# Review Study on Improvement of Overall Equipment Effectiveness through Total Productive Maintenance

Vivek B Patel[1], Hemant R Thakkar[2]
[1](PG Student – Department of Mechanical Engineering, G.H.Patel College of Engineering & Technology)
[2](Associate Professor, Department of Mechanical Engineering, G.H.Patel College of Engineering & Technology)

**Abstract : In the today's era of intense global competition, manufacturing industries are determined to improve and optimize their productivity in order to remain competitive. Overall Equipment Effectiveness (OEE) of a machine plays an important role where performance and quality of the product are of key importance to the company. The OEE intended at minimizing the breakdowns, increasing performance and quality rate and thus improving the effectiveness of the machine. The availability rate of the machine, performance rate of the machine and quality rate of the products are considered as parameters while maximizing the Overall Equipment Effectiveness (OEE) of a manufacturing system. It is found that the lagging in performance rate contributes more than availability rate and quality rate that deficiency of effectiveness in the system.The objective of the work is to enhance the overall equipment effectiveness (OEE) at a manufacturing company through the implementation of total productive maintenance (TPM).**

**Key Words -Maintenance, Manufacturing Performance, Overall Equipment Effectiveness, Availability, Quality Rate, Total Productive Maintenance**

## INTRODUCTION

Total Productive Maintenance (TPM) is fundamentally 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 brings maintenance into focus as a necessary and vitally important part of the business. It is no longer regarded as a non-profit activity. Down time for maintenance is scheduled as a part of the manufacturing day and, in some cases, as an integral part of the manufacturing process. The goal is to hold emergency and unscheduled maintenance to a minimum.

TPM was introduced to achieve the following objectives. The important ones are listed below.

1. Avoid wastage in a quickly changing economic environment.
2. Producing goods without reducing product quality.
3. Reduce cost.
4. Produce a low batch quantity at the earliest possible time.
5. Goods send to the customers must be non-defective.

### TPM – History

TPM is an innovative Japanese concept. The origin of TPM can be traced back to 1951 when preventive maintenance was introduced in Japan. However the concept of preventive maintenance was taken from USA. Nippondenso was the first company to introduce plant wide preventive maintenance in 1960. Preventive maintenance is the concept wherein, operators produced goods using machines and the maintenance group was dedicated with work of maintaining those machines, however with the automation of Nippondenso, maintenance became a problem, as more maintenance personnel were required. So the management decided that the operators would carry out the routine maintenance of equipment. (This is Autonomous maintenance, one of the features of TPM). Maintenance group took up only essential maintenance works.

Thus Nippondenso, which already followed preventive maintenance, also added Autonomous maintenance done by production operators. The maintenance crew went in the equipment modification for improving reliability. The modifications were made or incorporated in new equipment. This lead to maintenance prevention. Thus *preventive maintenance* along with *Maintenance prevention* and *Maintainability Improvement* gave birth to ***Productive maintenance***. The aim of productive maintenance was to maximize plant and equipment effectiveness.

By then Nippon Denso had made quality circles, involving the employee's participation. Thus all employees took part in implementing Productive maintenance. Based on these developments Nippondenso was awarded the distinguished plant prize for developing and

implementing TPM, by the *Japanese Institute of Plant Engineers* (JIPE). Thus Nippondenso of the Toyota group became the first company to obtain the TPM certification.

**PILLERS OF TPM**

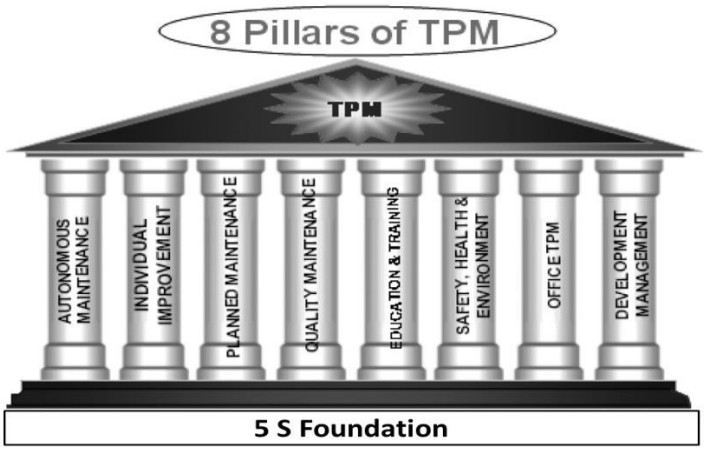


Figure 1: Eight Pillars of TPM

5S are defined as Sort, Set in Order, Shine, Standardize and Sustain. Because each of the five pillars begins with S, this method was appropriately named 5S. These 5S are implemented on TPM model section.

