

BENEFITS AND CHALLENGES OF TOTAL PRODUCTIVE MAINTENANCE IMPLEMENTATION

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ABSTRACT

As a maintenance programme that entails a modern approach for equipment and plant maintenance, Total Productive maintenance (TPM) underscores all features of production, as it aims to integrate maintenance and services of machines into a plant's daily routine, thereby reducing unscheduled and emergency stoppages and repairs to the barest minimum. This paper gave a detailed definition of Total Productive maintenance, and explained that its aim is to remarkably improve products' quality, and throughput, eliminate frequent machine stoppages and rework, leading to a dependable production system which will increase workers morale and job satisfaction. However, it was observed that TPM cannot be successfully implemented in a firm without the total approval and involvement of top management and employees, as they have to form teams that must oversee the activities of the manufacturing strategy. Apart from increase in quality of products and profitability, other benefits of a successful TPM implementation include better job satisfaction and staff morale, increased throughput and product's quality, as well as reduced manufacturing cost, this is because the main target is to reduce the occurrence of emergency breakdowns and unscheduled maintenance to the barest minimum. The challenges of TPM which must be overcome for enhanced benefits include inadequate knowledge of TPM, lack of leadership and management support, organizational culture, excess inventory, and inadequate trainings. The paper concluded by stating that the six major losses of faulty equipment and operation could be addressed by the introduction of Overall Equipment Effectiveness (OEE) model, which sets targets of zero breakdown and reduction of setup and adjustment.

KEYWORDS: wastage, maintenance, equipment, machine, implementation, manufacturing, losses, defects, quality, employees, strategy, teams.

1. INTRODUCTION

Stiff competitions and quest for enhanced profitability over the years has compelled the management of manufacturing companies to examine all their production processes including maintenance, in order to achieve flexibility and competitive advantage. This is because in a World Class Manufacturing, a dependable production system is a significant success factor for competitiveness, as the inability to efficiently manage maintenance will lead to increased lead time and inventory, as well as reduction in customer satisfaction, throughput, as well as overall plant performance.

The misconception that maintenance is an overhead expense that must be minimized is no longer tenable in today's manufacturing, as effective maintenance strategy enhances a firm's competitiveness, leading to improved process reliability and manufacturing excellence. One approach that has gained wide acceptance due to its numerous benefits in improving maintenance performance activities is Total Productive Maintenance system.

Formally presented as a set of procedures and methodologies centered on manufacturing equipment operation improvement, TPM which incorporates entire workforce participation and continuous improvement has greatly improved to become a comprehensive equipment centered effort to improve manufacturing.

Often referred to as the medical science of machines, Total Productive Maintenance (TPM) is a philosophy of machine maintenance that entails active participation of employees to ensure the improvement of the general effectiveness of a plant, by eliminating or reducing resources and time wastage through the incorporation of the skills of the workforce. As a maintenance programme that entails a modern approach for equipment and plant maintenance, TPM underscores all features of production, as it aims to integrate maintenance and services of machines into a plant's daily routine,

thereby reducing unscheduled and emergency stoppages and repairs to the barest minimum.

According to Paropate and Sambhe (2013), Total Productive Maintenance is a maintenance program which involves a newly defined concept for maintaining plants and equipment, with the aim of markedly increasing production, and also enhancing employee morale and job satisfaction. They explained that as a fundamental component of world-class manufacturing which has been recognized as one of the significant operation strategy to regain the production losses due to equipment inefficiency, that TPM is a methodology that aims to improve the accessibility of the existing equipment and in consequence curtail further capital investment.

By emphasizing on the importance of empowering shop floor workers to ensure constant maintenance of their equipment, TPM which is a unique philosophy eliminates the difference between the production and maintenance, thereby leading to daily preventative maintenance in order to enhance the operating efficiency of machines and equipment.

