The Strategy of Successful Total Productive Maintenance (TPM): Implementation and Benefits of TPM (Literature Review)

Kitalu Ricin Ngoy [1], Kipendo Israel [2]

[1]Department of Mechanical Engineering Science, University of Johannesburg, South Africa
[2]Department of Mechanical Engineering Science, University of Liege, Belgium

Abstract
Purpose: This article aims to review the literature based on Total Productive Maintenance (TPM) with the aim of providing a general framework for successful TPM implementation techniques used by manufacturers. It also aims to underline relevant drivers and success factors for addressing obstacles to TPM implementation success.

Approach/Methodology: The paper reviews and analyses the published researches which have been carried out in some manufacturing industries that have effectively adopted TPM and reaped considerable advantages as a result of TPM implementation, with the goal of justifying TPM implementation in manufacturing sectors.

Findings: The article covers a wide range of topics in Total Productive Maintenance, including maintenance procedures, the TPM framework, overall equipment effectiveness (OEE), TPM implementation strategies, challenges to TPM implementation, and success factors. The implications of strategic TPM programs to increasing businesses' manufacturing skills have also been recognized.

Practical Implications: There has been relatively little research on how to classify Total Productive Maintenance. The study examines a significant published articles on this topic and provides an overview of different TPM implementation techniques used by manufacturing companies throughout the world. It also discusses the techniques proposed by various scholars and practitioners, as well as a critical evaluation of the causes behind TPM program failure in companies. In addition, the facilitators and success criteria for TPM implementation have indeed been emphasized in order to ensure a robust and efficient TPM implementation in companies.

Originality: The article presents a comprehensive overview of successful TPM implementation. Understanding the relevance of TPM will be beneficial to researchers, maintenance professionals, and everyone interested in maintenance.

Keywords: Total Productive Maintenance, Implementation and Benefits of TPM, Manufacturing

1. Introduction

Due to the global crisis and increased competition, it is now a basic corporate necessity to provide quality products at competitive costs by lowering production costs, which can only be accomplished through increased manufacturing performance. As a result of the growing worldwide rivalry, companies are being forced to enhance and maximize their productivity in order to stay competitive. Organizations that wish to be competitive in today's market must have a diverse product line and features that are of high quality, low cost, and efficient.

In today's increasingly competitive globalized environment, organizations are looking at maintenance as a possible source of cost savings and competitive advantage.

When it comes to dealing with reliability, availability, maintainability, and performance concerns, efficient integration of the maintenance function with engineering and other manufacturing activities in the company may help save a lot of time, money, and other valuable resources.

Maintenance is generally seen as having a worse return on investment than any other significant budget item. However, by giving maintenance the managerial attention that it deserves, most companies can lower maintenance fees by at least one-third and increase productivity. That priority must be shared at all echelons of an organization's management system in order for everyone to realize how important maintenance is to the success or failure of the organization's goals.

Maintenance practices may be streamlined to reduce waste and achieve breakthrough efficiency where consumers place a high value. Equipment maintenance accounts for a significant proportion of operational costs in the transportation, mining, utilities, and manufacturing industries. Maintenance has a significant influence on production performance. Therefore, maintenance is in charge of keeping control of the costs of materials, manpower, and tools. Moreover, maintenance can account for 20% to 40% of the value contributed to a product as it goes through the manufacturing process.

In this term, maintenance can be defined as “all actions intended to keep or restoring an asset to the physical state identified as necessary for the achievement of its production function,” whereas the maintenance approach is defined as “a collection of maintenance policies and actions of various types, as well as the general decision framework in which these are scheduled and supported”.

The evolution of maintenance has started with "Reactive" maintenance, in which the preponderance of the working hours is reactive, therefore, the company is always on the lookout for challenges. Breakdown or run-to-failure maintenance are other terms for Reactive maintenance. And then there is the process of improvement, which establishes the expectation that all maintenance operations should be "Planned. Planned maintenance, often known as preventative maintenance, is performed at predetermined intervals through repair, service, or component replacement. Additional enhancements have been made in order to achieve "Predictive" maintenance. This kind aims at assessing the asset's condition through the analysis of quality, vibration, voltages, oil, and other aspects. It's also known as condition-based maintenance(CBM). While condition monitoring is used in predictive maintenance to help predict problems, it does not always uncover the root cause.

Maintenance techniques are evolving toward a "Proactive" technique, which concentrates on identifying the underlying cause of failure and attempting to prevent it from happening again by implementing appropriate modifications in production, construction, or operation. It's also known as Reliability-Based Maintenance (RBM).

2. Types of Maintenance

Breakdown Maintenance (BM)

Breakdown maintenance is a maintenance method in which repairs are performed after equipment failure/stoppage or when a substantial performance degradation occurs. Before 1950, this maintenance technique was mostly used by industrial companies all around the world. Machines are only maintained at this period if they need to be repaired urgently. The drawbacks of this technique include a lot of damage, unplanned stoppages, spare component difficulties, high repair costs, and high diagnostic challenges.

