breakdown loss</td>
<td>Losses that impede equipment efficiency</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Setup / adjustment losses</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Cutting blade loss</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Startup loss</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Minor stoppage / idling loss</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Speed loss - operating at low speeds</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Defect / rework loss</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Scheduled downtime loss</td>
<td></td>
<td></td>
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<tr>
<td>9</td>
<td>Management loss</td>
<td></td>
<td></td>
</tr>
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<td>10</td>
<td>Operating motion loss</td>
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<td>11</td>
<td>Line organization loss</td>
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<tr>
<td>12</td>
<td>Logistic loss</td>
<td></td>
<td></td>
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<tr>
<td>13</td>
<td>Measurement and adjustment loss</td>
<td>Losses that impede effective use of production resources</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>Energy loss</td>
<td></td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>Die, jig and tool breakage loss</td>
<td></td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>Yield loss.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 2.2   Major Losses in an Organization
3. Research Methodology-

This research aimed at studying the implementation of total productive maintenance of machines at M/s Adani Thermal Power Plant Maharashtra Ltd., Tiroda. TPM Implementation Stages at M/s Adani Thermal Power Plant Maharashtra Ltd. Tiroda are discussed below:

a. Stage A-Preparatory stage

Step 1-Announcement by management to all about TPM introduction in the organization: Proper understanding, commitment and active involvement of the top management in needed for this step. Senior management should have awareness programs, after which announcement is made. Decision the implement TPM is displayed on the notice boards and a letter informing the same is send to contractor and suppliers.

Step 2-Initial education and propaganda for TPM: Training is to be done based on the need. Some need intensive training and some just awareness training based on the knowledge of employees in maintenance.

Step 3-Setting up TPM and departmental committees: TPM includes improvement, autonomous maintenance, quality maintenance etc., as part of it. When committees are set up it should take care of all those needs.

Step 4-Establishing the TPM working system and target: Each area/work station of Power Plant is benchmarked and target is fixed up for achievement.

Step 5-A master plan for institutionalizing: Next step is implementation leading to institutionalizing wherein TPM becomes an organizational culture. Achieving PM award is the proof of reaching a satisfactory level.

b. Stage B-Introduction stage

A small get-together, which includes Adani contractor and suppliers participation, is conducted. Suppliers as they should know that we want quality supply from them. Some may learn from Adani and some can help and contractor will get the message from that Ada care for quality output, cost and keeping to delivery schedules in Maintenance.

c. Stage C-TPM implementation

In this stage eight activities are carried which are called eight pillars in the development of TPM activity. Of these four activities are for establishing the system for production efficiency, one for initial control system of new products and equipment, one for improving the efficiency of administration and are for control of safety, sanitation as working environment in Adani Power Plant.

d. Stage D-Institutionalizing stage

By now the TPM implementation activities would have reached maturity stage. Now is the time to apply for preventive maintenance award. The following is the brief description of each of the TPM implementation activities:

i. Master plan: The TPM team, along with manufacturing and maintenance management, and union representatives determines the scope/focus of the TPM program. The selected equipment’s and their implementation sequence are determined at this point. Baseline performance data is collected and the program’s goals are established.

ii. Autonomous maintenance: The TPM team is trained in the methods and tools of TPM and visual controls. The equipment responsibility for cleaning and inspecting their equipment and performing basic maintenance tasks. The maintenance staff trains the operators on how to perform the routine maintenance, and all are involved in developing safety procedures. The equipment operators start collecting data to determine equipment performance.

iii. Planned maintenance: The maintenance staff collects and analyzes data to determine usage/need based maintenance requirements. A system for tracking equipment performance metrics and maintenance activities is created (if one is not currently available). Also, the maintenance schedules are integrated into the production schedule to avoid schedule conflicts.

iv. Maintenance reduction: The data that has collected and the lessons learned from TPM implementation are shared with equipment suppliers. This ‘design for maintenance’ knowledge is incorporated into the next generation of equipment designs. The maintenance staff also develops plans and schedules for performing periodic equipment analysis (burner pump, fuel filter, rotary cup atomizer, furnace tube and valve, etc.). This data from analysis is also fed into the maintenance database to develop accurate estimates of equipment performance and repair equipment. These estimates are used to develop spare parts inventory policies and proactive replacement schedules.

v. Holding the gains: The new TPM practices are incorporated into the organization’s standard
operating procedures. These new methods and data collection activities should be integrated with the other elements of the production system to avoid redundant or conflicting requirements. The new equipment management methods should also be continuously improved to simplify the tasks and minimize the effort required to sustain the TPM program.