***5S – Sort:***The first pillar of 5S helps to clearly distinguish the items needed in a work area from those no longer needed.

***5S - Set in Order:*** The second pillar of 5S helps to keep the needed items in the correct place to allow for easy and immediate retrieval.

***5S – Shine*:** The third pillar of 5S helps to keep work areas, all work surfaces and equipment clean and free from dirt, debris, oil, etc.

***5S – Standardize:***The fourth pillar of 5S defines the standard activities, procedures, schedules and the persons responsible for keeping the workplace in a clean and organized manner.

***5S – Sustain:***Sustain is the last pillar of 5S and drives the organization to be disciplined in maintaining these new standards and procedures and in continuously improving the 5S state of the workplace.

***1. Autonomous maintenance:***

- Fostering operator ownership.
- Perform Mould cleaning – water flow – material flow – adjustment – inspection – readjustment on production equipment.

***2. Focused improvement:***

- Systematic identification and elimination of 16 losses.
- Working out loss structure and loss mitigation through.
- Structured why-why analysis, FMEA (Failure Mode Effective Analysis).
- Achieve improved system efficiency.
- Improved OEE on production systems.

***3. Planned maintenance:***

- Planning efficient and effective PM
- Establishing PM check sheets.
- Improving Mean Time between Failure (MTBR), Mean Time to Repair (MTTR).

***4. Quality maintenance:***

- Achieving zero defects.
- Tracking and addressing equipment problems and root causes.
- Setting3M (machine/man/material) conditions.

***5. Education and training:***

- Imparting technological, quality control, interpersonal skills.
- Multi-skilling of employees.
- Aligning employees to organizational goals.
- Periodic skill evaluation and updating

***6. Safety, health and environment:***

- Ensure safe working environment.
- Provide appropriate work environment.
- Eliminate incidents of injuries and accidents.
- Provide standard operating procedures.

***7. Office TPM:***

- Improve synergy between various business functions.
- Remove procedural hassles.
- Focus on addressing cost-related issues.
- Apply 5S in office and working areas.

***8. Development Management:***

- Minimal problems and running in time on new equipment
- Utilize learning from existing systems to new systems Maintenance improvement initiatives

**OEE (Overall Equipment Efficiency)**

The basic measure associated with Total Productive Maintenance (TPM) is the OEE. This OEE highlights the actual "Hidden capacity" in an organization. OEE is *not* an exclusive measure of how well the maintenance department works. The design and installation of equipment as well as how it is operated and maintained affect the OEE. It measures both efficiency (doing things right) and effectiveness (doing the right things) with the equipment. It incorporates three basic indicators of equipment performance and reliability. Thus OEE is a function of the three factors mentioned below.

1) Availability or uptime (downtime: planned and unplanned, tool change, tool service, job change etc.)
2) Performance efficiency (actual vs. design capacity)
3) Rate of quality output (Defects and rework)
4) *Thus* ***OEE = A x PE x Q***

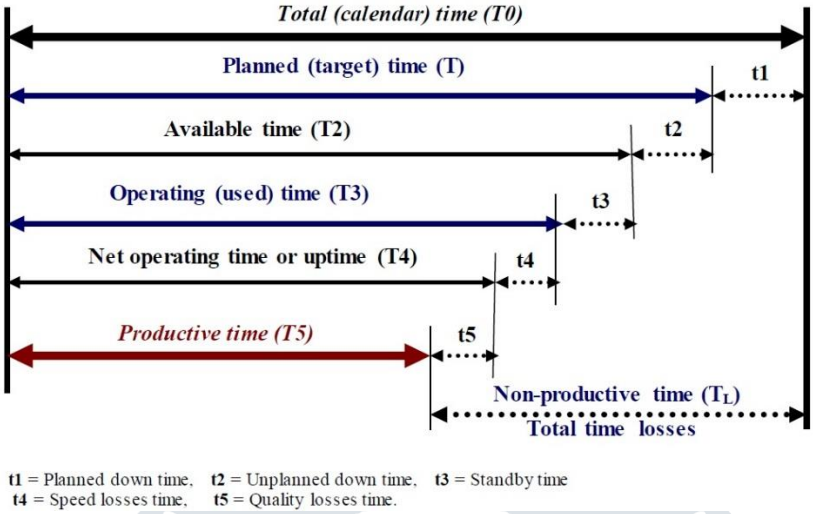


Figure 2 : Productive and No Productive Time

***A - Availability*** *of the machine*. Availability is proportion of time machine is actually available out of time it should be available.