Preventive Maintenance (PM)

Preventive maintenance is a type of physical inspection of equipment that was first established in 1951 to prevent equipment defects and extend its service life. Preventive maintenance refers to the maintenance operations that are performed after a certain length of time or equipment operation. This maintenance type is centered on the likelihood that the equipment may fail or decline in its inefficiency within the time period specified. Preventative maintenance duty includes lubrication, part replacement, cleaning, adjustment of equipment, and tightening. During preventive maintenance, the equipment can be assessed for indicators of damage.

Predictive Maintenance (PdM)

Predictive maintenance is also known as condition-based maintenance (CBM). This technique of maintenance is started as a result of a particular equipment problem or quality degradation. Diagnostic methods are used to evaluate noise temperature, lubrication, vibration, and corrosion. If one or more of these variables reaches a specified degree of degradation, maintenance efforts are launched to return the equipment to its original state. This implies that equipment is removed from service when there is clear proof of degradation. Predictive maintenance is modeled as preventive maintenance, but it uses a different criterion to determine when particular maintenance tasks are required. The extra benefit is from the requirement to do maintenance only when it is really necessary, rather than after a certain amount of time has passed.

Corrective Maintenance (CM)

Corrective maintenance is a technique introduced in 1957 in which the notion of preventing equipment failures is broadened to include equipment improvement so that malfunctions of equipment can be prevented (increasing reliability) while enhancing the equipment maintainability. The most significant distinction between preventive maintenance and corrective is that corrective actions must be done once a problem has been identified. Corrective maintenance aims to improve equipment performance, maintainability, and safety by addressing design issues (materials, forms), structural reforming existing equipment, reducing degradation and failures, and achieving maintenance-free equipment.

Maintenance data acquired by CM may be used to prevent future equipment from breaking down and to upgrade existing manufacturing operations. It is crucial to build setups in order to offer feedback on maintenance information.

Computerized Maintenance Management Systems (CMMS)

Computerized maintenance management systems help in the monitoring of a wide variety of information such as the maintenance staff, repair timetables spare-part inventories, and equipment histories. It can be used to organize and schedule repair orders and to control the entire maintenance workload. A CMMS may also be utilized to automate the PM function, as well as to help with inventory management and material purchases. The use of a CMMS can improve the analysis and reporting.

The capacity of a CMMS to handle maintenance data helps to better communicate and to make decisions within the maintenance department. The availability of data and communication related to CMMS promotes greater communication of service requirements, enhanced coordination via stronger working linkages between production and maintenance, and higher maintenance response.

Total Productive Maintenance (TPM)

TPM is a method of maintenance that improves equipment performance, reduces failures, and encourages operators to do autonomous maintenance by integrating the entire workforce in day-to-day operations.

A good strategy to enhance the quality of maintenance operations is the capacity to successfully adapt and establish effective TPM initiatives in a company. TPM presents the function of maintenance as an essential and critical component of the company. The TPM effort aims to improve businesses' competitiveness by using a powerful organized approach to changing employees' mindsets and resulting in a visible transformation in an organization's work culture. TPM aims to involve all levels and activities of an organization in order to improve the overall performance of the manufacturing equipment. TPM is a world-class manufacturing (WCM) program focused on increasing industrial machinery efficiency.

TPM actively engages employees from all levels and departments, from the ground of the plant to top management, to achieve consistent equipment operation. Whereas traditional preventive maintenance activities focus on maintenance departments.

2.1. Total Productive Maintenance (TPM) Literature Review

Total productive maintenance (TPM) is a Japanese philosophy based on Productive Maintenance methods and practices. This concept was first developed in 1971 by M/s Nippon Denso Co. Ltd., a supplier to M/s Toyota Motor Company, Japan.

2.1.1 TPM Definitions

There are several varieties of definitions for TPM, and this is justified by the fact that there are many ways by which the TPM approach is implemented, as certain organizations place a greater emphasis on teamwork than on equipment management, while others place a greater emphasis on equipment effectiveness. TPM is defined as a "strategic approach that brings together both production and maintenance activities by combining strong working behaviors, collaboration, and continuous improvement." Otherwise, TPM intends to establish a company-wide approach to reaching a world-class level of manufacturing performance in terms of the total effectiveness of equipment, tools, and processes."

2.1.2 TPM Objectives and Benefits

TPM is a critical component of lean manufacturing; therefore, one of TPM's main goals is to eliminate the six major production losses and to maintain equipment to its specified capacity. TPM aims for a zero product defect rate, which is no manufacturing waste or defect, no accident, no breakdown, and no damage during the process of transition. TPM's main objectives include:

- Enhancing the Overall Efficiency of the Equipment (OEE).
- Enhancing the efficiency and effectiveness of maintenance by engaging employees in doing maintenance every day and achieving autonomous maintenance.
- Personnel education and training: through engaging the participation of all employees in the organization.
- Developing equipment to facilitate maintenance prevention. Therefore, workers' and maintenance experts' suggestions may aid engineer designers to define and obtain more productive equipment.

As illustrated in Table 1, the advantages achieved from TPM implementation can be divided and organized into direct and indirect advantages.

Table 1: Direct and Indirect Advantages of TPM

Direct advantages	Indirect Advantages
• Decrease in breakdowns in the range of (65-78) %. • Decrease in faults and rework in the range of (65-80) %.	• Employees are more confident.
• Decrease in production and maintenance costs in the range of (18-45) %. • Providing the correct quantity at the right moment and in excellent quality).	• The workplace is clean, tidy, and attractive.
• Decrease in accidents in the range of (90-98) %. • Decrease in energy costs in the range of (8-27) %.	• Operators' attitudes are improved, and staff ideas are increased by (32-65%).
• Customer complaints are reduced by 50-75 percent. • Company profit and OEE increased by (14-45%).	• Increasing employee participation (sharing skills and knowledge via teamwork) and increasing job satisfaction by establishing a pleasant work environment.

2.1.3 TPM Pillars

TPM's fundamental activities are also referred to as TPM's pillars or components. TPM is formed on the basis of eight pillars. TPM provides a way for improved planning, coordinating, monitoring, and controlling activities with its unique eight-pillar approach.

The core TPM approaches are classified into eight TPM pillars or actions for achieving production performance improvements, these include: autonomous maintenance, focused maintenance, planned maintenance, quality maintenance, education and training, office TPM, development management, and safety, health, and environment.

Table 2. Shows the specific summary of the eight pillars.

Table 2: Specific Summary of the Eight Pillars

TPM pillars	Description	Benefits
Autonomous maintenance	Equipment operators are in charge of doing basic equipment maintenance.	Operators became more responsible for their equipment, and the equipment reliability increases
Planned maintenance	Maintenance program based on equipment failure rate encountered	Maintenance can be planned when there are few manufacturing operations.
Quality maintenance	Quality is integrated into the equipment to eliminate faults.	Defect elimination and, as a result, increased profit
Focused improvement	Improvement efforts are carried out with the help of cross-functional teams.	employees' ability to solve problems is improved
Development management	design of new equipment based on prior TPM activities	In a shorter time, new equipment reaches its full potential.
Education and training	addressing the skills and knowledge gap through all workers' training	Employees get the abilities they need to handle challenges at work.
Safety, health, and environment	ensuring a safe working environment free of accidents and injuries	unfavorable conditions are eliminated, and the workplace is made healthy.
Office TPM	Throughout a company, the concepts of administrative functions are spread	Support functions are aware of the advantages of these enhancements.

2.1.4 5Ss

The 5Ss is the TPM's foundation pillar from a Japanese concept that includes Seiri (sort, organization), Seiketsu (standardize the cleaning), Seiton (put in order), Seiso (shine, cleanliness), and Shitsuke (sustain, discipline). 5Ss is a strategy for reducing waste, increasing productivity, and improving quality by keeping a clean workplace and utilizing visual information to produce more reliable operating results. It's a Japanese technique of housekeeping. If the workplace is disorganized, problems will go undetected. Cleaning and arranging the workplace assists us in identifying and resolving issues. Making problems apparent and visible to the public allows for improvement. If 5S is not handled seriously, it will result in 5D, which stands for Defects, Delays, Declining Profits, Dissatisfied Customers, and Demoralized Employees.

2.1.5 TPM Tools/ Metrics

TPM evaluation may be done using a variety of methods, and the best tool for the job is determined by the implementation requirements. These tools are used to evaluate, detect losses, and verify the efficiency of machines in order to come up with solutions to efficiency issues.

To evaluate and solve equipment and process-related issues, TPM employs the following tools/metrics: Overall Equipment Effectiveness (OEE), Overall Resource Effectiveness (ORE), Overall Plant Efficiency (OPE), Pareto Analysis, Single Minute Exchange Die (SMED), Statistical Process Control (SPC), Control Charts, and others.

In this article, we will be only presenting the Overall Equipment Effectiveness (OEE) as it is the primary tool used to assess TPM implementation success.

2.1.6 Overall Equipment Effectiveness (OEE)

OEE is defined as a quantitative indicator that assesses the quality of a manufacturing system; it is the primary tool used to assess TPM implementation success. The availability, performance, and quality standards for OEE are all set at 90%, 95%, and 100%, respectively. A benchmark OEE of 85% is considered as a world-class quality.

Examining OEE variables can identify the most significant success boundaries. The goal of OEE is to increase the availability of equipment, as well as the performance rate, quality, and process efficiency. OEE may be used as a baseline for comparing a manufacturing plant's original and improved performance and therefore measuring the degree of improvement. The six main losses that have a significant impact on production system efficiency are equipment breakdown/failure, adjustment and setup, idling and minor halts, defect and rework, decreased speed, and start-up losses.

The OEE is obtained using the following equations:

$$\text{Availability} = \frac{\text{Required availability} - \text{Downtime}}{\text{Required availability}} \ 100\% \quad (1)$$

Required availability = Time of production to operate the machine – planned downtime (2)

$$\text{Performance rate} = \frac{\text{output of design cycle time}}{\text{Operating time}} \ 100\% \quad (3)$$

Operating time = [Planned Downtime + total working time] (4)

$$\text{Quality rate} = \frac{\text{Production amount} - \text{quality defects}}{\text{Production amount}} \quad (5)$$

OEE = Availability × Performance rate × Quality rate (6)

2.1.7 Phases of TPM Implementation

TPM can be introduced in any organization according to its size, nature, employees, effort, implementation method and management. Based on the implementation requirements, some companies may not implement all TPM pillars, but simply a selection of them.

The tool used in TPM implementation is chosen based on a number of parameters that could produce the desired results. It's crucial to assess overall efficacy before and after TPM implementation to track development. TPM is implemented in five phases, as depicted in Figure 1.

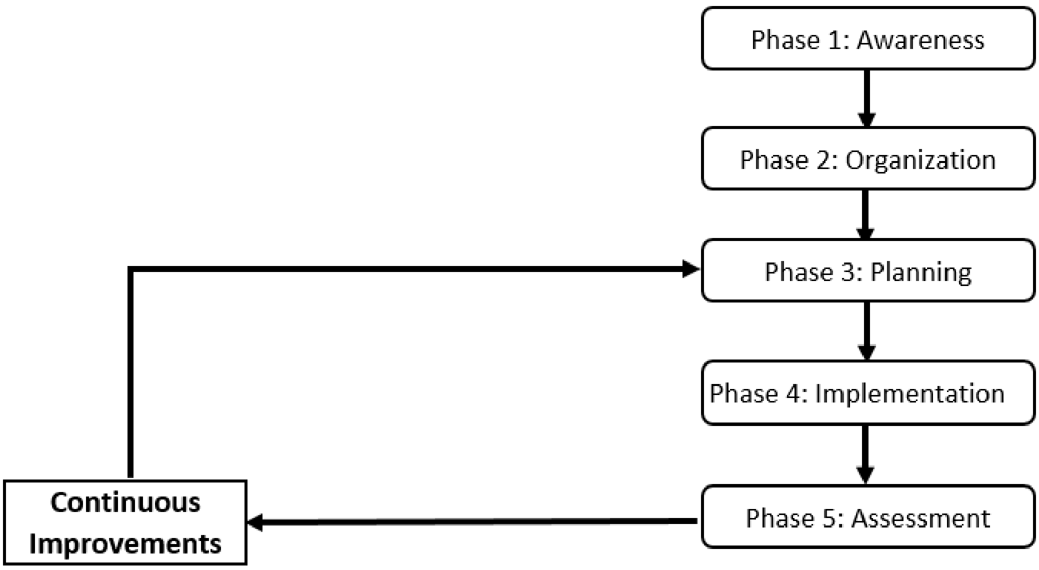

Figure 1: Phases of TPM Implementation

A. Awareness Phase

The goal of the awareness phase is to communicate the TPM approach and the general concepts in order to gain the commitment and support of everyone for good TPM operations. Its goal is to improve machines' understanding and discover previously undiscovered challenges.

The TPM awareness action contains the following activities:

- Things and equipment that are no longer needed are removed.
- Overall cleaning is completed in order to remove dust and dirt.
- Participating in TPM meetings, discussions, and workshops.
- Visits to companies that employ TPM, requesting consultants and TPM experts to present at the facility, and organizing and delivering an in-house introduction training on TPM to the management team.
- Process engineers analyze the current condition of the equipment management system, organize staff conversations to uncover difficulties.

B. Organization Phase

The goal of the organization phase is to create an organizational system that plans, promotes, implements, and supports the strategy at all levels of the company. During this phase, sources of different problems, oil, and dirt are eliminated to give access; areas that are difficult to clean and examine are repositioned or reassembled.

C. Planning Phase

To carry out this phase, the equipment must be in good working order and the operational circumstances must be consistent.

The lifespan of equipment can be reliably predicted, and technicians and operators can schedule routine checks and repairs. This phase starts the process of determining the appropriate type and frequency of inspections and repairs. In companies that implement a preventive maintenance program, decisions are made regularly. Operators should also be informed about the cause-and-effect relation between the process and the quality of the product. The operators can then use on-line tracking of process variables to detect equipment deterioration before it causes product quality issues.

To ensure that the cleaning is completed successfully, this step offers cleaning, oiling, and maintenance standards. The places where lubrication is not effective are explored. The procedure will be saved for auditing purposes, and the situation will be monitored both before and after cleaning.

D. Implementation Phase

TPM council decides to start an implementation process with the TPM pilot team to give the company hands-on experience. This is a single team that is responsible for completing all TPM activities on a single machine in order to improve its performance. The pilot team must figure out how to get things done in their own organization. The following are the primary factors for selecting equipment suitable for the pilot TPM strategy:

- Customers value importance.
- Capacity limitations.
- Great frequency of breakdowns.

The experience acquired from the pilot project can be utilized to improve the planning process and identify the resources needed for TPM employment.

Furthermore, in the pilot project, the proper selection of equipment and team members can result in considerable improvements in equipment quality in a relatively few amount of time. Workers' training and advice in functions that control the equipment will be provided during this phase to ensure that personnel are capable of executing simple maintenance activities and are informed about the machine functions with which they are working.

E. Phase of Evaluation

This phase encompasses the standards and knowledge gained throughout the previous phases of implementation, therefore, it is now time for the operator to begin performing basic maintenance activities and examination autonomously. The assessment system's goals are:

- Evaluate the progress achieved in TPM improvement initiatives by comparing it last data.
- Calculate the organization's TPM maturity level.
- Address areas of weakness and strength in the implementation process.
- Incorporate TPM improvement initiatives into the business plan of the enterprise.

The results of this phase will be compared to those of previous phases, and the TPM strategy's accomplishments will be documented. The TPM approach is based on the concept of "I operate and I fix," as indicated in Figure 2, rather than "I operate and you fix".

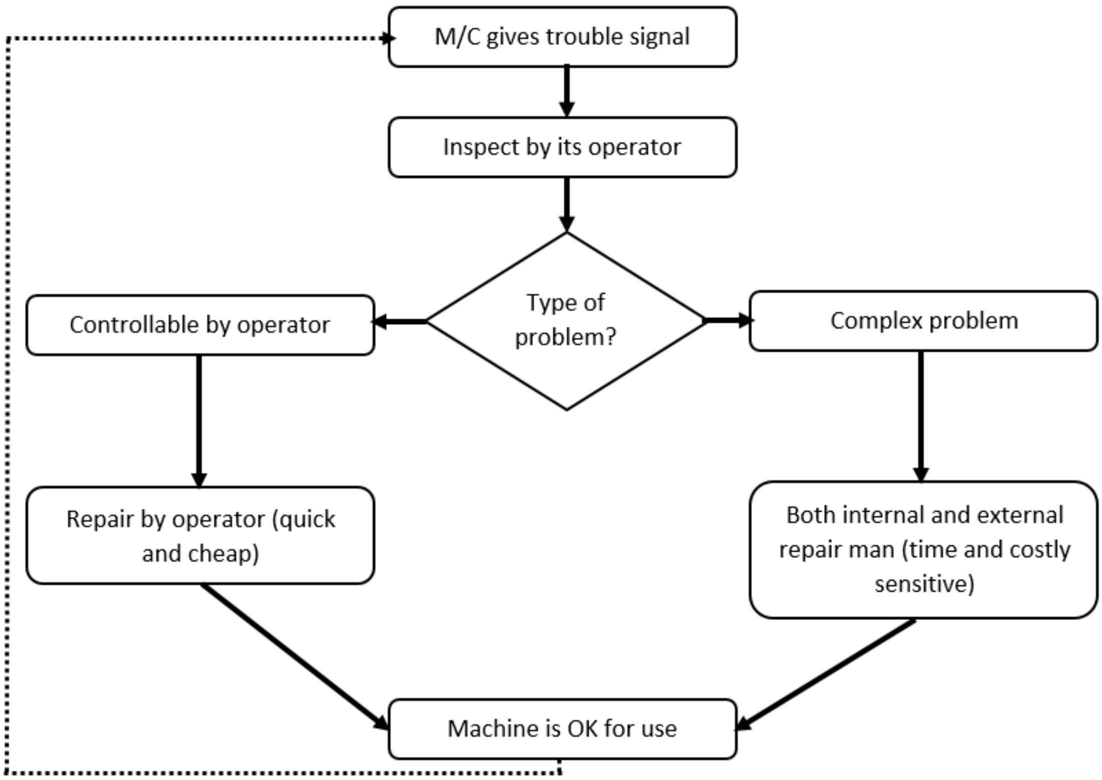

Figure 2: Diagram of "I operate and I fix"

2.1.8 TPM Implementation Challenges and Success Factors

There are many challenges in implementing TPM, one of which is that there is no fast way to do so, and the time between starting to implement TPM and seeing results can range from one to three years according to parameters such as the size of the institution, the type of manufacturing systems, workers, hard work, managerial staff, and the implementation method. Some companies may not be implementing all of TPM's pillars, and the rated tool selected is influenced by a variety of circumstances. TPM implementation challenges include:.

- For some personnel, it's challenging to understand the relationships between the TPM eight pillars.
- There aren't enough resources (time, money, people, etc.) or assistance available.
- Management's support and comprehension of the approach are lacking.
- A lack of adequate training.
- There is a lack of organization and connection to strategic objectives.
- In the TPM team, there is a lack of a suitable combination of skills and knowledge.
- People are typically resistant to change.

Therefore, there are a number of crucial success criteria to consider while implementing TPM, including.

- Financial assistance and leadership.
- Employee education and training.
- Planning for the phases of implementation.
- Rewarding the employees in order to encourage them.
- Partnership and a change in culture.

3. Literature Survey on Some Organizations that have Implemented the TPM Approach

TPM is applicable in many sectors such as the food industry, manufacturing and process industries, environment, health, and other services. In this literature survey, some researchers concentrated on one or more TPM tools while others implemented all of the TPM pillars.

- ❖ During one year of research, **Afeffy I. H.** worked on TPM in the Egyptian Salt company, utilizing the OEE tool for TPM to analyze the existing production efficiency. They stated that the company had a quality rate of 93%, an availability rate of 87%, with a performance efficiency rate of 87.5%.
- ❖ At Borealis Stenungsund, **Boussard P. K. and Safonovs J. Q.** implemented total productive maintenance in the process plant. OEE and SMED are two tools developed as a result of their study to improve visualization and planning. The use of the value stream mapping method resulted in considerable reductions in production downtime, as well as improvements in health, safety, quality, and environment. In the research, CMMS is also used. After implementing TPM, the company has seen a 30% reduction in production downtime during equivalent maintenance activities.

- ❖ In India, **M. Dogra et, al**. implemented the four pillars of TPM in a cold rolling factory. Autonomous Maintenance, Planned Maintenance, Kaizen, and Training and Education are the four pillars used in this TPM implementation. The OEE tool is used to identify bottlenecks in the main equipment. The company obtained an OEE of 83.95% after 18-20 months of implementation. They stated that implementing TPM successfully takes two years or more of effective time. They said that TPM adoption improved communication between departments at all levels, resulting in a rise in employee teamwork spirit and a good organizational environment.
- ❖ **Kocher G. et. al** examined the effect of total productive maintenance activities in India's manufacturing industries. The research is conducted in the case of Leader Valves Ltd. in India. They started the TPM strategy to figure out what elements affect the company's successful implementation. The availability, performance, and quality results obtained during an eight-month period are (95%), (33%), and (99%), respectively, whereas the OEE is 31%. They concluded that performance efficiency is the most important element influencing OEE value.
- ❖ **Kumar P. et. al** conducted an empirical study in Manipal Shivally Industrial Area on high-end printing press machines and packaging machinery used in manufacturing. For four machines across 10 shifts, overall equipment efficiency and total production are calculated. As a result, the average OEE values for these machines were found to range from 15% to 60%, with overall productivity ranging from 9% to 34%. The findings highlight the main reasons for downtime and productivity loss.
- ❖ **Iftekhar A. et. al** applied TPM at a Bangladeshi manufacturing company. Mean Time to Repair (MTTR) and Mean Time Between Failure (MTBF) are two TPM tools that are employed. They likewise utilized maintenance checklists daily, weekly, and monthly. The four pillars that have been implemented are; Planned Maintenance, Kaizen, Autonomous Maintenance, Education, and Training. They observed significant benefits after one year of implementation, including a 50% reduction in time lost, a 13% increase in availability, a reduction in MTTR, and an increase in MTBF period.
- ❖ **Nilmani S. and Sridhar K.** employed Overall Equipment Effectiveness to execute all TPM pillars in a cylinder liner manufacturing firm in India (OEE). After two years of TPM implementation, their OEE results improved from 46% to 61%, and with these findings, they aspire to improve to a world-class OEE level of (85% - 90%) by enhancing equipment availability, enhancing quality and performance rates.
- ❖ **Singh J. et. al** have applied TPM in India's automobile industry. their research used four TPM pillars include planned maintenance, Kaizen, and autonomous maintenance. OEE has been used, and the company's findings revealed (58.7%) value, but after a year of TPM implementation, it demonstrated progress till OEE reached (70%) value. This shows an increase in equipment availability, a reduction in defects and rework, and an improvement in performance rate.
- ❖ **Almeanazel O. T. R** analyzed TPM and assessed the performance of current equipment in a Steel Company in Jordan that uses a continuous production method. OEE was used to evaluate data collected over the course of fifteen working days for two shifts. The company met (55 percent) of its existing OEE, according to the results. After calculating OEE, a set of strategies such as SMED, computer maintenance management system, and production planning were recommended for the industry to increase their maintenance and productivity.
- ❖ In Ethiopia's K. K. Textile Industry P. L. C., **Lemma E.** recommended total productive maintenance. All of TPM's pillars have been applied. The OEE measure is used to assess current equipment efficiency, which is equivalent to 27 %. Breakdown and preventative maintenance are two of the company's current maintenance programs. Visual Basic and Microsoft Access were combined in the software utilized by the researcher. He observed limited progress in the 5S and office TPM pillars after six months of implementation.

Four major points can be derived from prior studies:

- TPM can be used in any industry, regardless of the industry size.
- The overall equipment effectiveness (OEE) is the most often used evaluation technique because it implicitly incorporates quality, performance, and availability.
- Depending on the problem to be solved and the available implementation requirements, only one or more TPM pillars could be implemented. TPM may be reliant on a single evaluation tool.
- TPM success is dependent on the organization's ability to consolidate teamwork. Management, employee awareness training, and operator and maintenance team participation are all major elements in TPM implementation.

Concluding Observations

TPM concepts can be used to achieve fundamental changes in manufacturing performance in an organization, allowing it to compete successfully in a highly competitive market. TPM has the potential to be a successful global strategy for improving company performance in terms of reaching strategic key competencies. Thus, in today's highly competitive environment, TPM may show to be one of the most proactive strategic initiatives that may push firms to greater levels of performance and make the difference between success and failure.

References

[1] E. Nnabuife, O. P. Itua, E. I. Chimezie (2019) "Total Productive Maintenance and Performance of Bottling Company Plants in Edo State", Int. J. Sci. Res. Manag., Vol. 7, No. 12, PP 1449–1458, DOI: **10.18535/ijsrm/v7i12.em03**

[2] F. Khan (2014) "Literature Review on Implementation of TPM," Vol. III, No. IV, PP 144–147

[3] I. Madanhire, K. Mugwindiri, S. Ndlovu, C. Mbohwa (2018) "Adjudging the efficacy of total productive maintenance: Case study", Proc. Int. Conf. Ind. Eng. Oper. Manag., PP 1899–1912

[4] M. S. Islam (2011) "Improvement of Overall Equipment Efficiency (OEE) By Total Productive Maintenance (TPM) - A Case Study"

[5] M. Sahib (2018) "Studying the Requirements of (TPM) Total Productive Maintenance in Production System", Doctoral Diss., University of Technology

[6] D. K. Mukhedkar, V. N. Arts, "A Study of Total Productive Maintenance & its impact on organization's performance for Nashik Zone Industry"

[7] R. Kennedy (2006) "Examining the Processes of RCM and TPM :," Group, no. January, PP 1–15

[8] A. Jain, R. Bhatti, H. Singh (2014) "Total productive maintenance (TPM) implementation practice: a literature review and directions", Vol. 5, No. 3

[9] I. P. S. Ahuja, J. S. Khamba (2008) "Total productive maintenance: Literature review and directions", Int. J. Qual. Reliab. Manag., Vol. 25, No. 7, PP 709–756, DOI: **10.1108/02656710810890890**

[10] N. Prabowo (2010) "5S: workplace organization and standardization", Plant Maint. Resour. Center, http://www.plant-maintenance.com/articles/5S.pdf

[11] R. Tondato, M. B. Gonçalves (2013) "Total Productive Maintenance: A casey study", 22nd Int. Conf. Prod. Res. ICPR 2013, Vol. 12, No. 1

[12] K. E. McKone, R. G. Schroeder, K. O. Cua (2001) "Impact of total productive maintenance practices on manufacturing performance", J. Oper. Manag., Vol. 19, No. 1, PP 39–58, DOI: **10.1016/S0272-6963(00)00030-9**

[13] A. Pandey, S. Malviya, S. Jain (2019) "Implemented the Overall Equipment Effectiveness (OEE) by the techniques of Total Productive Maintenance (TPM) in MSEs - A case study", Int. J. Adv. Res. Ideas Innov. Technol., Vol. 5, No. 1, PP 503–511

[14] D. Ottosson (2009) "The initiation of Total Productive Maintenance to a pilot production line in the German automobile industry", PP 1–41

[15] E. Y. T. Adesta, H. A. Prabowo, D. Agusman (2018) "Evaluating 8 pillars of Total Productive Maintenance (TPM) implementation and their contribution to manufacturing performance", IOP Conf. Ser. Mater. Sci. Eng., Vol. 290, No. 1, DOI: **10.1088/1757-899X/290/1/012024**

[16] R. Singh, A. M. Gohil, D. B. Shah, S. Desai (2013) "Total productive maintenance (TPM) implementation in a machine shop: A case study", Procedia Eng., Vol. 51, No. NUiCONE 2012, PP 592–599, DOI: **10.1016/j.proeng.2013.01.084**

[17] C. K. Jha, A. Singh (2016) "Study of Total Productive Maintenance : A Case Study of OEE Improvement in Automobile Industry, Benefits and Barriers in TPM Implementation", Int. J. Technol. Res. Eng., Vol. 3, No. 9, PP 2400–2406

[18] R. Ranjan, M. Niraj (2018) "Total Productive Maintenance model for effective implementation: Case study of a chemical manufacturing company", Int. J. Mech. Eng. Technol., Vol. 9, No. 2, PP 580–588

[19] Daniel Kiptoo Arusei (2020) "TPM-based Focused Breakdown Reduction Strategy in Industry", Int. J. Eng. Res., Vol. 9, No. 7, PP 828–833, DOI: **10.17577/ijertv9is070317**

[20] T. Djatna, I. M. Alitu (2015) "An Application of Association Rule Mining in Total Productive Maintenance Strategy: An Analysis and Modelling in Wooden Door Manufacturing Industry", Procedia Manuf., Vol. 4, No. IESS, PP 336–343, DOI: **10.1016/j.promfg.2015.11.049**

[21] V. D. Wakchaure, K. N. Nandurkar, S. P. Kallurkar (2010) "Enhancing manufacturing excellence through integrated manufacturing programme", Int. J. Integr. Supply Manag., Vol. 5, No. 4, PP 376–400, DOI: **10.1504/IJISM.2010.035644**

[22] H. M. Lazim, M. N. Salleh, C. Subramaniam, S. N. Othman (2013) "Total Productive Maintenance and Manufacturing Performance: Doeas Technical Complexity in the Production Process Matter?", Int. J. Trade, Econ. Financ., Vol. 4, No. 6, PP 380–383, DOI: **10.7763/ijtef.2013.v4.321**

[23] W. Kam Loi (2001) "Total Productive Maintenance and effectiveness of Occupational Health and Safety Management Systems Declaration of Originality", University of western Sydney In conjunction with the Hong Kong polytechnic University, Australia

[24] M. Madewell (1998) "Total productive maintenance," SAE Tech. Pap., DOI: **10.4271/982092**

[25] J. P. Acharya, M. J. Bhatt (2014) "A Brief Literature Review on Total P roductive Maintenance A Positive Approach to Solve manufacturing Problem", International Journal of Advance Engineering and Research Development, Vol. 1, No. 5, PP 1–8

[26] T. P. Maintenance, "The TPM Guide"

[27] M. K. S. Sr, (2008) "Total Productive"

[28] Afefy I. H. (2013) "Implementation of total productive maintenance and overall equipment effectiveness evaluation", International Journal of Mechanical and Mechatronics Engineering, Vol. 13, No. 1, PP 69–75

[29] J. Boussard P. K., Safonovs J. Q. (2014) "The introduction of TPM at Borealis Stenungsund", MSc. Thesis, Chalmers University of Technology, Goteborg, Sweden

[30] Dogra M., Sharma V. S., Sachdeva A., Dureja J. S. (2011) "TPM: A Key Strategy for Productivity Improvement in Process Industry", Journal of Engineering Science and Technology, Vol. 6, No. 1, PP 1–16

[31] Kocher G., Kumar R., Singh A., Dhillon S. S. (2012) "An Approach for Total Productive Maintenance and Factors Affecting its Implementation in Manufacturing Environment", International Journal on Emerging Technologies, Vol. 3, No. 1, PP 41–47

[32] Kumar P., Varambally K. V. M., Rodrigues L. L. (2012) "A Methodology For Implementing Total Productive Maintenance In Manufacturing Industries – A Case Study", International Journal of Engineering Research and Development, Vol. 5, No.

2, PP 32–39

[33] Iftekhar A., Sazedul K., Md. Mosharraf H., (2012) “Effective Implementation of Total Productive Maintenance and Its Impacts on Breakdown, Repair and Setup Time”, Proceedings of the Global Engineering, Science and Technology Conference, Dhaka, Bangladesh

[34] Nilmani S., Sridhar K. (2013) “Methodology of Evaluating the Overall Equipment Effectiveness in a Cylinder Liner Manufacturing Firm Through Total Productive Maintenance”, International Journal of Industrial Engineering & Technology (IJIET), Vol. 3, Issue 3, PP 1–10

[35] Singh J., Rastogi V., Sharma R. (2013) “Total Productive Maintenance Review: A Case Study in Automobile Manufacturing Industry”, International Journal of Current Engineering and Technology, Vol. 3, No. 5, ISSN 2277-4106

[36] Almeanazel O. T. R. (2010) “Total Productive Maintenance Review and Overall Equipment Effectiveness Measurement”, Jordan Journal of Mechanical and Industrial Engineering, Vol. 4, No. 4, PP 517–522

[37] Lemma E. (2008) “Implementation of TPM (Total Productive Maintenance) in Ethiopian Textile Industries”, MSc. Thesis, Addis Ababa University, Ethiopia