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PLANT EFFECTIVENESS IMPROVEMENT OF OVERALL EQUIPMENT EFFECTIVENESS USING AUTONOMOUS MAINTENANCE TRAINING: - A CASE STUDY

ASEEM ACHARYA, DHAIRYA GARG, NAVNIDH SINGH & UTKARSH GAHLAUT

Department of Mechanical Engineering, Amity University,

Noida, Uttar Pradesh, India

ABSTRACT

In order to be successful in today's world-class manufacturing environment, companies have to fulfil several requirements. The organizations are making hard efforts to enhance their productivity and quality to stay competitive. Total productive maintenance has provided a quantitative metric tool, which is known as overall equipment effectiveness (OEE) to make them fit and agile for this competition. The OEE is a maintenance performance measurement tool that measures different types of production losses and indicates the areas of process improvement. This study involves tabulation and calculation of all components of the OEE and the productivity index in a TPM Manager Model machine of a selected automobile industry. In this paper an approach is developed to impart special autonomous maintenance training for Pilot team by an Education and Training pillar with a goal to raise operator's skill levels and ownership for carrying out the measurement of OEE. The objective of this paper is to focus the measurement of OEE by incorporating the autonomous maintenance training. It has been concluded that OEE is a significant key performance indicator tool that results into improvement of an overall operational performance and plant efficiency.

KEYWORDS: Autonomous Maintenance Training, Overall Equipment Effectiveness, Total Productive Maintenance & Manufacturing

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A CASE STUDY

INTRODUCTION

The manufacturing industries have encountered an exceptional level of change in the previous decades, including significant changes in administration approaches, mechanical methodologies, client necessities and furthermore in their aggressive nature. In this time of globalization, it is essential for the businesses to move towards the cutting edge improvement in all territories including support. Comprehensively, the market is facing heavy pressure from its clients and competitors in the manufacturing sectors [1]. The present mechanical industries are having high rivalries among them with very aggressive, challenging and difficult work environment. Hence it is important in any association to incorporate the upkeep work with specialized manufacturing capacities, customer satisfaction policy and quality [2].

Therefore in order to achieve all this a theory named as total productive maintenance is applied in mostly all the industries around the world [3]. TPM i.e. total productive maintenance is a one of a kind Japanese philosophy, which has been created in view of the profitable upkeep ideas and procedures. This philosophy was introduced for the first time by a supplier of M/s Toyota Motor Company in Japan in the year 1971 [4]. The term Total productive maintenance basically means keeping the equipments and plant in perfect condition at all times without any wastage of time or compromising with production and quality of the goods with the help of every individual in the company, from office bearers to the shop floor labour. TPM is a creative way to deal with maintenance that increases equipment effectiveness, reduces breakdowns and regulates autonomous maintenance with the help of operators in the form of everyday exercises in the manufacturing area [5]. TPM focuses on the solution of the six major losses that are; equipment failure, set-up and adjustment time, idling and minor stoppages, reduced speed, defects in the process, reduced yield. The company understudy for this research is a manufacturer of automobile sector. This case study will focus on autonomous maintenance and Overall Equipment Effectiveness (OEE) that helps explain how the workers can reduce the breakdowns and increase the machine in efficiency [6].

Maintenance is generally considered as a support system which is non -productive since it can never generate cash directly but help the firm generate profit. The main objective of this case study was to observe the existing maintenance system of the company and improving it with the help of overall equipment effectiveness using autonomous maintenance training.

LITERATURE REVIEW

After reviewing several papers, it is clear that the gaps of the research in this field are in the area of key enablers. This is a new field so the research done here is lacking the necessary amount of literature. Although some papers have highlighted the enablers, but it does not provide a clear view of the. Here various types of literatures reviewed have been discussed. The next subsection highlights the findings of researchers regarding various applications, implementations of Total productive maintenance (TPM) and OEE in manufacturing industry.

Researchers have discussed the Total productive maintenance (TPM) implementation plans, gain/profits and overall equipment effectiveness. To enhance the outcome and productivity by decreasing the activities yielding less profit, sudden breakdowns and downtimes, is a difficult task. Maintenance practices and policies in OEE and TPM implementations in the manufacturing sector have been studied by various researchers, few of which have been discussed below.