$$\boldsymbol{Availability} = \frac{(Planned\ production\ time - unscheduled\ downtime)}{Planned\ production\ time}$$

Production time = Planned production time – Downtime

Gross available hours for production include 365 days per year, 24 hours per day, and 7 days per week. However this is an ideal condition. Planned downtime includes vacation, holidays, and not enough loads. Availability losses include equipment failures and changeovers indicating situations when the line is not running although it is expected to run.

***PE - Performance Efficiency***. The second category of OEE is performance. The formula can be expressed in this way:

$$\boldsymbol{Performance\ (Speed)} = \frac{(Cycle\ time\ x\ Number\ of\ products\ processed)}{Production\ time}$$

***Q - Refers to quality rate.***Which is percentage of good parts out of total produced. Sometimes called "yield". Quality losses refer to the situation when the line is producing, but there are quality losses due to in-progress production and warm up rejects. We can express a formula for quality like this:

$$\boldsymbol{Quality\ (Yield)} = \frac{(Number\ of\ products\ processed - Number\ of\ products\ rejected)}{(Number\ of\ products\ processed)}$$

A simple example on how OEE is calculated is shown below.

- Running 60 percent of the time (in a 24-hour day)
- Operating at 65 percent of design capacity (flow, cycles, units per hour)
- Producing quality output 95 percent of the time

When the three factors are considered together (60% availability x 65% efficiency x 95% quality), the result is an overall equipment effectiveness rating of 37.0 percent.

**World Class OEE**

World class OEE is a standard which is used to compare the OEE of the firm. The percentage of World Class OEE is given in Table.

| OEE Factors | OEE world class |
|---|---|
| A % | 90.0 |
| PE % | 95.0 |
| Q % | 99.9 |
| OEE % | 85.0 |

**SIX LOSS CATEGORIES**

1) ***Break down losses:*** These are losses of quantity via defective products and losses of time due to decreased productivity from equipment breakdowns.
2) ***Setup and adjustment losses:*** These losses stem from defective units and downtime that may be incurred when equipment is adjusted to shift from producing one kind of product to another.
3) ***Idling and minor stoppage losses:*** Typically, these kinds of small losses are relatively frequent. They result from brief periods of idleness when between units in a job or when easy to clear jams occur.
4) ***Reduced speed losses:*** These losses occur when equipment is run at less than its design speed.
5) ***Quality defects and rework:*** These are product related defects and corrections by malfunctioning equipment.
6) ***Startup losses:*** These are yield losses incurred during early production, from machine startup to steady state.

**Review of Research Articles:**

1. **S.R.Vijayakumar, S.Gajendran** (2014) have suggested in their study, the organization should introduce a maintenance system to improve and increase both the quality and productivity continuously. OEE is one of the performance evaluation methods that are most common and popular in the production industries. The Overall Equipment Effectiveness was improved with low machine breakdown, less idling and minor stops time, less quality defects, reduced accident in plants, increased the productivity rate, optimized process parameters, worker involvement, improved profits through cost saving method, increased customer satisfaction and increasing sales. In their work, the OEE of the injection moulding process was increased from 61% to 81% through the implementation of availability, better utilization of resources, high quality products and also raised employee morale and confidence.

2. **Ramesh C.G, Mohammedasif Mulla** (2014) have mentioned in their study and they have implemented TPM and 5S techniques to improve the availability, performance and quality of the machines. Though TPM, 5S technique, design of multi-fixture were focused, the availability and performance were improved significantly by minimizing the equipment deterioration and failure. After the implementation of TPM, 5S techniques and design of multi-fixture, the availability of machine has been increased from 67.73% to 70.78%, performance from 60.63% to 63.91% and the OEE of machine increased from 40.08% to 44.41%.