Katkamwar, Wadatkar, and Parapote (2013), defined TPM as an approach for "fundamental improvement of the maintenance functions in an organization, which involves all its entire human resources." They observed that the primary concept is that there will be a sharp decline in machine breakdowns, safety, and quality problems if plant machinery is properly maintained. Also, Bhadury (2000), explained that Total productive maintenance is an innovative approach to maintenance that optimizes equipment effectiveness, eliminates breakdowns and promotes autonomous maintenance by operators through everyday activities involving the entire workforce.

With the rising stiff competition in the manufacturing sector, the implementation of TPM as a maintenance enhancement strategy has helped many firms to achieve efficient plants. According to Wakjira, and Singh (2012), an effective TPM strategy and programs are needed, which can cope with the

dynamic needs and discover the hidden but unused or under-utilized resources like human brainpower, man-hours, and machine-hours. They concluded that the methodology has the potential to meet the current demands. A well conceived TPM implementation program not only improves the equipment efficiency and effectiveness, but also brings appreciable improvements in other areas of the manufacturing enterprise.

The objective of Total Productive Maintenance is to involve the entire workforce in all the levels of a manufacturing company by forming teams and assisting operators to fully maintain their machines and equipment, lay a strong foundation for enhanced production, by drastically reducing defects, and stoppages that may arise due to accidents and machine breakdowns in all functional areas of the plant.

2. TOTAL PRODUCTIVE MAINTENANCE IMPLEMENTATION

For a successful implementation of TPM in a manufacturing company, the entire workforce must be mobilized and carried along. This entails the provision of extensive training relating to their jobs for the enhancement of their knowledge, skills and competencies. Adequate trainings that cover all the facets of TPM should be organized; also visits to acclaimed TPM practicing companies should be encouraged, in order to acquaint the staff with the maintenance philosophy best practices.

The major impact factors for successful implementation of Total Productive Maintenance include: approval and total participation of management and the entire workforce, organizational infrastructure, linking of TPM to quality, business strategy, customers and staff, culture of teamwork, co-operation, and collaboration, employee selection training on TPM methodology and prioritization of projects.

Total Productive Maintenance cannot be successfully implemented in a firm without the total approval and involvement of top management and employees, as they have to form teams that must oversee the activities of the manufacturing strategy. According to Poduval, Pramod, and Raj, (2013), the team which should consist of employees from all the levels of an organization right down to the operator level will be responsible for identifying the goals, and laying down strategies and outlining resources required to achieve the goals. They highlighted that the goals should be specific and quantifiable with all the team members having a clear idea of what to achieve, and also responsible for identifying and rectifying issues in the equipment to which they are assigned and also developing master plan for failure prevention

With the formation of the teams and the identification of the machines and equipment they will work on, the next step of TPM implementation is the adoption of pillars of TPM, which comprise of the eight pillars or elements on which the entire structure of TPM stands and is built on. The eight element implementation blueprint leads to an increase in throughput through maintenance control, and reduction in downtimes, production stoppages, and costs of maintenance.

As shown in figure 1, the major TPM plans categorized into eight elements or activities for achieving performance improvements are autonomous maintenance, focused maintenance, planned maintenance, quality maintenance, education & training, safety, health & environment, office TPM, development management and safety, health and environment.

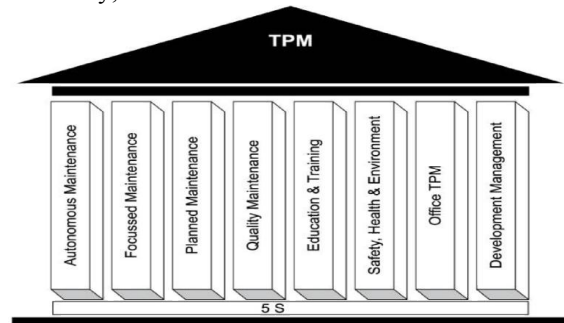


Figure 1: The Pillars of TPM

As faults and mistakes cannot be easily identified in a very dirty and unorganized shop floor, TPM begins with 5S practice which entails systematic housekeeping, cleaning and arranging of the workplace for easy uncovering of problems. The 5S philosophy with their English meanings shown in Table 1, when properly implemented leads to reduction of defective products, lead time, unhappy customers, demoralized workers, and declining profits.