Adoption of Total Productive Maintenance (TPM) can reduce losses and reduce rework to or below the acceptable levels. Total productive maintenance (TPM) can also help the company to increase profitability and image, both of which will ensure its competitiveness in the current economic turmoil. By minimizing the equipment deterioration and failure, cost and quality were improved significantly. Thus OEE also improved significantly [2]. The system of high performance ratio of machinery gave new dimensions for the measurement and analysis of OEE [5]. TPM implementation dimensions, namely PM, QM and T&E are the essential components in OEE improvements so, the companies should embark on implementing the TPM practices [16]. The drive for profits are forcing companies to implement various productivity improvement efforts. In this paper, an approach, based on overall equipment effectiveness (OEE), is developed to model the productivity of a manufacturing system in terms of overall throughput effectiveness (OTE) [7]. In order to implement Total Productive Maintenance (TPM) it is imperative to determine the value of various types of manufacturing losses so as to command activities and allocate resources in an optimal way [4]. The general shortcomings of the production lines, which were their inability to gauge flow exposure or external effectiveness to any great extent. They also performed field experiments in the studied organisations which showed that use of OEE in combination with an open central organisation design could ameliorate several of those enfeeblements [8]. In a research study of three companies in which Total productive maintenance (TPM) was implemented, senior managers in these companies themselves took the initiative to implement TPM because the companies were facing lack of finance [9]. The accurate and precise estimation of equipment utilization plays a big role in industries. Since the sole aim of TPM is to spike overall equipment effectiveness. Total Productive Maintenance was to share a good and effective relationship with negligible cost, high levels of quality and strong delivery performance [10]. In a research whose sole objective was perfect manufacturing. He viewed the basic concepts of Total productive maintenance (TPM) and researched various literature of design, implementation and maintenance of Total productive maintenance (TPM) in manufacturing related processes [12]. Customer satisfaction lies in product quality, delivery time and cost of the product. Hence, a maintenance system must be implemented by the firms to enhance and improve both productivity and quality continuously [14]. Operators were able to develop the responsibility to autonomously carry out activities related to cleaning actions, organisation and daily checks of the critical points at the workstation, thus ensuring that their machines and equipment were in good working order after the implementation of Total productive maintenance (TPM) [17].

Thus, TPM and OEE provides and effective and implementable way of analysing and reviewing the efficiency or proficiency of all the machine systems.

OVERVIEW OF OVERALL EQUIPMENT EFFECTIVENESS AND SIX BIG LOSSES

Overall Equipment Effectiveness (OEE) is basically a method of changing metrics from all equipment manufacturing guidelines to a measurement system which can help manufacturing and quality teams all over the world to improve their equipment performance and hence, reduce the equipment cost of ownership (COO).

Autonomous maintenance focuses upon preventing major losses and breakdowns, it plays a vital role in an increment of production and quality. In a manufacturing unit Overall Equipment Effectiveness (OEE) can be improved by applying the pillars of TPM and primarily reducing the six big losses. The main reason behind the low Overall Equipment Effectiveness is the Six Major losses, these losses must be reduced in order to improve the working conditions, productivity, quality and therefore profits.

Calculation of Overall Equipment Effectiveness (OEE) works for Total productive maintenance as a tool for measuring the performance of a production system. It can be also said that the main goal of Total productive maintenance (TPM) is to improve the Overall Equipment Effectiveness (OEE). Overall Equipment Effectiveness (OEE) is calculated by product of three values i.e. Availability of the equipment, Performance efficiency of the process and Quality rate as shown in equation 1. We can calculate Overall Equipment Effectiveness (OEE) by the following formulas.

$$OEE = \text{Availability of the equipment } (A) \text{ X Performance efficiency } (PE) \text{ X Quality rate } (QR) \quad (1)$$

This method of calculation is a widely accepted and used as a tool for measurement of productivity in manufacturing industries. High Overall Equipment Effectiveness (OEE) can be attained only when all the three indexes are having high values, and this can be achieved by reducing the six major losses.

Some benchmarks have been already set which tells us if the calculated Overall Equipment Effectiveness (OEE) fulfils the world class performance standards or not. The value of the three indexes and Overall Equipment Effectiveness (OEE) is standardised. The value of the parameter availability of the equipment (A) must be 90% whereas 95% is set for performance of efficiency. The quality rate (QR) is required to be 99% and overall Equipment Efficiency (OEE) should be minimum 85%.

The six big losses are the losses that directly affect the production speed, availability, performance and quality of equipment. Seichi Nakajima was the man behind developing the six big losses in 1971. In order to attain the major goals of Total productive maintenance (TPM) and Overall Equipment Effectiveness (OEE) the elimination/reduction of these losses is compulsory.

Six Big Losses

- **Equipment Failure:** It may be defined as the period of time in which production is scheduled, but is not carried out because of some unpredicted stop in the production line or accidental down time.
- **Set-Up and Adjustment Losses:** It may be defined as the period of time in which production is scheduled, but is not carried out because of some predicted or planned stop like tool adjustment or maintenance, lubrication or quality inspection.
- **Idling and Minor Stop Losses:** It comes under performance loss, in this the equipment stops working for a very short span of time (a minute or two) and the problem is solved by the operators.
- **Reduced Speed Losses:** The losses caused when the machine works at a slower speed in comparison to its ideal speed at which it should work.
- **Reduced Yield Losses:** These losses are caused by a machine when it goes from startup stage to stabilization stage.
- **Quality Defects and Reworks:** It can be defined as the quality loss which occurred in a machine due to its malfunctioning.

