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A Total Productive Maintenance (TPM) Approach To Improve Overall Equipment Efficiency

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ABSTRACT:*Good maintenance is fundamental to productive manufacturing system. Total Productive Maintenance (TPM) is an alternative approach to equipment maintenance that seeks to achieve zero breakdowns and zero defects. TPM is an approach to keep the current plant and equipment at its higher productive level through cooperation of all areas of organization. In this paper the selected machines were carefully studied in an industry. Data for past have been analyzed and results achieved are quite encouraging in terms of motivated employees, improvement in overall equipment effectiveness (OEE) and reduction in no. of accidents on shop floor. The analysis has revealed that there are 98% good components, 2% rework losses, where the nine most common causes were identified for the machine stoppages. The OEE was 67% and the six big losses represent 35% loss of the product time. Based on the findings, it was recommended to implement a TPM to improve the OEE of the plant.*

Keywords**:** *Manufacturing performance, overall equipment effectiveness implementation, planning, training, TPM, etc.*

I. INTRODUCTION

In this competitive world total elimination of waste is necessary for the survival of the organization. The wastes generated due to the failure shutdown of facilities that have been built, with huge investment and also waste such as defective products should be absolutely eliminated. In a manufacturing scenario, the desirable productivity, cost, inventory, quality and delivery all depend on the efficient functioning of the company's facilities. The philosophies like, total quality management (TQM), just in time (JIT), flexible manufacturing systems (FMS),etc. have led to a comprehensive maintenance technique known as total productive maintenance (TPM) [1]. Hartman defines TPM as "Total Productive Maintenance permanently improves the overall effectiveness of equipment with the active involvement of operators" [2]. The aim of TPM to reduce

The six major equipment losses, to zero, have been recognized as necessary for corporate survival. TPM is a unique Japanese system of plant management, developed from preventive maintenance concept. This approach emphasizes the role of teamwork, small group activities, and the participation of all employees to accomplish equipment improvement objectives [3]. It challenges a sense of joint responsibility between operators and maintenance workers, not only to keep the machines running smoothly, but also to extend and optimize their overall performance [4]. It is also defined as, bringing both functions (production and maintenance) Together by a combination of good working practices, team working,

And continuous improvement [5]. TPM is intended to bring both functions (production and maintenance) together by a combination of good working practices, team working and continuous improvement [6].

II. PILLARES OF TPM

The Japan Institute of Plant Maintenance propose the introduction of TPM program is based on the implementation of a series 8 pillars of TPM in a systematic way to optimize plant and equipment efficiency by crating perfect relationship between man and equipment. The diagram below represents a common structure of TPM. Figure 1

- Autonomous Maintenance / Jishu Hozen.
- Focused Improvement /Kobestu Kaizen.
- Planned Maintenance.
- Quality Maintenance.
- Training.
- Office TPM.
- Safety, Health and Environment.
- Initial Flow Control.

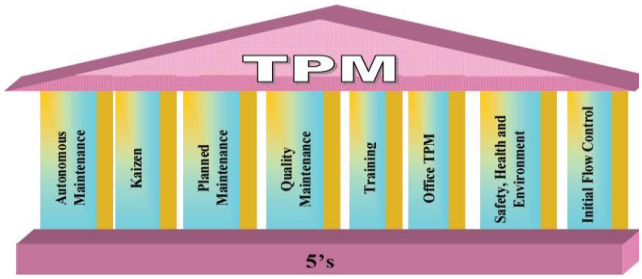


Fig. 1 Pillars of TPM

III. AUTONOMOUS MAINTENANCE/JISHU HOZAN

Japanese name of autonomous maintenance is JISHU HOZEN. This activity 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. Autonomous maintenance includes any activity performed by the production department that has a maintenance function and is intended to keep the plant operating efficiently and stable in order to meet production plans [1]. Autonomous maintenance is closely linked with focused improvement in that both support equipment restoration and sustaining basic equipment conditions [14].

Following policies are adopted for developing JISHU HOZEN:

- Uninterrupted operation of equipment's.
- Flexible operators to operate and maintain other equipment's.
- Eliminating the defects at source through active employee participation.
- Stepwise implementation of JH activities.

IV. FOCUSSED IMPROVEMENT/ KAIZAN

Focused improvement includes all activities that maximize the overall effectiveness of equipment, processes and plants through elimination of losses [15]. It includes identification, quantification and elimination of losses that affect productivity, quality, performance, etc. OEE is a key metric of focused improvement. Focused improvement is characterized by a drive for zero losses meaning continuous improvement effort to eliminate any effectiveness losses. Kaizen is a Japanese word for improvement. According to Kaizen, it is a fact that every employee of the company is capable of improving his work and the method of working. Kaizen forms an essential part of TPM.

V. OEE AND SIX MAJOR LOSSES

The literature reveals that no standard exists for calculation of OEE. The OEE calculation is quite general and can be applied to any manufacturing organization [7]. OEE is a measurement used to determine how efficiently a machine is running. Though the definition implies that OEE is the measure of a particular machine, but it can also be used to measure efficiency of product lines, sections of a plant or even the entire plant. Philip Godfrey [8] notes that the effective operation of individual pieces of production equipment, assembly lines or whole factory is dependent on the three factors of OEE [9]. OEE is the most effective measure for driving plant improvement. It continuously focuses the plant on the concept of zero-waste [10]. Unless careful monitoring occurs, the reduced capacity goes unnoticed or is accepted as normal. OEE can be considered to combine the operation, maintenance and management of manufacturing equipment and resources [2]. The losses are divided into six major categories, which affect the overall performance of the equipment namely [10]:

1. Equipment failures/breakdown losses are the time losses and quantity losses caused by defective products.
2. Set-up and adjustment losses are defined as time losses resulting from downtime and defective products that occur when production of one item ends and the equipment is adjusted to meet the requirements of another item.
3. Idling and minor stop losses occur when the production is interrupted by a temporary malfunction or when a machine is idling.
4. Reduced speed losses refer to the difference between equipment design speed and actual operating speed.
5. Reduced yield losses occur during the early stages of production from machine start up to stabilization.
6. Quality defects and reworks are losses in quality caused by malfunctioning of production equipment.

The first two losses are known as down time loss and are used to calculate availability of a machine. The third and fourth are speed losses that determine the performance efficiency and the final two losses are considered to be losses due to defects in the products. OEE is measured in terms of these six losses, which are function of availability, performance rate and quality rate of the machine, production line or factory [11]. And claims, increasing productivity, reducing costs, shrinks inventory, decreasing accidents and promoting employee involvement [12]. Suzuki cites Productivity, Quality, Costs, Delivery, Safety and Morale (PQCDSM), improvement for early TPM implantation.

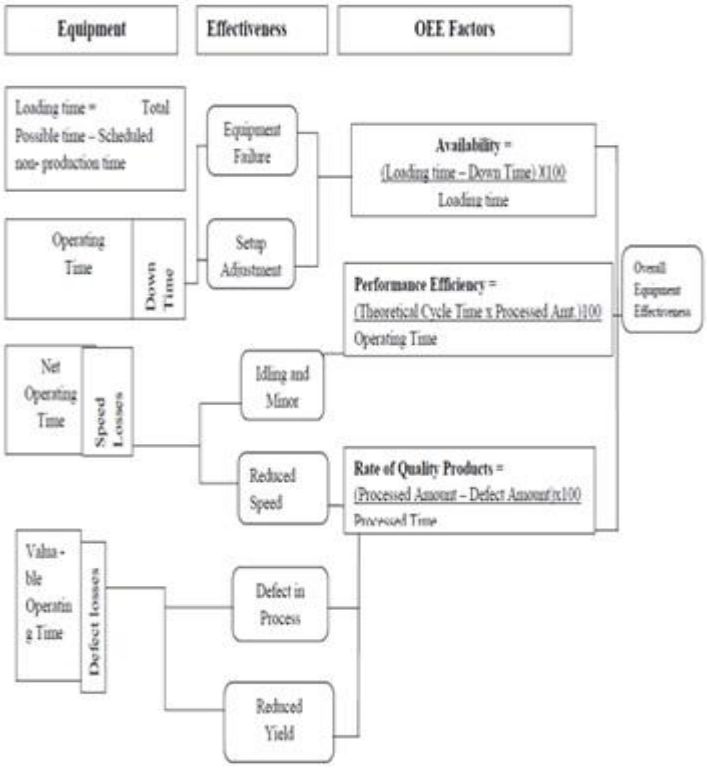


Fig.2 Impact of OEE on Competitiveness [13]

The overall performance of equipment's can be enhanced by identifying and eliminating the root causes. OEE is used as a tool to measure the effectiveness of equipment's to know the current condition. It helps to identify the areas of improvement required in terms of availability, performance efficiency and quality rate of products classifying them into six major losses, as identified by Nakajima in the OEE model [10]. These six major losses are overcome by the Focused Equipment Improvement (FEI) and Autonomous Maintenance (AM) activities of TPM, (Refer fig. 2). These activities will be more effective if carried, in small groups or teams, which are more active, dynamic, self-motivated and also increasing one's-self-confidence of participants.

VI. PROBLEM STATEMENT

Model Machine selected for the implementation of TPM is Shot Peening Machine for the following reasons.

- Poor performance among the other shot -peening machines
- Oldest machine
- Dusty and dark atmosphere
- Poor house-keeping
- Poor safety

VII. OBJECTIVES

The objectives of this case study were,

- Improve equipment reliability and maintainability.
- To cultivate the equipment-related expertise among operators.
- Maximize OEE, through total employee involvement.
- Create an enthusiastic work environment.