4. Result Analysis

Manufacturing is considered to be an important element in a firm’s endeavor to improve firm performance. Superior manufacturing performance leads to competitiveness TPM is a highly structured approach, which uses a number of tools and techniques to achieve highly effective plants and machinery. TPM has proved to be the maintenance improvement philosophy preventing the failure of an organization. Today, an effective TPM strategy and programs are needed, which can cope with the dynamic needs and discover the hidden but unused or underutilized resources. TPM methodology has the potential to meet the current demands.

In Adani Power Maharashtra Ltd, Tiroda TPM starts with 5S. It is a systematic process of housekeeping to achieve a serene environment in the work place involving the employees with a commitment to sincerely implement and practice housekeeping.

Problems cannot be clearly seen when the work place is unorganized. Cleaning and organizing the workplace helps the team to uncover problems. Making problems visible is the first step of improvement. 5S is a foundation program before the implementation of TPM.

This 5S implementation has to be carried out in phased manner. First the current situation of the workplace has to be studied by conducting a 5S audit. This audit uses check sheets to evaluate the current situation. This check sheet consists of various parameters to be rated say on a 5-point basis for each ‘S’. The ratings give the current situation. The each of the above-mentioned 5S is implemented and audit is conducted at regular intervals to monitor the progress and evaluate the success of implementation. After the completion of implementation of 5S random audits could be conducted using company check sheets to ensure that it is observed in true spirits by everyone in the work place. Table 1 depicts the key activities to be holistically deployed for effective 5S implementation at the workplace.

TPM aims at maximization of machine utilization and not merely machine availability maximization. As one of the pillars of TPM activities, kaizen pursues efficient equipment, operator and material and energy utilization that is extremes of productivity and aims at achieving substantial effects. Kaizen activities try to thoroughly eliminate losses. Six major losses that were identified are-equipment failure, set-up and adjustments, small stops, speed losses during production, and losses during warm-up.

Adani evolve his efforts from a reactive to a proactive method and use trained maintenance staff to help train the operators to better maintain their equipment. In PM policy are achieve and sustain availability of machines, optimum maintenance cost, reduces spares inventory, and improve reliability and maintainability of machines.

PM targets are zero equipment failure and break down, improve reliability and maintainability by 50 percent, reduce maintenance cost by 20 percent, and ensure availability of spares all the time.

Six steps in planned maintenance are equipment evaluation and recording present status; restore deterioration and improve weakness; building up information management system; prepare time based information system; select equipment, parts and members and map out plan; prepare predictive maintenance system by introducing equipment diagnostic techniques; and evaluation of planned maintenance.

In Quality Management policy are defect free conditions and control of equipments, quality maintenance activities to support quality assurance, focus of prevention of defects at source, focus on Poka-Yoke (fool proof system), in-line detection and segregation of defects, and effective implementation of operator quality assurance. QM targets are achieve and sustain customer complaints at zero, reduce in-process defects by 50 percent, and reduce cost of quality by 50 percent.

Training policies are focus on improvement of knowledge, skills and techniques, creating a training environment for self-learning based on felt needs, etc. related to safety can be organized at regular intervals.

TPM implementation steps, OEE value in boiler plant was calculated and analyzed before and after implementation of TPM in industry. In the process industry it is very much essential to maximize the production effectiveness; the effectiveness of a plants production depends on the effectiveness with which it uses equipment materials people and methods. This is done by examining the inputs to the production process and
identifying, eliminating the losses associated with each to maximize the production. Major industry losses were identified and shut down (planned maintenance), production adjustment, equipment failure (mainly boiler), process failures, normal production loss, abnormal production loss, quality defects, and reprocessing.