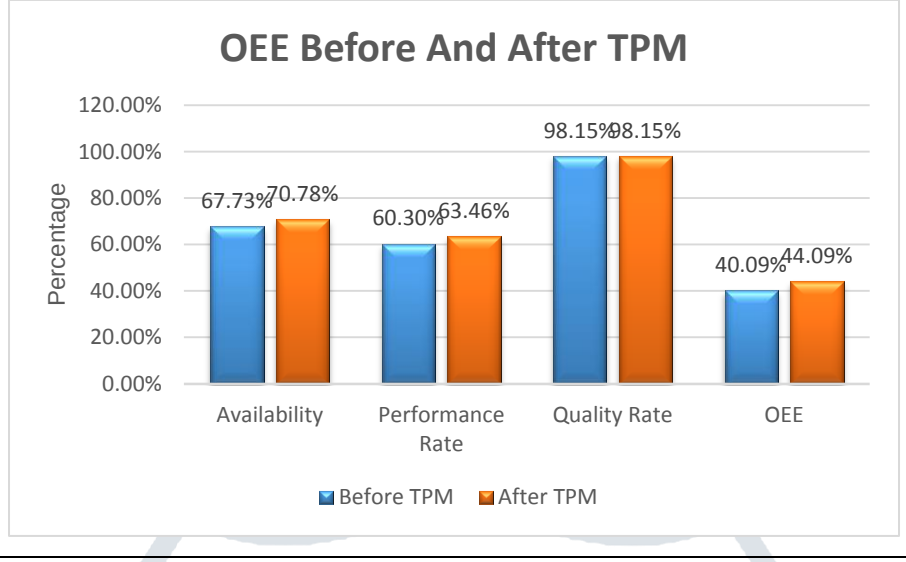


Figure 3 : OEE Before And After TPM

3. **M. VivekPrabhu, R. Karthick, Dr.G. Senthil Kumar** (2014) have stated that an OEE is an important performance measure for effectiveness of any equipment, careful analysis is required to know the effect of various components. A excel sheet can be used as simplest tool to measure and monitor true data collection. An attempt has been done in their study to optimize the OEE by using Genetic Algorithm (GA). Their study indicates that OEE will be significantly improved if focus is given on performance rate improvement. To achieve the OEE of 84.645%, optimized values are Availability 90%, Performance Rate95% and Quality Rate 99%. Simulated values of above scenario will add more valuable information to industry.

4. **Binoy Boban, Jenson Joseph E** (2013) have suggested in their study that, presently competition in industry at an all-time high, TPM may be the only thing that stands between success and total failure for some companies TPM can be adapted to work not only in industrial plants, but also in construction, building maintenance, transportation, and in 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 is necessary for full implementation. If everyone involved in a TPM program does his or her part, a usually high rate of return compared to resources invested may be expected. TPM success requires strong and active support from management, clear organizational goals and objectives for TPM implementation.

