

# Implementation of TPM to Enhance OEE in Medium Scale Industries: A Review

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## Abstract

In today’s highly competitive and rapidly changing business environment, industries have to offer variety of products at a high quality level, in least time and for an acceptable price. Therefore machine maintenance and in general, implementing an appropriate maintenance strategy has become increasingly important. Total productive maintenance (TPM) is one of the most popular maintenance strategies to ensure high machine reliability, maintaining equipments in top working condition to avoid breakdowns and minimize downtimes in the manufacturing process. This paper reviews the significant literature related to implementation of TPM program in small and medium scale industries in order to achieve increase in machine availability, performance & process quality thereby increasing overall equipment effectiveness (OEE). Investigations includes implementation of TPM pillars to reduce losses associated with OEE.

**Keywords:** Total Productive Maintenance, Availability, Performance, Quality, Overall Equipment Effectiveness.

## 1. Introduction

In today’s industrial scenario huge losses occur in the manufacturing shop floor. This waste is due to operators, maintenance personal, process, tooling problems and non-availability of components in time etc. Other forms of waste include idle machines, idle manpower, break down machine, rejected parts etc. In this situation, a revolutionary concept of Total Productive Maintenance (TPM) has been adopted in many industries across the world to address the above said problems. TPM builds a close relationship between maintenance and productivity, showing how good care of equipment will result in higher productivity. It is a philosophy of continuous improvement. TPM is a maintenance program, which involves a newly defined concept for maintaining plants and equipment. It is a proven and successful procedure for introducing maintenance considerations into organizational activities. It involves operational and maintenance staffs working together as a team to reduce wastage minimize downtime and improve end product quality.

Equipment maintenance is still at low priority in most of the small & medium scale manufacturing industries and also lack of knowledge about equipment maintenance is

one of the main obstacles. These industries are facing challenges related to product quality, cost and technology. They have some distinct limitations since most of them are owner-cum-manager centered where a systematic approach is very much lacking. But on other hand these industries have potential advantages to give training to their managers and workers in their workplace, because each manager has a very few numbers of manpower and also they are working very close to one another. The scope of team formation and participation in these industries is easier than in large companies. Therefore, it is very easy and cheap to train and educate their employees and the amount of time required to transfer training to lower levels is much shorter than that of large companies. TPM includes organizational structures, human interactions, analytical tools thus providing a systematic approach for the achieving world class levels of overall equipment effectiveness not through technology or systems alone but also through total involvement of people working in the organization.

### 1.1 Implementation of TPM

Implementation of TPM is based on systematic implementation of its pillars. The pillars of TPM are shown in below figure.

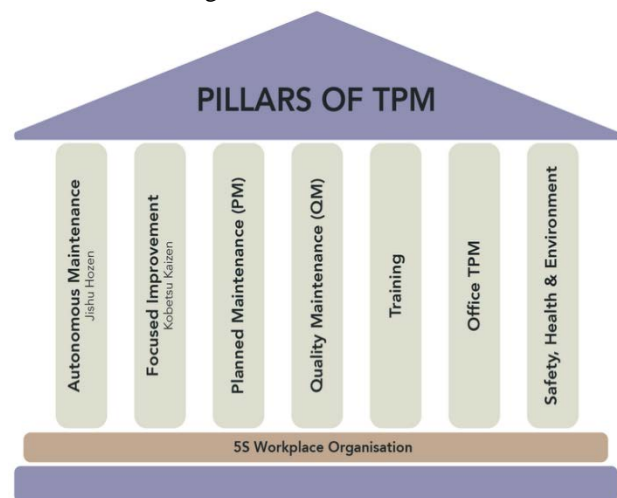


Fig. 1 Pillars of TPM

Many companies struggle today to implement TPM due to two main reasons. First is having insufficient knowledge and skills especially in understanding the linkages between the pillar activities in TPM. The second reason is that TPM requires time, resources and efforts than most of these companies believe they can afford.. 5S forms the base and is the starting point for TPM implementation. The TPM pillars are explained below in tabular format.