4.1 Overall Equipment Efficiency

TPM employs OEE as a quantitative metric for measuring the performance of a productive system. OEE is a core metric for measuring the success of TPM implementation program. The overall goal of TPM is to raise the overall equipment efficiency. OEE is calculated by obtaining the product of availability of the equipment, performance efficiency of the process and rate of quality products.

Overall Equipment Efficiency = Availability x Performance efficiency x Rate of Quality.

Where,

Availability: - Available Time required to produce a finish product.
Availability = (Required availability – Downtime) / (Required availability) *100.

Performance: - It can be defined as the design cycle time to produce the item multiply by the output of the equipment and then divided by the operating time.
Performance = (design cycle time*output) / (operating time)*100

Quality = It is the ratio of production output to the production input.
Quality = output/input.

4.2 Calculations on OEE of the boiler plant for January, 2016 (before TPM implementation):

<table>
<thead>
<tr>
<th>Type of Loss</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mechanical breakdown</td>
<td>43.43hrs</td>
</tr>
<tr>
<td>Electrical breakdown</td>
<td>11.25hrs</td>
</tr>
<tr>
<td>Electronics/safety device breakdown</td>
<td>2.03hrs</td>
</tr>
<tr>
<td>Total breakdown</td>
<td>57.11hrs</td>
</tr>
<tr>
<td>Setup and other conditions</td>
<td>7.30hrs</td>
</tr>
<tr>
<td>Total loss</td>
<td>64.41hrs</td>
</tr>
<tr>
<td>Net loss</td>
<td>720 hrs</td>
</tr>
</tbody>
</table>

Availability rate = (Net loss/Total good hours)*100

Availability rate = (64.41/720)*100 = 90.99%

Thus, availability rate is 90.99%.

Percentage of quality = (Total steam produced-Defected steam) / Total steam produced

Defected steam = Total breakdown × Steam produced per hour = (7200-571.1) / 7200 = 92.07%

Thus, quality rate is 92%.

(Consumption item furnace oil per batch= 5550 litters and 210,316 litter's/month, Management loss=90 hrs, Startup loss=15hrs). Thus, performance rate is 83.97%.

OEE = (Availability rate) × (Performance rate) × (Quality rate) × 100 = (0.9099) × (0.8397) × (0.9207) = 70.35%

[Note: If OEE is less than 85% (world class manufacturing performance for continuous production)]

4.3 Calculations on OEE of the boiler plant for June, 2016 (after TPM implementation):

Mechanical breakdown=13.35hrs
Electrical breakdown=2.50hrs
Electronics breakdown=0
Total breakdown=16.25hrs
Setup and other conditions=7.30hrs
Total loss = 23.55hrs (Summation of all above losses)
Net loss (Total good hours-Total loss) = 720 hrs - 23.55hrs = 696.05hrs

Availability rate = (Net loss/Total good hours)*100 = (696.05/720) × 100 = 96.67%

Thus, availability rate is 96.67%.

Percentage of quality = (Total steam produced-Defected steam) / Total steam produced

Defected steam = Total breakdown × Steam produced per hour = (7200-162.5) / 7200 = 97.74%

Thus, quality rate is 98%.

(Consumption item furnace oil per batch= 5550 litters and 210,316 liters per month, Management loss=90hrs, Startup loss=15hrs)

Thus, performance rate is 84.91%.

The results of total loss (hours) and OEE calculation for three months during TPM implementation (before and after) in boiler plant at M/s Adani Power Maharashtra Ltd. Tiroda are shown in Tables 1 and 2.
--- | ---
Month | Total loss | Month | Total loss
--- | --- | --- | ---
January | 64.48hrs | May | 41.40hrs
February | 81.40hrs | June | 23.55hrs
March | 62.50hrs |  

Table 4.1: OEE loss for three months

--- | ---
Month | OEE value | Month | OEE value
--- | --- | --- | ---
January | 70.35% | May | 75.60%
February | 66.44% | June | 80.23%
March | 70.81% |  

Table 4.2: OEE value for three months

4.4 Findings and Analysis

Q1. Top management has proper understanding and active involvement in TPM process

27% respondents were strongly agreed however 14% respondents were disagreed with the above statement

Q2. Every employee get timely notification before a new TPM implementation process

29% respondents were strongly agreed however 16% respondents were disagreed with the above statement

Q3. While setting up TPM, managers always take care of all those needs

23% respondents were strongly agreed however 18% respondents were disagreed with the above statement

Q4. Managers are able to identify the problem easily before implementing the TPM

30% respondents were strongly agreed however 14% respondents were disagreed with the above statement

Q5. The operators are responsible for upkeep of their equipment to prevent it from deteriorating.
32% respondents were strongly agreed however 15% respondents were disagreed with the above statement.