OVERVIEW OF AUTONOMOUS MAINTENANCE

When top managements execute Total Productive Maintenance, they commonly emphasize more on autonomous maintenance (AM). It is the most important activity to implement, when it comes about implementation of TPM in industries. It is an internal implementation activity within TPM. Autonomous maintenance was not originally invented so as to depreciate maintenance, but it was a result of manufacturing groups desiring to enhance and regulate their equipments. In this the operator is given a sort of semi ownership, and he is taught so that production does not stop even when machine faces minor failures. Generally breakdowns, energy losses, speed losses occur due to the breakdown of equipments and machinery.

Table 1

Serial No	Name	Activities
1	Initial cleaning	Eliminate dust and dirt from main body of equipment
2	Tackling contamination sources and hard to access area	Reduce housekeeping time
3	Provisional autonomous maintenance standards	Formulate provisional standards to enable cleaning, tightening and checking to be sustained dependably with minimal time and effort.
4	General inspection	Train operators by providing them inspection manuals, and making them capable of repairing equipment defects.

Table 1: Contd.,

5	Autonomous checking	This means periodically doing lubrication, cleaning and inspection.
6	Standardization	Develop a housekeeping system by devising additional standards for items such as: • Data recording • Proper maintenance of tools and fixtures. • Transportation of the material within the factory. • Assurance of quality
7	Full-self management	Proper implementation of company policies and improving them time to time. Continually improve the equipment by maintaining accuracy in MTBF and other maintenance records.

Autonomous maintenance is called as *"Jishu Hozen"* in Japanese language. In autonomous maintenance operator is taught few basic things so that production does not stop even machine faces minor failures. Operators are taught the functions like checks on a daily basis, lubrication of machine components, substitutes of minor parts, repair work and precision checks.

CASE STUDY

The present study was carried out in country's biggest producer of two wheeled automotive plant, which has faced a lot of positive changes by the implementation of TPM. This study involves imparting autonomous maintenance to shop floor operators and calculation of all the parameters of Overall equipment effectiveness. There are various sections in the selected zone area such as welding machines, paint shop and engine assembly. The study focuses on the single Total productive maintenance manager model machine in machine shop areas.

RESEARCH METHODOLOGY

For improving the efficiency of a plant Overall Equipment Effectiveness (OEE) can be used as a simple and a very effective tool. Case study is taken and is used as a methodology in this research paper. With the help of skilled operator which is already trained by an autonomous maintenance team different parameters like downtime, MTBF, quality of the products and output of the machine are noted down. The case study was carried out at a two wheeler manufacturing unit based in India.

The primary step was to select a suitable machine for case study from the shop floor. Any machine which is under observation or on which study is to be conducted is known as a TPM manager model machine. In this case study a TPM manager model machine is selected from the machine shop area. The details of the machine are as follows:-

CNC Lathe machine -9201192 (Machine SAP No.)

The autonomous maintenance training was developed for the above mentioned single manager model machine from the machine shop area. The main objective of this is to train the machine operators for handling the small tasks of maintenance of the machine under study through a specialized training program by equipment configuration. This would help the operate connect with the machine and he would then develop a bond with his machine which would lead to an ownership feeling and therefore the operator would contentedly take care of the regular cleanliness, lubrication and repairs of the machine.

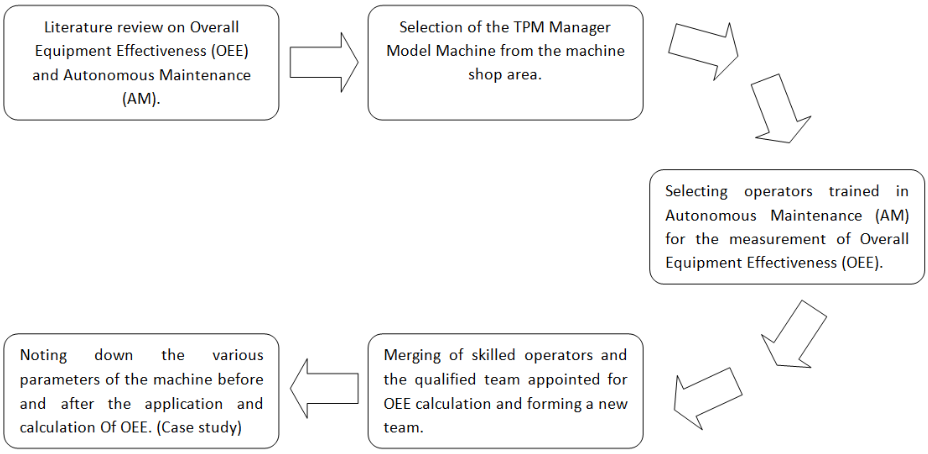

Figure 1: Study Methodology

MEASUREMENT OF OVERALL EQUIPMENT EFFECTIVENESS

Data was collected from countries' largest two wheeler automotive manufacturing industries in which the operators were already aware about Total productive maintenance. A combined team was formed, including those operators too. CNC Lathe Machine was selected from the selected zone and the team began to collect the readings. The initial readings were taken. Factors such as shift length, short breaks, meal breaks, downtime, total pieces, rejected pieces etc were recorded and then Availability, Performance Efficiency, Quality rate were calculated. The overall equipment effectiveness was calculated by this relation.

OEE = Availability*Performance efficiency*Quality Rate

The readings were re-taken after the implementation of Autonomous maintenance and same factors were recorded again and the overall equipment effectiveness was calculated and then changes done due to the implementation were observed.

DISCUSSIONS ON OVERALL EQUIPMENT EFFECTIVENESS ASSESSMENT

Table 2: Initial Values before OEE Implementation

Serial No	Assessment Factors	Initial Values (min)
1	Shift Time	450
2	Short Breaks (CLIT)	15
3	Meal breaks	45
4	Downtime	55
5	Total Pieces	230
6	Rejected Pieces	19
7	Machine Speed (No. of Components per year)	0.80
8	Planned Production Time (Shift Length- Breaks)	390
9	Operating Time (Planned Production Time-Downtime)	335
10	Good Pieces (Total Pieces-Rejected Pieces)	211
11	Availability (Operating Time/Planned Production Time)	0.85
12	Performance Efficiency (Total Pieces/Operating Time) Ideal Run Time	0.68
13	Rate of Quality (Good Pieces/Total)	0.91
14	OEE=Availability*performance efficiency*Quality Rate	0.525

Table 3: Final Values after OEE Implementation

Serial No	Assessment Factors	Final Values
1	Shift Time	450
2	Short Breaks (CLIT)	15
3	Meal breaks	45
4	Downtime	25
5	Total Pieces	255
6	Rejected Pieces	5
7	Machine Speed (No. of Components per year)	0.80
8	Planned Production Time (Shift Length Breaks)	390
9	Operating Time (Planned Production Time-Downtime)	365
10	Good Pieces (Total Pieces-Rejected Pieces)	250
11	Availability (Operating Time/Planned Production Time)	0.935
12	Performance Efficiency (Total Pieces/Operating Time) Ideal Run Time	0.698
13	Rate of Quality (Good Pieces/Total)	0.98
14	OEE=Availability*performance efficiency*Quality Rate	0.639

GRAPHS

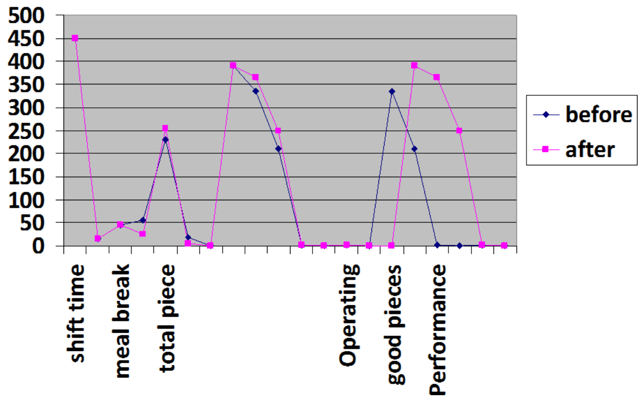

Figure 2: Before and After Values

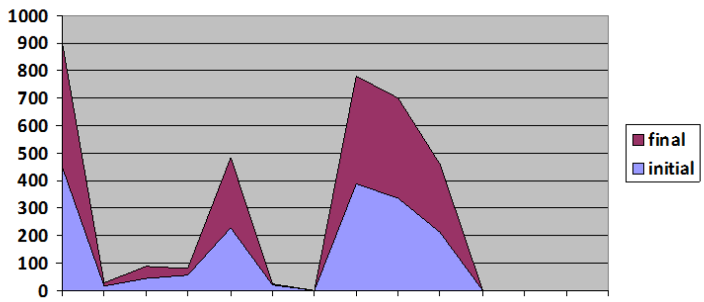

Figure 3: Graphs Representing Final and Initial

CONCLUSIONS

With the implementation of Total productive maintenance using Autonomous training in the Indian automotive industry, many factors fluctuated. Due to this implementation total piece, operation time, good prices, availability, performance, efficiency and Rate of quality spiked up by a considerable amount and Rejected pieces, downtime decreased down and hence overall equipment effectiveness increased. The initial value of OEE was 0.525 and final value was 0.639. Due to the implementation of autonomous maintenance in the industry, OEE spiked up by 11.4%.

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