Table 1: Summary of TPM pillars

Pillar	Description	Benefits
Autonomous Maintenance	Responsibilities of basic maintenance activities on the hands of operators	Workers become more responsible and reduction in downtime
Focused Improvement	Structured team based approach to drive elimination of identified losses	Large base of employees with right tools for solving problems
Planned Maintenance	Structured approach to establish maintenance plan	Breakdowns reduces and no expensive parts in inventory
Quality Maintenance	Controlling interactions between men material and machine & methods that enables defects to occur	Defects minimized by getting quality right the first time and quality issues with permanent solutions
Training	Companywide initiative including all levels from operators to managers	Successful implementation of TPM
Office TPM	TPM in administrative functions with large pool of workers understanding TPM principles	Improve order processing procedures and quick reactions to changing customer requirements
Safety, Health and Environment	Safe working environment and harmful conditions eliminated	Zero accidents, Zero overburden and Zero Pollution

## 2. TPM & OEE

Overall equipment effectiveness (OEE) is a term coined by Seiichi Nakajima. It provides a way to measure the effectiveness of manufacturing operations from a single piece of equipment to an entire set of equipments in an organization. In any industry, it is not possible to operate any equipment 100% of the time at its maximum capacity to get 100% quality output. Losses are quite common, bringing out the difference between actual and desired

performance.OEE is a function of the three factors namely availability, performance and quality.

$$\text{Availability} = \frac{(\text{Planned production time} - \text{Downtime})}{\text{Planned production time}}$$

$$\text{Performance} = \frac{\text{Ideal cycle time} \times \text{Parts produced}}{\text{Available time}}$$

$$\text{Quality} = \frac{(\text{Total units started} - \text{Defective units})}{\text{Total units started}}$$

Therefore OEE= Availability × Performance × Quality. The losses associated with OEE are divided into six major categories, which affect the overall performance of the equipment are shown in below figure.

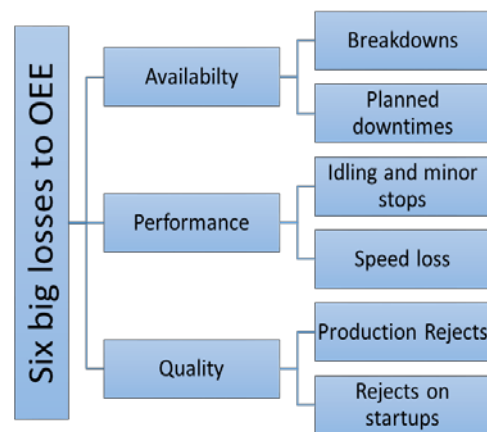


Fig. 2 Losses to OEE

OEE measurement is essential for every organization that is committed to eliminate the above mention losses through the implementation of TPM. A TPM program uses OEE as a quantitative parameter for measuring the performance of a production system. A comparison between the expected and current OEE measures can provide the much-needed driving force for the manufacturing organizations to improve on its maintenance policy. An overall 85% benchmark OEE is considered as world-class performance which requires 90% availability, 95% performance and 99% quality to be achieved.

## 3. Related Work

Ashok Kumar, Rajesh Kumar Singh and Tasmeeem Ahmad Khan, have evaluated the barriers before manufacturing organizations for adapting to proactive total productive maintenance (TPM) initiatives. They categorized the difficulties faced by the organizations into organizational, behavioral, technological, operational, and departmental barriers. It has also been revealed by the study that successful implementation of TPM initiatives can be realistically achieved by the whole hearted commitments

of top management. They suggested that top management should focus on improving co-ordination between departments, improving communication skills, education and training of employees [1].

Ashwin B. Virupakshar and Anil Badiger, have stated that to achieve overall equipment efficiency TPM is ideal tool. TPM helps the management to improve the overall performance of the firm and by proper implementation of TPM concepts the manufacturing industries can gain great benefits with the very less investment. They achieved reduction of cycle time for each operation by combining two or more operations and by providing special attachment wherever possible for a traub machine thereby increasing its productivity [2].