Q6. By using a detailed and thorough procedure we eliminate losses in a systematic method using various Kaizen tools.

27% respondents were strongly agreed however 18% respondents were disagreed with the above statement.

Q9. The company always creates a safe workplace and a surrounding area that is not damaged by their procedures.

31% respondents were strongly agreed however 12% respondents were disagreed with the above statement.

Q7. The company always uses the trained maintenance staff to help train the operators to better maintain their equipment.

22% respondents were strongly agreed however 17% respondents were disagreed with the above statement.

Q10. TPM keeps all equipment in top working condition to avoid breakdowns.

28% respondents were strongly agreed however respondents were disagreed with the above statement.

Q8. The company always considers current quality concerns first, and then move to potential quality concerns.

19% respondents were strongly agreed however 12% respondents were disagreed with the above statement.

Q11. In order for TPM to be effective, the full support of the total workforce is required.
25% respondents were strongly agreed however 12% respondents were disagreed with the above statement

5. Conclusion and Recommendation

5.1 Summary and Contributions

Today, with competition in industry at an all-time high, TPM may be the only thing that stands between success and total failure for some companies. It has been proven to be a program that works. It can be adapted to work not only in industrial plants, but in construction, building maintenance, transportation, and in a variety of other situations. Employees must be educated and convinced that TPM is not just another "program of the month" and that management is totally committed to the program and the extended time frame necessary for full implementation.

A manufacturing facility has been studied and analyzed to study TPM implementation issues, the roadmap followed and the key benefits achieved from OEE as a result of TPM implementation. It can be seen that OEE on boiler plant has shown a progressive growth (Table 1), which is an indication of increase in equipment availability, decrease in rework, rejection and increase in rate of performance. As a result overall productivity of industry also increased. OEE value is encouraging and with the passage of time results will be quite good and may reach a world class OEE value of 85%-90%.

Through TPM process focus, the cost and quality were improved significantly by reducing and minimizing equipment deterioration and failures. Cost of rework and repairs reduced due to very limited products rejected due to equipment failure. Thus, the overall effectiveness of equipment also improved significantly. Additionally, equipment deterioration was eliminated as the equipment operated efficiently. Autonomous maintenance activities were carried out with total employee participation. The investment in training and education managed to boost operator’s morale and the commitment towards company’s goals.

5.2 Future Directions

• Operator should be skilled in their particular working area, so Training the operator is very much important.

• Launch of Reliability Centered Maintenance: - In this, the operator will gain the knowledge about the machine in the rolling a mill, if any failure occurs he would know how to repair that machine.

• There should be flexibility in pinch roll machine, so that miss guide of the billet is reduced.

• Proper setup and adjustment of the section change is needed. For this, a good Engineer along with the worker who do this job in needed for proper guiding of each activity.

• TPM has keeping on all equipment in top working condition to avoid breakdowns and delays in the manufacturing process and power plant.

• Today, with competition in industry at an all-time is high; TPM may be the only thing that stands between success and total failure for some companies. It has been proven to be a program that works.

• It can be adapted to work not only in industrial plants, but in construction, building maintenance, transportation, and in a variety of other situations. Employees must be educated and convinced that TPM is not just another "program of the month" and that management is totally committed to the program and the extended time frame necessary for full implementation.

• If everyone involved in a TPM program does his or her part, an unusually high rate of return compared to resources invested may be expected.

• Total quality management (TQM) and total productive maintenance (TPM) are considered as the key operational activities of the quality management system.

• In order for TPM to be effective, the full support of the total workforce is required. This should result in accomplishing the goal of TPM: “Enhance the volume of the production, employee morale and job satisfaction

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