Table 1: The 5S practice.

Japanese Term	English Translation	Equivalent 'S' term
Seiri	Organization	Sort
Seiton	Tidiness	Systematize
Seiso	Cleaning	Sweep
Seiketsu	Standardization	Standardize
Shitsuke	Discipline	Self - Discipline

Without the 5S strategy, the implementation of TPM in an organization will be an arduous task as the lack of understanding of its principles and action plans will impede the envisaged success. It should be encouraged among both the machine operators and other staff through group activities by determining their overall participation, thereby reducing constant directives and interventions from the management. This will enable the management to focus on more important issues, while the activities will enable workers to develop the feeling of ownership, autonomy, and responsibility.

According to Ahmed and Hassan (2002), the major elements of Total Productive Maintenance implementation are the understanding and development of its awareness, identification and classification of problems, development of human resources and formation of small groups, collection of data on losses and flow of information. Others are identification of engineering methods for their minimization, implementation of those methods and evaluation by statistical analysis and interpretation, documentation, as well as measures for further improvement.

The major functions involved in TPM implementation is shown in Table 2.

Table 2: Major Functions Involved in TPM Implementation

Type	Phase 1	Phase 2	Phase 3	Phase 4
Preventive maintenance	Reduce variability of life span – restore neglected equipment Eliminate inferior equipment – adhere to condition of use	Lengthen life span - Correct design weakness Eliminate unexpected breakdowns – external repair and maintenance of equipment	Make occasional repair – project life span and plan periodic renovation Identify symptoms of deterioration	Predict life span – use equipment diagnostic techniques Do technical analysis of major breakdowns
Autonomous maintenance	a. Basic cleaning, b. address sources of problems, c. set cleaning & lubrication standards	d. general inspection of equipment	e. autonomous inspection	f. organization & orderliness, g. autonomous activities
Education & training	Basic training on cleanliness, use of nuts & bolts etc.	Training in handling keys & bearings, power transmission system, hydraulics pneumatics & sealing	Training in operations and maintenance methods: loss calculations	Training in analysis and evaluations
Startup maintenance and economic evaluation	Startup maintaining records	Functional analysis; cost reduction analysis; design standards	Maintenance prevention analysis; standardization of practices	Evaluate economic efficiency

The TPM implementation activities include: a master plan, independent maintenance, scheduled maintenance, reduction in maintenance, and consolidation. However, the recommended steps for TPM Implementation in an organization include:

Step 1 – The Beginning Stage. This entails informing the entire workforce, provision of a general overview of what TPM is, setting up of TPM teams and targets, as well as adoption of working strategies to achieve the desired targets.

Step 2 – Introduction. Here TPM is gradually introduced into the company.

STEP 3 – Implementation. At this stage, the eight pillars of TPM are implemented starting with the 5S principle.

Step 4 – Consolidation. At the consolidation stage, all the activities of TPM reaches maturity stage, and with dedication, team work, and unity of purpose, the company begins to benefits immensely from the production strategy.

3. BENEFITS OF TPM IMPLEMENTATION

A properly implemented TPM leads to remarkable improvements in all the facets of manufacturing, and also enhances the effectiveness and efficiency of machines and equipment. This is because it generates a better involvement of workers at the shop floor, thereby enabling them to share the responsibility of equipment maintenance and repairs, in order to improve their productivity, and also reduce cycle time and defects.

Carannante (1995), pointed out that successful TPM implementation leads to significant intangible benefits such as continuous improvement of workforce skills and knowledge, fostering employee motivation through adequate empowerment, clarification of roles and responsibilities for employees, a system for continuously maintaining and controlling equipment, enhanced quality of work life, reduced absenteeism and enhanced communication in the workplace.

Since TPM encourages manufacturers to combine financial and technical impacts with its human aspects, it leads to better job satisfaction and staff morale, increased throughput and product's quality, as well as reduced manufacturing cost. Here, the main target is to reduce the occurrence of emergency breakdowns and unscheduled maintenance to the

barest minimum, as downtime is seen as a key part of the manufacturing process.

The ability to achieve maximum customer satisfaction by delivering the right quality and quantity of products to the customer at the right time is one of the major benefits of successfully implementation of Total Productive Maintenance. Others are enhancement of the employees' level of confidence, up to thirty percent reduction of manufacturing cost, improvement of overall equipment efficiency, achievement of set out goals by working as teams, considerable accident reduction, sharing of knowledge and experience, as well as reduction of stoppages, wastes, breakdowns, and manufacturing cost.

4. CHALLENGES OF TPM IMPLEMENTATION

Despite the numerous benefits of TPM, there are a lot of challenges that if not properly addressed will hamper its successful implementation, this is because the manufacturing strategy which appears so easy in theory is actually difficult to actualize. These challenges could be attributed to some factors which lead to the inability of manufacturing companies to fully understand the entire concepts of TPM before dabbling into it. Some of these factors include:

➤ Inadequate Knowledge of TPM

Inadequate knowledge of TPM is a major impediment to its successful implementation as all the manufacturing companies that are today reaping the benefits of the production strategy really took a lot of time to fully learn and institutionalize efficient implementation of TPM, thereby improving the knowledge, competencies, and skills of the entire staff.

➤ Lack of Leadership and Management Support

Without the total support and commitment of the leadership and management of a firm, the implementation of TPM will not be successful, as they are the ones to adopt, drive, and also ensure that all the workers accept it. Also, as the benefits of TPM take a long time to manifest, the management must be willing to invest in it without considering it as irrelevant expenses that negatively affects the finance.

➤ Organizational Culture

Boundaries and unnecessary bureaucracies between the leadership and non management staff that some

manufacturing companies have as their culture enhance indifference, and also hamper easy flow of information among the staff. To achieve a successful TPM, all the negative culture should be jettisoned while the company should ensure that all departments, teams, and employees are involved in decision making processes and also share their experiences, skills, knowledge, and ideas.

➤ Inadequate Workshops and Trainings

To equip the staff to overcome the challenges of TPM implementation, their knowledge and skills should be enhanced through the organization of workshops and trainings. The trainings which must be broad based should be suitably designed to address all specific topics, rudiments, approaches, and procedures of TPM. According to Kedaria and Deshpande (2014), “All shop-floor training should be based on a clear understanding of the human resource development systems and policies laid out by the company’s personnel and training departments.” They concluded that the prospective trainees are

selected, and their training needs assessed, and that the assessment may be based on past work performance evaluations, daily observation, or the individual’s own stated wish for training.

➤ Excess Inventory

Keeping of excess inventory by manufacturing companies is a major challenge of achieving a successful TPM implementation, as it is a major manufacturing waste does not allow firms to be innovative, as it ties money down thereby impeding research, development, and new product introduction. According to Okpala (2013), this challenge should be reduced through the “use of “kanban” which entails the keeping of small amounts of inventory at where they are required at the shop floor, thereby ensuring the constant flow of materials, increase in productivity, cost reduction and elimination of wastes.”

Faulty machines and equipment is also a major challenge of successful TPM implementation as it leads to six major losses as shown in Table 3.

Table 3: Six Major Losses (Gupta, Tewari, and Sharma (2013))

Six major losses that can result from faulty equipment or operation		
S.No.	Loss Category	Costs to Organization
1	Unexpected breakdown losses	Results in equipment downtime for repairs. Costs can include downtime (and lost production opportunity or yields), labor, and spare parts.
2	Set-up and adjustment losses	Results in lost production opportunity (yields) that occurs during product changeovers, shift change or other changes in operating conditions.
3	Idling and Stoppage losses	Results in frequent production downtime and that difficult to record manually. As a result, these losses are usually hidden from efficiency reports and are built into machine capabilities but can cause substantial equipment downtime and lost production opportunity.
4	Speed losses	Results in productivity losses when equipment must be slowed down to prevent quality defects or minor stoppages. In most cases, this loss is not recorded because the equipment continues to operate.
5	Quality defect & Rework losses	Results in low standard production and defects due to equipment malfunction or poor performance, leading to output which must be reworked or scrapped as waste.
6	Equipment and capital investment losses	Results in wear and tear on equipment that reduces its durability and productive life span, leading to more frequent capital investment in replacement equipment.

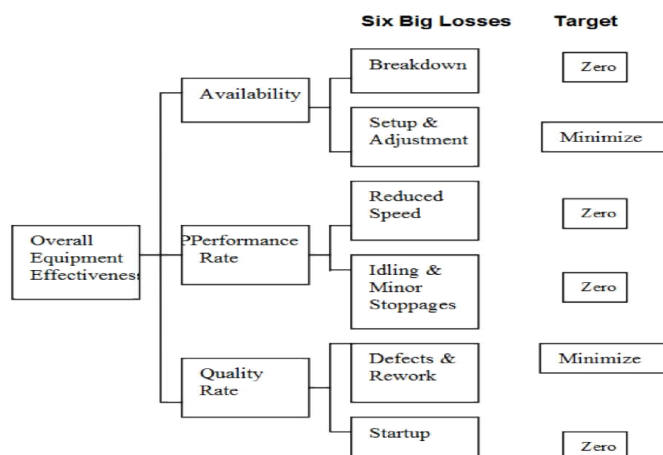


Figure 2: Overall Equipment Effectiveness Model (Gupta, Tewari, and Sharma (2013))

However, as shown in figure 2, the six losses could be addressed by the introduction of Overall equipment effectiveness model which sets targets of

zero breakdown and reduction of setup and adjustment. As one of the best measurements of Total Productive Maintenance, overall equipment

effectiveness is a measure of rate of quality, availability, and performance efficiency, as it addresses machines stoppages, production of defects and poor quality products by machines, as well as machines and equipment that work below their production capacity.

As the important function of production line, rate of production, availability, rate of performance, and

$$\text{Availability (in percent)} = \frac{\text{Actual working time (in minutes)} * 100}{\text{Planned working time (in minutes)}} \dots (1)$$

$$\text{Rate of Performance (in percent)} = (\text{Operating speed} * \text{Net operating rate}) * 100 \dots (2)$$

$$\text{Quality rate} = \frac{\text{Total quantity produced} - \text{Scrapped quantity} * 100}{\text{Total quantity produced}} \dots (3)$$

Therefore,

$$\begin{aligned} \text{OEE (in Percent)} \\ &= \text{Availability (in percent)} * \text{quality rate (in percent)} \\ & * \text{rate of performance (in percent)} \dots (4) \end{aligned}$$

The major objective of Overall Equipment Effectiveness is the identification of the area where improvement is required.

Other challenges of successful TPM implementation include: employees resistance to change, wrong attitudes towards manufacturing processes, and unavailability of effective system of employees' reward.

5. CONCLUSION

As an effective tool for improved productivity, Total Productive Maintenance is an innovative system for equipment and machine maintenance which optimizes performance efficiency and quality rate, enhances autonomous operator maintenance through daily activities, and also drastically reduces breakdowns. However, Total Productive Maintenance cannot be successfully implemented in a firm without the total approval and involvement of top management and employees, as they have to form teams that must oversee the activities of the manufacturing strategy.

Successful TPM implementation leads to numerous benefits such as improved quality of products, work life and job satisfaction, continuous improvement of workforce knowledge and competence, enhanced sharing of information by the various teams, ensures workers motivation through adequate empowerment, increase in throughput, quality of products, as well as customers' satisfaction.

Although there are many benefits of TPM, there are a lot of challenges that if not properly addressed will frustrate its successful implementation, this is because the manufacturing strategy which appears so easy in theory is actually difficult to actualize. However, with leadership and management support as well as relevant trainings and workshops, most of the challenges will be overcome.

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machine's quality rate, Overall Equipment Effectiveness is calculated with regards to the six major losses that can result from faulty equipment or operation which include unexpected breakdown, setup and adjustment losses, idling and stoppage losses, speed losses, quality defect and rework losses, as well as equipment and capital investment losses.

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