Rishi J, Dr. Ramachandra C and Dr. T R Srinivas, stated that TPM can be best suited for achieving lean manufacturing. They successfully implemented TPM in Automotive Axles and achieved higher efficiency by reducing setup time and increasing OEE. They carried out SWOT analysis in order to analyse the problem associated with the original equipment manufacturers [3].

Vijay Lahri and Dr. Pramod Pathak, have stated that OEE tool is route map to boost the effectiveness of manufacturing process and equipment. OEE extracts all the reason for delay of the job and not just only measures inefficiency but also categorizes those into 3 categories for better understanding of manufacturing procedure. They carried out carried out OEE on CNC Table type boring & milling machine to find out the bottleneck and hidden losses and achieved increased in OEE after implementing various suggestions [4].

Parth N Chandegra and Vivek A. Deshpande, have studied that with the help of Total Productive Maintenance (TPM) approach cycle time reduction can be achieved. They did the same for PCF gear assembly using 5S methodology and other pillars and refined the assembly in appropriate manner. They also found that by applying the approach of TPM, improvement in production effectiveness by identifying and eliminating production losses in the production system through active participation of all employees can be achieved [5].

Prof. Ravi Ngaich, Pavan Kumar Malviya, evaluated the contributions of total productive maintenance (TPM) towards improving manufacturing performance in Small and Medium scale Enterprises. They investigated the relationship between Total Productive Maintenance (TPM) and manufacturing performance (MP) and improving it by using the fundamental TPM Pillars and reducing the six big losses in a Manufacturing Industry [6].

Nithin Raj and Sanukrishna S, have stated that improvement in OEE can be achieved by improving maintenance strategies of critical equipment's. They

analyse imperfections in existing maintenance policy and suggested corrective actions for the same. The machines under study were Vertical Turret Lathe & Drilling Machine. They achieved impact growth in OEE in a short period of time [7].

Chowdury M. L. Rahman and M. A. HoqueRaj, have studied and evaluated implementation of autonomous maintenance & planned maintenance in an semi-automated manufacturing industry. They carried out pareto and statistical analysis of downtimes and based on the results suggested maintenance management & productivity planning in order to improve maintenance [8].

Pradeep Kumar, Raviraj Shetty and Lewlyn L.R. Rodrigues, carried out empirical study based on real time data analysis to achieve results. They distributed questionnaires to asses information on successful implementation of TPM. They carried out autonomous maintenance (AM) & productive maintenance (PM) to detect faults and thereby improve output, total productivity and OEE of printing machine [9].

E.Sivaselvam and S.Gajendran, have stated that using overall equipment effectiveness calculations one can determine the present situation in the production system, effectiveness of the maintenance system, conditions of the machines, worker's skill and utilization of the machines. Calculating the OEE also gives the company where they are and where the weakness point is and how to improve. From the calculated OEE high cycle time, more waiting time and Low productivity can be identified [10].

Jagtar Singh, Vikas Rastogi and Richa Sharma, have stated that TPM is only the one thing that stands between success & total failure. They implemented TPM in automobile manufacturing industry on three machines namely broaching, cylindrical grinding and surface grinding and achieved increase in equipment availability, decrease in rework and rejection & increase in rate of performance [11].

Binoy Boban and Jenson Joseph, have stated that change in performance & quality can be achieved by changing the maintenance policy. They further found that if everyone involved in TPM program does his or her part, high rate of returned as compared to investment can be expected. They implemented 5S, kaizen and AM in manufacturing sector and achieved progressive growth in OEE [12].

Sarang G. Katkamwar, Sadashiv K. Wadtkar and Ravikant V. Paropate, have stated that TPM is the effective tool to increase the productivity of Indian industries and India can compete with the other countries in this increased globalization. They suggested that using a see through JH-Check sheet, PM-Check sheet, One Point Lessons, empirical and comprehensive approach towards the methodology results in proper implementation

of TPM. After implementation of TPM on model machine they showed both direct and indirect benefits obtained for equipment and employees respectively [13].

