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APPLICATION OF TOTAL PRODUCTIVE MAINTENANCE: AN ACTION CASE STUDY ON MILLING CENTRE

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Abstract

Now a day's manufacturing systems have become continuously complex with the introduction of new technologies and are more costly to operate and maintain. The manufacturing systems are often operated at less than their full capacity, resulting in low productivity and high operating costs. In today's global economy, the survival of companies depends on their ability to rapidly innovate and improve. As a result, an increasing search is for methods and processes that drive improvements in quality, costs and productivity. TPM is a one such standard philosophy, which emphasizes proactive and preventative maintenance to maximize the operational efficiency of equipment. Total productive maintenance is a comprehensive strategy that supports the purpose of equipment improvement to maximize its efficiency and quality of the product it produces. T.P.M. is a world class enabling tool, which is process and result oriented. T.P.M. must be led by manufacturing industry as it encourages production and maintenance to work as equal partners. This research work deals with study of TPM and Manufacturing performance of a manufacturing industry. Methodology has been framed to obtain best possible results based on target objectives. After finishing of detailed literature survey, a manufacturing industry is selected for data collection and TPM analysis work. By visiting this industry both primary and secondary data's are collected. Values of Overall Equipment Effectiveness (OEE) are calculated standard methods. By scheduling method of data collection four TPM pillars are analysed by framing questions. Finally all required results are obtained and analysed properly for obtaining conclusions.

Key Words: Total Productive Maintenance, Overall Equipment Effectiveness, Availability, Performance rate and Quality

INTRODUCTION

In modern day manufacturing and service industries, improved quality of products and services increasingly depend upon the features and conditions of the organization's equipment and facility. In order to survive every industry has to strive for improving productivity in all spheres of activities. Hence it is logical to utilize the resources like machinery, men, and material as optimally as possible. Maintenance of facilities and equipment in good working condition is essential to achieve specified level of quality and reliability and efficient working. Plant maintenance is an important service function of an efficient production system. It helps in maintaining and increasing the operational efficiency of plant facilities and thus contributes to revenue by reducing the operating costs and increasing the effectiveness of production. TPM has been proven to be successful for helping to increase the productivity and overall equipment effectiveness. The concepts of TPM has been introduced and developed by Japanese in 1971. TPM is all about Total plant Maintenance. The Underlying concepts are, if you properly maintain plant machinery there will see a sharp decline in machine breakdowns, safety and quality problems. There is emerging need of TPM implementation in the Indian industry and need to develop TPM Implementation practice and procedures. TPM should promote better team working in the workplace, as the operator will be helping the maintenance team with their task. The aim of the TPM is to bring together management, supervisors and trade union members to take rapid remedial action as and when required. Hence, TPM can be considered as the medical science of machines.

HISTORY OF TPM

TPM evolved from TQM, which evolved as a direct result of Dr. W. Edwards Deming's influence on Japanese industry. Dr. Deming began his work in Japan shortly after World War II As a statistician, Dr. Deming initially began to show the Japanese how to use statistical analysis in manufacturing and how to use

the resulting data to control quality during manufacturing. The initial statistical procedures and the resulting quality control concepts fuelled by the Japanese work ethic soon became a way of life for Japanese industry. This new manufacturing concept eventually became known as Total Quality Management or TQM. When the problems of plant maintenance were examined as a part of the TQM program, some of the general concepts did not seem to fit or work well in the maintenance environment. Preventative maintenance (PM) procedures had been in place for some time and PM was practiced in most plants. Using PM techniques, maintenance schedules designed to keep machines operational were developed. However, this technique often resulted in machines being over-serviced in an attempt to improve production. The thought was often "if a little oil is good, a lot should be better". Manufacturer's maintenance schedules had to be followed to the letter with little thought as to the realistic requirements of the machine. There was little or no involvement of the machine operator in the maintenance program and maintenance personnel had little training beyond what was contained in often inadequate maintenance manuals. The need to go further than just scheduling maintenance in accordance with manufacturer's recommendations as a method of improving productivity and product quality was quickly recognized by those companies who were committed to the TQM programs. To solve this problem and still adhere to the TQM concepts, modifications were made to the original TQM concepts. These modifications elevated maintenance to the status of being an integral part of the overall quality program. The origin of the term "Total Productive Maintenance" is disputed. Some say that it was first coined by American manufactures over forty years ago. Others contribute its origin to a maintenance program used in the late 1960's by Nippondenso, a Japanese manufacturer of automotive electrical parts. Seiichi Nakajima, an officer with the Institute of Plant Maintenance in Japan is credited with defining the concepts of

TPM and seeing it implemented in hundreds of plants in Japan.

Books and articles on TPM by Mr. Nakajima and other Japanese as well as American authors began appearing in the late 1980's. The first widely attended TPM conference held in the United States occurred in 1990. Today, several consulting companies routinely offer TPM conferences as well as provide consulting and coordination services for companies wishing to start a TPM program in their plants.

NEED OF TPM

The following aspects necessitate implementing TPM in the contemporary manufacturing scenario;

- To become world class, satisfy global customers and achieve sustained organizational growth.
- To improve productivity and quality.
- To improve organizations works culture and mindset.
- To make the job simple and safer.
- 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.

SIX BIG LOSSES

One of the major goals of TPM and OEE programs is to reduce and/or eliminate what are called the **Six Big Losses** – the most common causes of efficiency loss in manufacturing. Following are the six big losses which occurs during the production process which are as follows,

1. **Breakdown losses:** This type of losses is occurs due to the failure of parts, which causes stop of production.
2. **Setup and adjustment losses:** This type of losses occurs during to change in production process such as change of section, change operating condition, start of different shift, change of product.
3. **Minor stoppages losses:** Minor stoppage occurs due to jamming, machine idling.
4. **Speed losses:** These losses are due to reduction in speed of the equipment.
5. **Quality defect and rework losses:** These losses are due to the defective product produced during the production process and therefore rework has to be done to remove the defects.
6. **Yield losses:** -These losses are due to wasted raw material.

IMPLEMENTATION STEPS OF TPM

Step 1: Announcement of TPM- Top management needs to create an environment that will support the introduction of TPM.

Step 2: Launch a formal Education Program- This program will inform and educate everyone in the organization.

Step 3: Create an Organizational support structure- This group will promote and sustain TPM activities once they

began and include members from every level of the organization.

Step 4: Establish basic TPM policies and quantifiable goals- Analyze the existing conditions and set goals that are specific, Measurable, Attainable, Realistic and Time-based.

Step 5: Outline a detailed master deployment plan- This plan will identify what resources will be needed and when for training, equipment restoration and improvements, maintenance management system and new technologies.

Step 6: TPM kick-off- Implementation will begin at this stage.

Step 7: Improve the effectiveness of each piece of equipment- Project teams will analyze each piece of equipment and make necessary improvement.

Step 8: Develop an autonomous maintenance program for operators- Operators routine cleaning and inspection will help stabilize conditions and stop accelerated deterioration.

Step 9: Develop a preventive maintenance program- create a schedule for preventive maintenance on each piece of equipment.

Step 10: Conduct training to improve operation and maintenance skills- The maintenance department will take on the role of teachers and guides to provide training, advice and equipment information to the teams.

Step 11: Develop an early equipment management program apply preventive maintenance principles during the design process of equipment.

Step 12: Continuous improvement-As in any lean initiative, the organization needs to develop a continuous improvement mind-set.

BENEFITS OF TPM

- Productivity Improvement - Productivity is improved through fewer losses in the company.
- Quality Improvement - Quality is improved as a result, that the failures and malfunctions is reduced.
- Cost Reduction – The cost is reduced because the losses and other not value added work is reduced.
- Employee Ownership - Ownership of equipment by operators through Autonomous Maintenance
- Employee Confidence - "Zero failure", "zero defect" and "zero accident" conditions builds employee self-confidence.
- Improved working environment - Clean working conditions provides a good working environment.
- Increased Plant Reliability.
- Customer Satisfaction - TPM leads to high delivery performance and customer satisfaction.

OVERALL EQUIPMENT EFFICIENCY

Equipment effectiveness is the product of the availability, the performance rate and the quality rate. This measurement combines the current availability and speed of the equipment with its quality rate. It reflects the overall capability of the plant:

$$\text{Availability} = \frac{\text{Total time} - \text{Total downtime}}{\text{Total time}} \times 100$$

$$\text{Performance rate} = \frac{\text{Output} \times \text{actual cycle time}}{\text{Loading time} - \text{Downtime}} \times \frac{\text{Ideal cycle time}}{\text{Actual cycle time}}$$

$$\text{Quality Rate} = \frac{\text{Number of Good Pieces} \times 100}{\text{Total Pieces}}$$

Number of good pieces = Input - (start up defects + Process defects + trial products)

$$\text{Overall equipment effectiveness} = \text{Availability} \times \text{Performance} \times \text{Quality}$$

It is worked out by most of world-class organization that if availability is 95%, then the OEE comes out.

$$\text{OEE} = 0.95 \times 0.95 \times 0.95 = 85.7\%$$

This is taken as a benchmarking figure for defining the expected OEE for any equipment. The organization, which achieves more than 85% OEE, is considered to follow best practices (World Class Value). Hence, while working on the TPM, the objectives are to maximize OEE to 85% or above level.

A CASE STUDY

In this section technical specification and production data of the machine is collected. This is a vertical milling center, which is

highly automated CNC machine with 24 ATC. The M/C constitutes automatic tool changer (ATC) as well as three axis drive bed which can move in x, y & z axis. The machine is HMT model VMC-1200. Due to breakdowns & improper management the productivity of machine is very less. TPM will be implemented on this machine and its OEE will be increased.

PROBLEM STATEMENT

Major industry losses were identify which are shut down, production adjustment, equipment failure, process failure, normal production loss, abnormal production loss, quality defect and reprocessing. Following are some of the losses listed which occurs during the production process:

1. Improper Tooling.
2. Very small work table.
3. Poor material handling.
4. Controls are far away from operator's table.
5. Poor Chip removal

Data Analysis

Chart 1

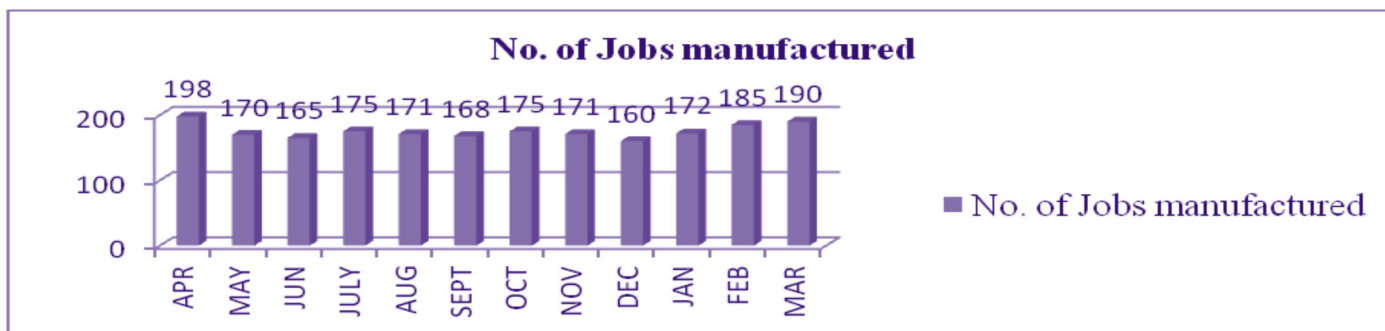


Chart 2

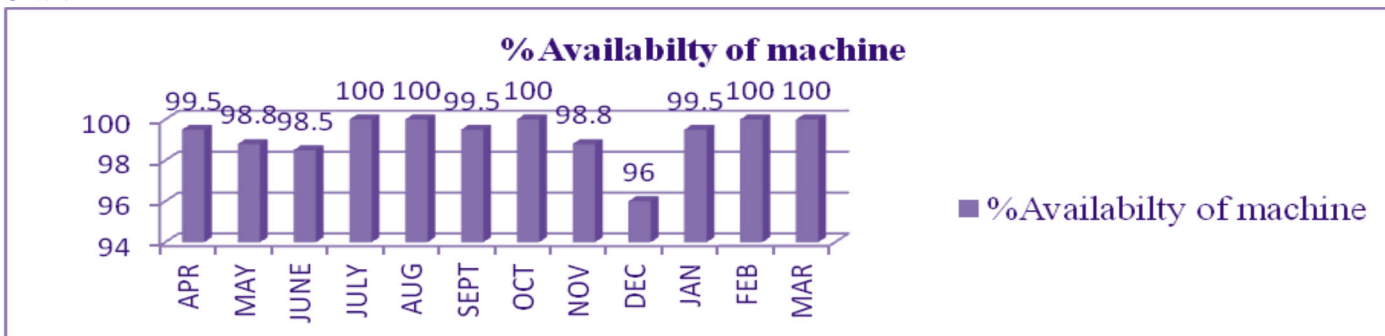


Chart 3

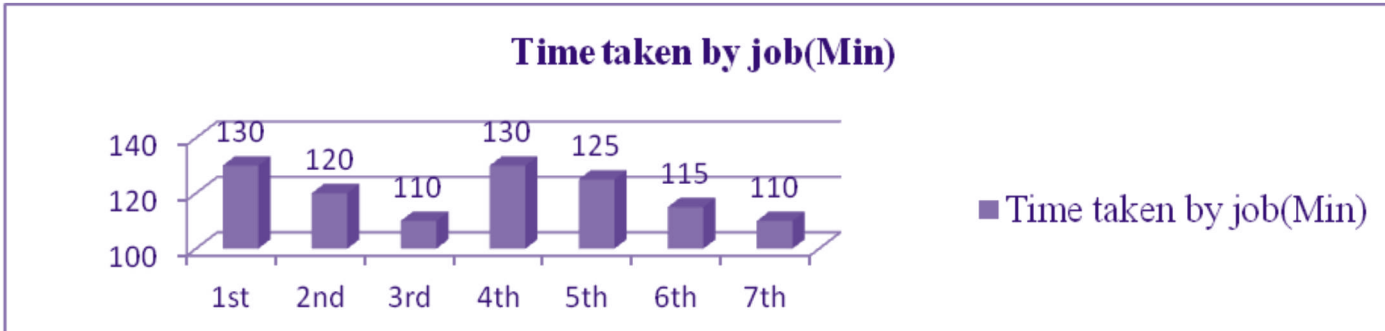
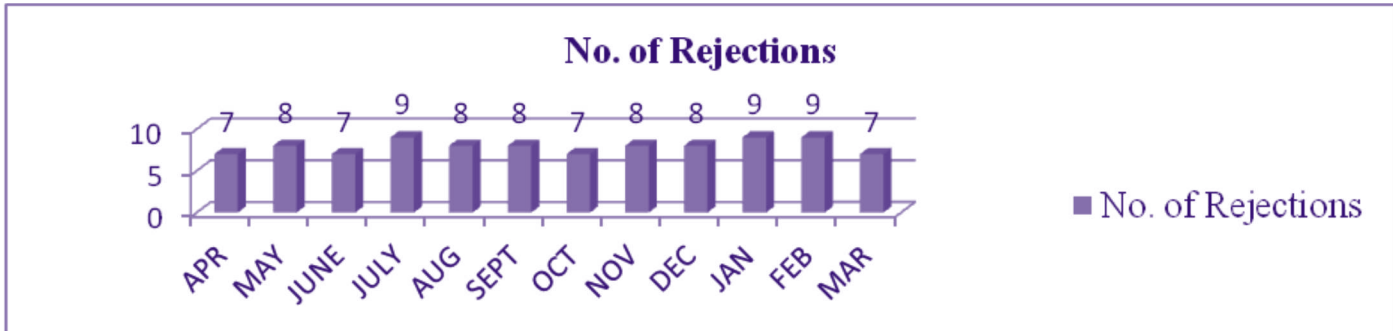


Chart 4



Calculating OEE

Working hours/day	-	16 hours	=	960 min/day
Loading time/day	-		=	30 min/day
Down time/day				
Start up losses	-	20 min/day		
Adjustment	-	20 min/day		
Minor breakdown losses	-	20 min/day		
Operating time per day	-	870 min.		
Output/day	-	7 jobs		
Quality Rate	-	95%		
Availability of Machine	-	99.20%	(Refer Chart No. 2)	
Cycle Time (Ideal)	-	100 minutes		
(Actual)	-	120 minutes		
Operating Speed rate	=	$\frac{\text{Ideal cycle time}}{\text{Actual cycle time}}$		(i)
(Loss due to speed)				
Net operating Rate	=	$\frac{\text{Output} \times \text{actual cycle time}}{\text{Total Operating time}}$		(ii)
(Loss due to minor stoppage)				
(i) × (ii) = Performance Rate	=	$\frac{\text{Ideal Cycle time} \times \text{Output}}{\text{Total Operating time}}$		
	=	$\frac{100 \times 7}{870}$		
	=	80.45%		
Quality Rate	=	$\frac{\text{No. of Good Pieces} \times 100}{\text{Total No. of Pieces}}$		
	=	$\frac{(1942-95) \times 100}{1942}$ (Refer Chart No. 4)		
	=	95.10%		
OEE	=	Performance Rate × Availability × Quality		
	=	0.80 × 0.99 × 0.95		
	=	75.24%		

Time saved= 2 min.

III. Crane is jib type which take more time to handle the job if electrically operated crane is used (Place the job on Machine & from the Machine to rack)

Original time of 4 min reduced to 2 min.
Time saved=2 min.

IV. Jig should be of hydraulic lock type so that clamping of job is easy. (Bolting & loosening the job on jig)

Original time of 4 min reduced to 2 min.
Time saved=2 min.

V. Switches behind the Machine should be nearer to the operator so as to easy setting of machine

Original time of 3 min reduced to 1 min.
Time saved=2 min.

VI. Conveyor should be more spacious so that big chips can be removed by itself

Original time of 30 min/day reduced to 26 min/day
Time saved=4 min/job

Total time saved by these alternations

3 + 2 + 2 + 2 + 2 + 4 = 15 min./job

The new cycle time = 120-15 = 105 minutes

Now the cycle time for one job is reduced, new output will be = 8 jobs/day

New performance rate = (100 × 8) / 870 = 91.95%

OEE = 0.91 × 0.99 × 0.95 = 85.58%

The new O.E.E. is improved which is the expected result.

CONCLUSIONS

Some retrofitting for increasing the productivity of machine is done. With these design changes, the OEE that was 75.24% previously is now increased up to 85.58%. This gain in Equipment effectiveness increases the production rate from 2100 items to 2400 items per year and job satisfaction to operators. The main goals of TPM are zero defects, zero breakdowns and zero accidents cannot be achieved only by using '5S'. To achieve these operators has to follow some predictive maintenance standards and safety measures. Only by application of these the desired goal can be achieved. Along with

This is less than 85% level (World Class Level) hence there is scope of improving overall equipment effectiveness.

For increasing OEE changes in some design of machine is planned with brainstorming with supervisors and operators so that obstacle of machining can be removed & the cycle time can be reduced to increase the equipment effectiveness

DESIGN CHANGES AND TIME SAVED FROM THESE CHANGES

These data are taken only after talking with the machine operator & Maintenance personnel as well as production department.

I. Proper tooling required (bit drill used takes less time while with another tools take more)

Original time of 78 min reduced to 75 min.
Time saved=3 min.

II. Need more work place and need more table space, so that the loading, unloading, Machine setting time can be reduced.

Original time of 4 min reduced to 2 min.

this, planning to provide training to the maintenance personnel and operators to provide a better knowledge about operating and maintenance the machine with increased efficiency is done. TPM is not a type of concept, which has a starting, or an ending. Since this is a continuous process which is applicable to the machine and plant for its whole life span.

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