VIII. PROPOSED IMPLEMENTATION PLAN FOR TPM

The following plan were used for the implementation of TPM activities,

- Initial cleaning
- Listing and classification of abnormalities
- Why-Why Analysis
- Kaizen
- Jishu Hozan
- Safety

IX. DATA ANALYSIS

First of all out of the whole plant process equipment's bottleneck equipment is identified and was decided to consider this for TPM implementation study. Major losses during the production on this equipment were pointed out using a time study. The study was carried out in all three shifts for two continuous hours in each shift. Two persons standing on either side of the line with the stop watches noted down whenever there was a stop or any other situation occurring, which led to idle or stoppage time on equipment. Three days continuously the study was conducted and finally average of all these readings were calculated in order to decide the final values of various losses on respective equipment. According to study, small interruptions were the biggest contributors to the time losses. So looking into the type of losses it seems that there is lot of scope for improvement in the profitability after implementation of TPM.

Calculation of OEE:

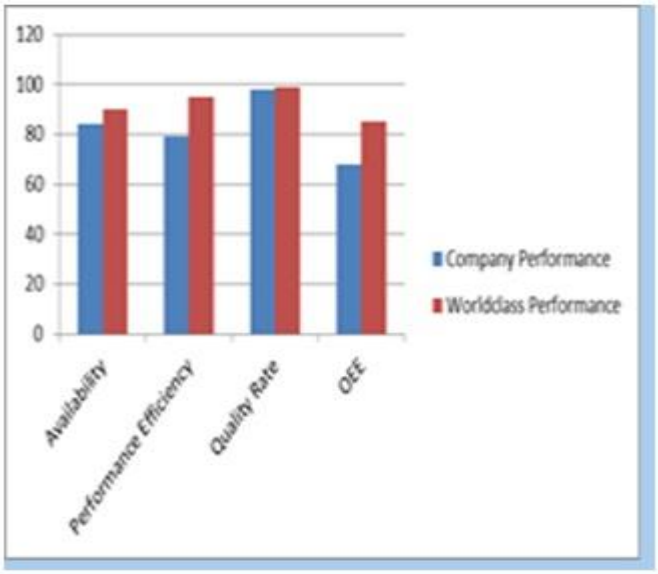
Working days in a month = 30 × 24 hrs.
Planned down time in a month = 10 hrs.
Setup adjustment losses per day (Which includes material not available, Job setting, rework) = 1.75hrs
Setup adjustment losses per month = 52.5 hrs.
Breakdown time in hrs. Per day = 1 hrs.
Breakdown time per month = 30 hrs.
Total down time per month = (Planned down time + setup adjustment losses + breakdown time)/month = 10 + 52.5 + 30 = 92.5 hrs. /month
Operating time per month = Running Time - Total down time = 720 hrs. -92.5 hrs. = 627.5 hrs.
Availability = (loading Time – Down Time)/Loading time = (720-92.5)/720 = 87.15%
Performance efficiency (PE) is calculated as
PE = ((TCT×PA)/OT) ×100
Where,
TCT - theoretical cycle time,
PA - processed amount, and
OT - operating time.
Targeted capacity of shot peening machine is 22 MT/hr.
Theoretical cycle time is 2.72min./MT and
Processed Amount (PA) 11000 MT/ month (approx.)
Performance efficiency (PE) = 2.72 × 11000/627.5 × 100 = 79.4%
PE = Speed efficiency × Rate efficiency
Where,
Speed efficiency = ICT /ACT
ICT - Ideal cycle time and
ACT - Actual cycle time
Rate efficiency = (PA × AT) /OT,
Where,
AT is Actual time. These losses occur due to machine running at slower speed than the designed speed because of vibration and improper maintenance, also due to idle and minor stoppage etc.
Rate of Quality products = ((PA-DA) /PA) × 100

= (11000-220)/11000 × 100 = 98%.

Defected Amount = 2% of PA = 440 MT (app)

OEE on Shot Peening Machine = Availability × Performance Efficiency × Rate of Quality

= 0.8715 × 0.794 × 0.98 = 66.4%



X. CONCLUSION

The process of recording information must remain simple, but effective for future data analysis .if provisions were made to highlight such problems and possible causes, then it may lead to the correction of common problems such as breakdowns and rework. Ultimately if possible, the aim is to eliminate such causes. Information provided by the trend analysis can provide a basis for forming- long-term plans. The maintenance department can plan spending requirements by using historical information to state the return on investments by contributing to the annual business plan of the company. Therefore if the world-class performance of 85%OEE was

achieved then 20%increase in OEE would have represent enhance the annual earning .To achieve this target efficient maintenance is necessary, in order to establish autonomous maintenance teams, better Communication and team- work must be promoted. It is essential that the company devices an efficient data recording systems, so that up-to date and accurate information will be available to the management Information provided by the trend analysis can provide a basis for forming- long-term plans.

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