Praveen Kumar R and Rudramurthy, have carried out study on hydraulic press in order to analyzed repeated breakdowns along with identification of the critical parts, which were under breakdown condition. They analyzed the reason for the breakdown and inspected it by the method of Fish bone diagram and why-why analysis. By this analysis and methods the root causes of the breakdowns were identified which in turn helped to develop and improve a new Preventive maintenance checklist for the machine. Through their recommended procedures they achieved increase in availability of the machine to a certain extent and also increase the production capacity, minimize the maintenance cost and reduce the down time [14].

Wasim. S. Hangad and Dr. Sanjay Kumar, have studied total productive maintenance (TPM) is one of the best tools for making Indian industries competitive and effective, in the field of maintenance. 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. They also found that successful TPM implementation can achieve better and lasting result as compared to other isolated programs because there is an ultimate change in people's knowledge, skills, and behaviour during the process of TPM implementation [15].

Amit Kumar Gupta and Dr. R. K. Garg, stated that 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 is necessary for full implementation of TPM. They suggested that the organization should introduce a maintenance system to improve and increase both quality and productivity continuously [16].

D.Sivakumar, S.M.Sapuan, N.Ismail and M.Y.Ismail, have studied how focus improvement can be used to improve non-stick on pad (NSOP) in IC packaging. They took a unique set of methodologies, which focuses on the steps and directions to make the necessary strides. They also provided the information and decision making tools necessary to determine where and how to make process improvements, to improve the quality and reduce the cost of final product. Their research work provides excellent insight into the power of TPM and focus improvement activity as a process improvement tool. The improvements introduced by focus improvement activities had brought down NSOP from 1300 ppm to 650 ppm within one year [17].

Chen Shin Min, Rosmaini Ahmad, Shahrul Kamaruddin and Ishak Abdul Azid, have suggested that the key to TPM success is the development of autonomous maintenance (AM). They developed a frame work for implementation of AM based on three systematic stages: AM initial preparation, AM training and motivation. They found that the main challenge in implementing the AM practice is to change the thinking, habits and culture of the operators, technicians and engineers in taking the responsibility when they are assigned certain tasks [18].

Sanjeev Reddy, K. Hudgikar and K Prahlada Rao, have stated that TPM helps to maintain and improve the integrity of production system through machines, equipment's process and employee that add value. The objectives of TPM are to ensure zero accidents, zero defects and zero failures. They found that in addition to the tangible benefits, TPM also offers various intangible benefits, such as fostering of team work, increased morale, safety and numbering of the workforce with increased intellectual capabilities to meet the desired level of the competition and challenges [19].

Kamran Shahanaghi and Seyed Ahmad Yazdian, have analyzed through system dynamics concepts, the effects of implementation of TPM on machine reliability, process quality and net throughput. Results obtained show the effectiveness and usefulness of TPM in reducing breakdown maintenance (BM). They also stated that maintaining an efficient and effective maintenance strategy is crucial to keep high-level process quality, achieve high machine and labour force efficiency, and also to reach time competence [20].

#### 4. Conclusions

The present study reveals that OEE can be enhance by implementation of TPM especially in medium scale industries. The three factors of OEE i.e. availability, performance and quality can be improved by reducing cycle time, setup time, breakdowns ,downtimes and identifying & eliminating production losses which can be achieved through implementation of pillars of TPM. In addition TPM focuses on involvement of each & everyone in the organization right from managers to operators thereby improving coordination between different departments in setting up maintenance program. About 75% of the total industries in India are of small and medium size industries. The large scale industries on other hand purchase most of the parts and components from these industries. Thus it is essential that these industries produce quality products which are available in time and at optimum cost. So it is concluded that there is need to implement TPM in medium scale industries in order to achieve overall equipment effectiveness.

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