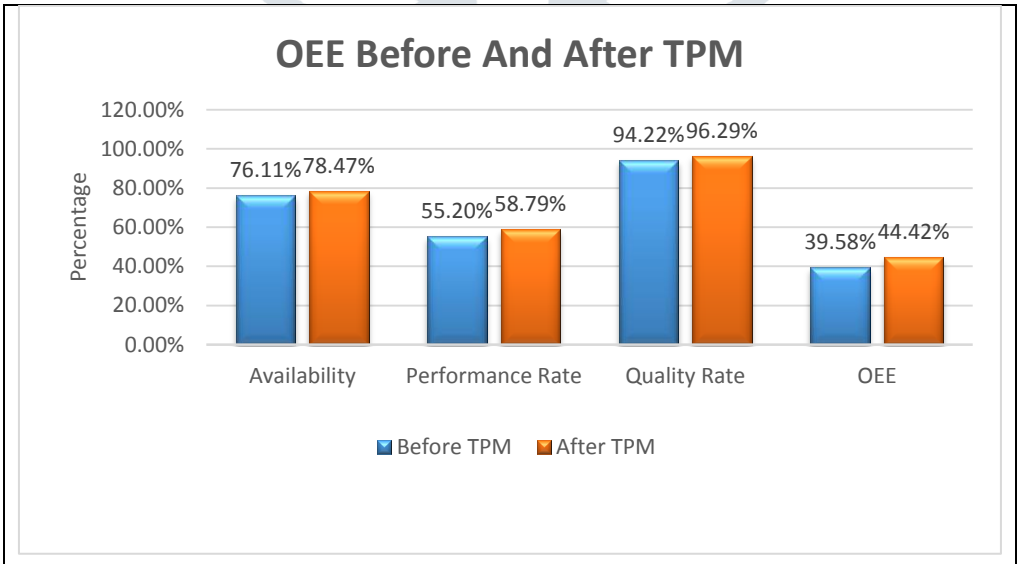


Figure 4 : OEE Before and After TPM

## CONCLUSION

1) Success of TPM depends on various pillars like 5-S, Jishu Hozen, Planned Maintenance, Quality maintenance, Kaizen, Office TPM and Safety, Health & Environment. The key factors for this implementation are workers involvement and top management support.
2) To improve productivity it is essential to improve the performance of the manufacturing systems. The desired production output is achieved through high equipment availability, which is influenced by equipment reliability and maintainability.
3) TPM is a structured equipment-centric continuous improvement process that strives to optimize production effectiveness by identifying and eliminating losses associated with equipment and production efficiency throughout the production system life cycle through active team-based involvement of employees across all levels of the operational hierarchy.
4) Total productive maintenance (TPM) methodology is a proven approach to increase overall equipment effectiveness (OEE) of equipment. It consists of eight activities; focused improvement and autonomous maintenance are two important activities to enhance equipment performance. These activities aim to educate the participants in the concepts and philosophy of equipment maintenance and give them an opportunity to develop their knowledge and skills.
5) The perceptible impact of TPM lies in attaining the far-reaching productivity and quality standards. Attempts have been made to examine TPM for the feasibility in Indian industries.

## REFERENCES

[1] Abdul Talib Bon, Lim Ping Ping, Berhanuddin Mohd Salleh and Asri Selamat, "Evaluating total productive maintenance using overall equipment effectiveness: fundamental study", Production Management, Elixir Prod. Mgmt. 36 (2011) 3293-3295.

[2] Binoy Boban, Jenson Joseph E, "Enhancing Overall Equipment Effectiveness for a Manufacturing Firm through Total Productive Maintenance", International Journal of Emerging Technology and Advanced Engineering, Volume 3, Issue 8, August 2013.

[3] F. Ireland and B.G. Dale, "A study of total productive maintenance implementation", Journal of Quality in Maintenance Engineering, Vol. 7 No. 3, 2001, pp. 183-191.

[4] Hemant Singh Rajput, Pratesh Jayaswal, "A Total Productive Maintenance (TPM) Approach to Improve Overall Equipment Efficiency", International Journal of Modern Engineering Research (IJMER), Vol.2, Issue.6, Nov-Dec. 2012 pp-4383-4386.

[5] Islam H. Afefy, "Implementation of Total Productive Maintenance and Overall Equipment Effectiveness Evaluation", International Journal of Mechanical & Mechatronics Engineering IJMME-IJENS Vol: 13 No: 01.

[6] M. VivekPrabhu, R. Karthick, Dr.G. Senthil Kumar, "Optimization of Overall EquipmentEffectiveness in A Manufacturing System", International Journal of Innovative Research in Science, Engineering and Technology, Volume 3, Special Issue 3, March 2014.

[7] Mohammed Asif Mulla, Ramesh C.G, "Enhancing Overall Equipment Effectiveness of HMC Machines Through TPM and 5S Techniques in a Manufacturing Company", International Journal on Mechanical Engineering and Robotics (IJMER), Volume-2, Issue-2, 2014.

[8] Muhammad Abdus Samad, Muhammed Rifat Hossain, Md. Asrafuzzaman, "Analysis of Performance by Overall Equipment Effectiveness of the CNC Cutting Section of a Shipyard", ARPN Journal of Science and Technology, VOL. 2, NO. 11, Dec 2012.

[9] Osama Taisir R.Almeanazel, "Total Productive Maintenance Review and Overall Equipment Effectiveness Measurement", Jordan Journal of Mechanical and Industrial Engineering, Volume 4, Number 4, September 2010.

[10] S. Fore, L. Zuze, "Improvement of Overall Equipment Effectiveness through Total Productive Maintenance", World Academy of Science, Engineering and Technology 61 2010.

[11] S.R.Vijayakumar, S.Gajendran, "Improvement of overall equipment effectiveness (OEE) in injection moulding process industry", IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE).