Project Dissertation Report on

"Total Productive Maintenance Overview"

Submitted by:

Harsh Kumar
2K22/EMBA/10

Under the Guidance of: -

Mr. Yashdeep Singh

DELHI SCHOOL OF MANAGEMENT

Delhi Technological University

Bawana Road Delhi 110042

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CERTIFICATE

This is to certify that Harsh Kumar 2K22/EMBA/10 has submitted the project report titled "Total Productive Maintenance Overview" in partial fulfillment of the requirements for the award of the degree of Master of Business Administration (MBA) from Delhi School of Management, Delhi Technological University, New Delhi during the academic year 2023-24.

Mentors name and signature

Mr. Yashdeep Singh

Assistant Professor

Delhi School of Management (DSM)

Delhi Technological University

DECLARATION

I, **Harsh Kumar** student MBA Executive Delhi School of Management, Delhi Technological University, Bawana Road, Delhi-42 hereby declare that the Project Report on " Total Productive Maintenance Overview" has been result of my own work.

I declare that this submitted work is done solely by me and to the best of my knowledge.

I also declare that all the information collected from various secondary sources has been duly acknowledged in this project report.

PLACE: New Delhi **Harsh Kumar**

DATE: 02/05/2024 **2K22/EMBA/10**

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I am extremely grateful to **Mr. Yashdeep Singh,** for his invaluable help and guidance throughout my work. He kindly evinced keen interest in my work and furnished some useful comments, which could enrich the work substantially.

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Harsh Kumar
2K22/EMBA/10

Executive summary

This study invaginates the influence of skills on various factors contributing to the effectiveness of Total Productive Maintenance (TPM). TPM is a methodology to equipment maintenance that aims to achieve zero breakdown, zero accident & zero defect. The research focuses on understanding how the skills of maintenance personnel impact specific aspects of TPM implementation.

The study employs a heterogeneous approach, for combining quantitative analysis and qualitative insights gathered from industry thinktanks. Surveys are used to assess the skill levels of maintenance personnel, while in-depth interviews provide qualitative data on their experiences and perceptions. The selected factors under investigation include equipment reliability. overall equipment effectiveness (OEE), cost efficiency, and employee satisfaction.

Preliminary findings suggest a strong correlation between the proficiency of maintenance personnel and the success of TPM initiatives. Highly skilled individuals demonstrate a positive impact on equipment reliability, leading to improved OEE. Furthermore, effective skill development programs contribute to cost savings through optimized maintenance practices.

Employee satisfaction is also positively influenced by enhanced skills, as employees feel more confident and capable in their roles.

This research contributes to the existing body of knowledge by highlighting the critical role of skills in TPM effectiveness. The outcomes of this study have practical implications for organizations seeking to enhance their maintenance strategies, emphasizing the importance of investing in skill development programs for maintenance personnel.

Objective:

This concept focused to evaluate the skills of key factors affecting the effectiveness of TPM. TPM is a dynamic approach for equipment maintenance to emphasizes involvement of all employees to achieve optimal equipment performance. The focus of this research was on understanding how the skills of the workforce contribute to the success of TPM implementation.

Methodology: The concept employed a heterogeneous approach, combining quantitative analysis % and qualitative insights. Surveys were distributed to employees involved in TPM

activities, and in-depth discussions were conducted with key owners. The selected factors under examination included equipment downtime, overall equipment efficiency (OEE), and employee engagement.

Key Findings:

1. Skills and Training: There is a direct relation with the level of skills possessed by the workforce and the effectiveness of TPM. Well-trained employees demonstrated a higher ability to identify and address equipment issues promptly, resulting in reduced downtime.
2. Employee Engagement: The study found that employee engagement plays a crucial role in TPM success. Skilled employees were more likely to actively participate in maintenance activities, fostering a culture of continuous improvement and collaboration.
3. Overall Equipment Efficiency (OEE): A positive relationship was identified between workforce skills and OEE. Skilled employees were better equipped to maximize equipment output, contributing to improved overall productivity.
4. Challenges: Despite the positive impact of skills, challenges such as a lack of continuous training programs and limited resources were identified as potential barriers to achieving optimal TPM effectiveness.

Recommendations:

Based on the observations, the recommendations are suggested to enhance the impact of skills on TPM effectiveness:

a. Implement Regular Training Programs: Establish a structured and ongoing training program to enhance the skills of the workforce in line with evolving maintenance requirements.

b. Foster a Culture of Continuous Improvement: Encourage a proactive approach to problem-solving and continuous improvement, emphasizing employee involvement and engagement in TPM activities.

c. Allocate Sufficient Resources: Ensure that the organization allocates adequate resources, both in terms of time and budget, to support skill development initiatives and TPM implementation.

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CHAPTER 1

INTRODUCTION

1.1 Introduction

In today's dynamic industrial landscape, the pursuit of operational excellence is a paramount objective for organizations aiming to maximize efficiency, minimize downtime, and achieve sustainable competitive advantages. At the heart of this quest lies the methodology of TPM, a stimulated approach that transcends traditional repair practices for fostering a culture of continuous improvement and reliability within manufacturing and production systems.

TPM originated in Japan and gained prominence as key component for the lean manufacturing philosophy. It represents the holistic approach for equipment management that extends beyond routine maintenance tasks. TPM is grounded in the philosophy that every individual within an organization plays an important role for ensuring optimal machines functioning, with ultimate achieving goal overall equipment effectiveness (OEE).

The core tenets of TPM involve fostering a sense of ownership and responsibility for equipment among all personnel, from the shop floor to the executive suite. It seeks to eliminate the traditional divide between production and maintenance functions, promoting a collaborative and cross-functional approach to ensure equipment reliability. The pillars of TPM include proactive and preventive maintenance, autonomous maintenance by operators, effective skills development, and a relentless pursuit of continuous improvement.

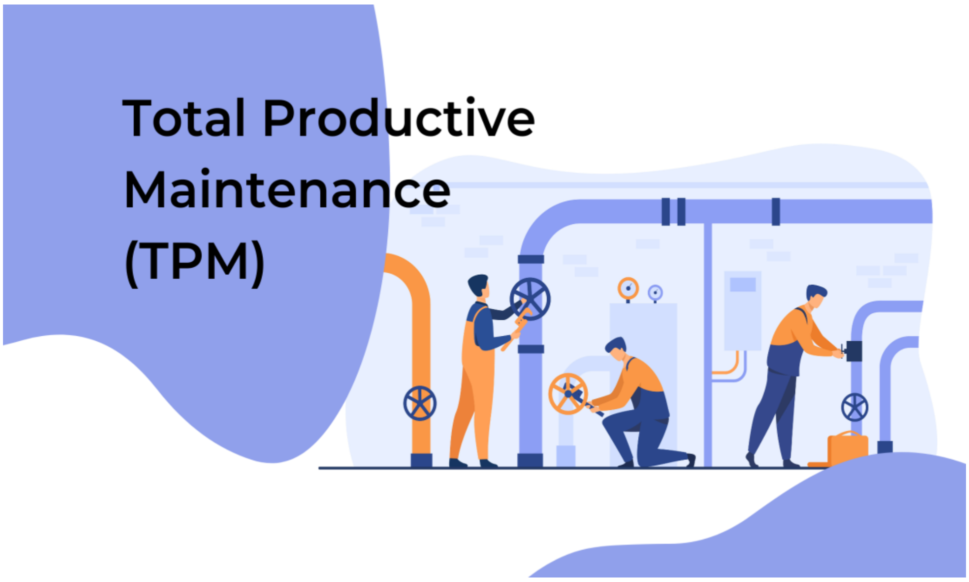


Figure 1 TPM

One important TPM feature is its emphasis on addressing the 6 major losses in manufacturing: equipment down, setup adjustment time, equipment idle and minor stoppages, slow speed, not good product in production, yield loss. By systematically tackling these losses, TPM strives to achieve higher levels of OEE, which is a key performance indicator encompassing availability, performance efficiency, and quality.

As industries worldwide increasingly embrace TPM as a fundamental strategy for optimizing asset performance, it becomes imperative to delve deeper into the various factors that influence the effectiveness of TPM implementation. Among these factors, the skills and competencies of the workforce emerge as critical determinants, playing a pivotal role in the success of TPM initiatives.

This approach aims for assess on the impact of skills on selected factors of TPM effectiveness, recognizing the symbiotic relationship between the proficiency of personnel and the overall success of TPM strategies. By scrutinizing the interplay between skills development and key TPM performance indicators, it seeks to give valuable insights which can inform best practices in workforce training and development, ultimately contributing to the advancement of TPM in contemporary industrial environments.

1.2 Define the key terms and concepts:

Skills:

Skills refer to the abilities, knowledge, and expertise possessed by individuals that enable them to perform tasks, solve problems, and achieve specific objectives. In the context of Total Productive Maintenance (TPM), skills may encompass technical proficiencies, problem-solving capabilities, communication skills, and other competencies relevant to the effective operation and maintenance of equipment.

Total Productive Maintenance (TPM):

TPM is a comprehensive maintenance philosophy and strategy originated in Japan. TPM target to optimize the operational productivity of any equipment by involving whole organization in the equipment repair process. It focuses on proactive and preventive maintenance, employee empowerment, and continuous improvement to eliminate losses and enhance overall equipment effectiveness (OEE).

TPM Effectiveness:

TPM effectiveness refers to the degree to which Total Productive Maintenance strategies and practices achieve their intended goals. It involves assessing the positive results of TPM on major performance indicators such as OEE, reduced downtime, increased productivity, improved quality of product on global benchmarks.

TPM Factors:

TPM factors are the key components or elements that contribute to the success and effectiveness of Total Productive Maintenance. These factors can include, but are not limited to, autonomous maintenance, planned maintenance, focused improvement, skills development, early equipment management, and safety, among others. Each factor plays a specific role in achieving the overarching objectives of TPM.

These definitions provide a foundational understanding of the key terms and concepts related to the assessment of the impact of skills on selected factors of Total Productive Maintenance effectiveness. It's essential to refer to authoritative sources and scholarly literature to ensure accuracy and depth in understanding these concepts within the specific context of your research.

1.3 Background

The effective functioning of industrial machinery and equipment is crucial for achieving optimal production output, minimizing downtime, and ensuring overall operational efficiency. In pursuit of these objectives, Total Productive Maintenance (TPM) has emerged as a holistic and proactive approach to maintenance management. Rooted in the principles of continuous improvement and employee involvement, TPM aims to maximize the performance and reliability of production assets.

Total Productive Maintenance (TPM) has emerged as a transformative paradigm in the realm of industrial maintenance, challenging conventional practices and promoting a holistic approach to ensure the optimal performance of production equipment. Originating in Japan and gaining prominence in the latter half of the 20th century, TPM represents a departure from traditional reactive maintenance models by emphasizing proactive, preventive, and collaborative strategies.

At its core, TPM seeks to engage the entire organizational hierarchy, instilling a sense of shared responsibility for equipment maintenance. The philosophy rests on the belief that by involving every employee, from frontline operators to upper management, organizations can achieve higher levels of overall equipment effectiveness (OEE) and minimize losses associated with equipment breakdowns, setup times, and other inefficiencies.

The pillars of TPM serve as the foundational principles guiding its implementation. Autonomous Maintenance empowers operators to take charge of routine maintenance tasks, Planned Maintenance introduces scheduled and systematic approaches to minimize unplanned downtime, and Focused Improvement (Kaizen) fosters a culture of continuous improvement through small, incremental changes.

As industries evolve, the role of skills in TPM effectiveness has garnered increased attention. Technical proficiency, problem-solving abilities, and a commitment to ongoing education are now recognized as essential components for successful TPM implementation. Organizations are acknowledging that the effectiveness of autonomous maintenance, planned maintenance, and continuous improvement initiatives is intricately tied to the skills and competencies of their workforce.

Despite the proven benefits of TPM, challenges persist in its adoption. Resistance to change, a lack of understanding or commitment at various organizational levels, and the need for a cultural shift towards proactive maintenance practices are common hurdles. This underscores the importance of not only robust TPM frameworks but also a workforce equipped with the requisite skills to navigate the complexities of modern industrial environments.

Considering these considerations, assessing the impact of skills on selected factors of TPM effectiveness becomes a crucial endeavor. The objective is to unravel the intricate relationship between skills and key performance indicators such as OEE, mean time between failures (MTBF), and mean time to repair (MTTR). This assessment aims to provide actionable insights, guiding organizations in tailoring training programs, fostering a culture of continuous improvement, and addressing skill-related challenges to unlock the full potential of TPM in optimizing maintenance practices. In the dynamic landscape of industrial operations, this exploration of skills within the context of TPM stands as a cornerstone for achieving sustained operational excellence.

Overview of Total Productive Maintenance (TPM):

Total Productive Maintenance (TPM) is a comprehensive approach to maintenance management that goes beyond traditional practices by involving all employees in the organization. It aims to maximize the effectiveness of equipment, eliminate breakdowns, and enhance overall operational efficiency. TPM originated in Japan and is often associated with the manufacturing industry, particularly in the automotive sector.

Key Principles of TPM:

Focused on Employee Involvement: TPM emphasizes the active involvement of all employees, fostering a sense of ownership and responsibility for equipment maintenance.

Preventive and Predictive Maintenance: TPM advocates for proactive maintenance strategies, including preventive and predictive maintenance, to prevent equipment failures and reduce unplanned downtime.

The Four Pillars of TPM:

JH (Jishu Hozen - Autonomous Maintenance):

Jishu Hozen involves empowering equipment operators to take responsibility for routine maintenance tasks on their machines. Operators are trained to conduct inspections, clean equipment, and address minor issues. The goal is to develop a sense of ownership among operators, reduce the likelihood of breakdowns, and create a proactive culture of self-maintenance on the shop floor.

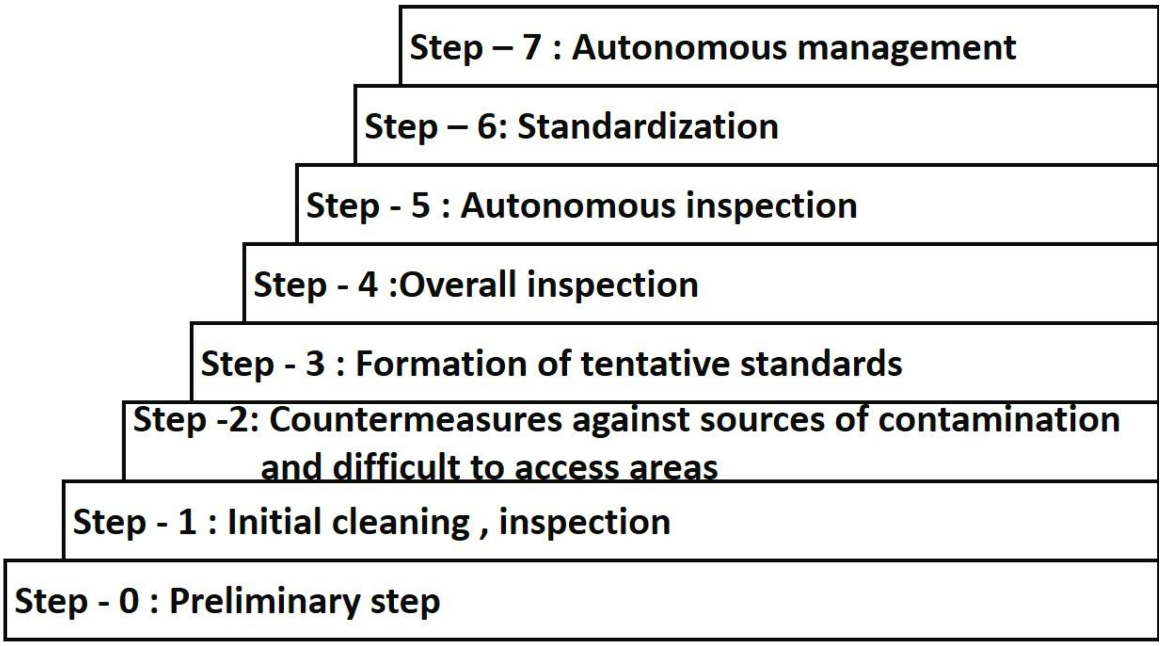


Figure 2 JH (Jishu Hozen - Autonomous Maintenance)

KK (Kobetsu Kaizen - Planned Maintenance):

Focuses on detailed, scheduled maintenance activities to ensure optimal equipment performance and longevity.

KK (Kobetsu Kaizen) is a pillar of Total Productive Maintenance (TPM) that focuses on eliminating the losses that affect the overall equipment effectiveness (OEE) and the transformation cost. There are 16 major losses that are classified into four categories: availability, performance, quality, and others.

Here is a table that summarizes the definition of each loss and its category:

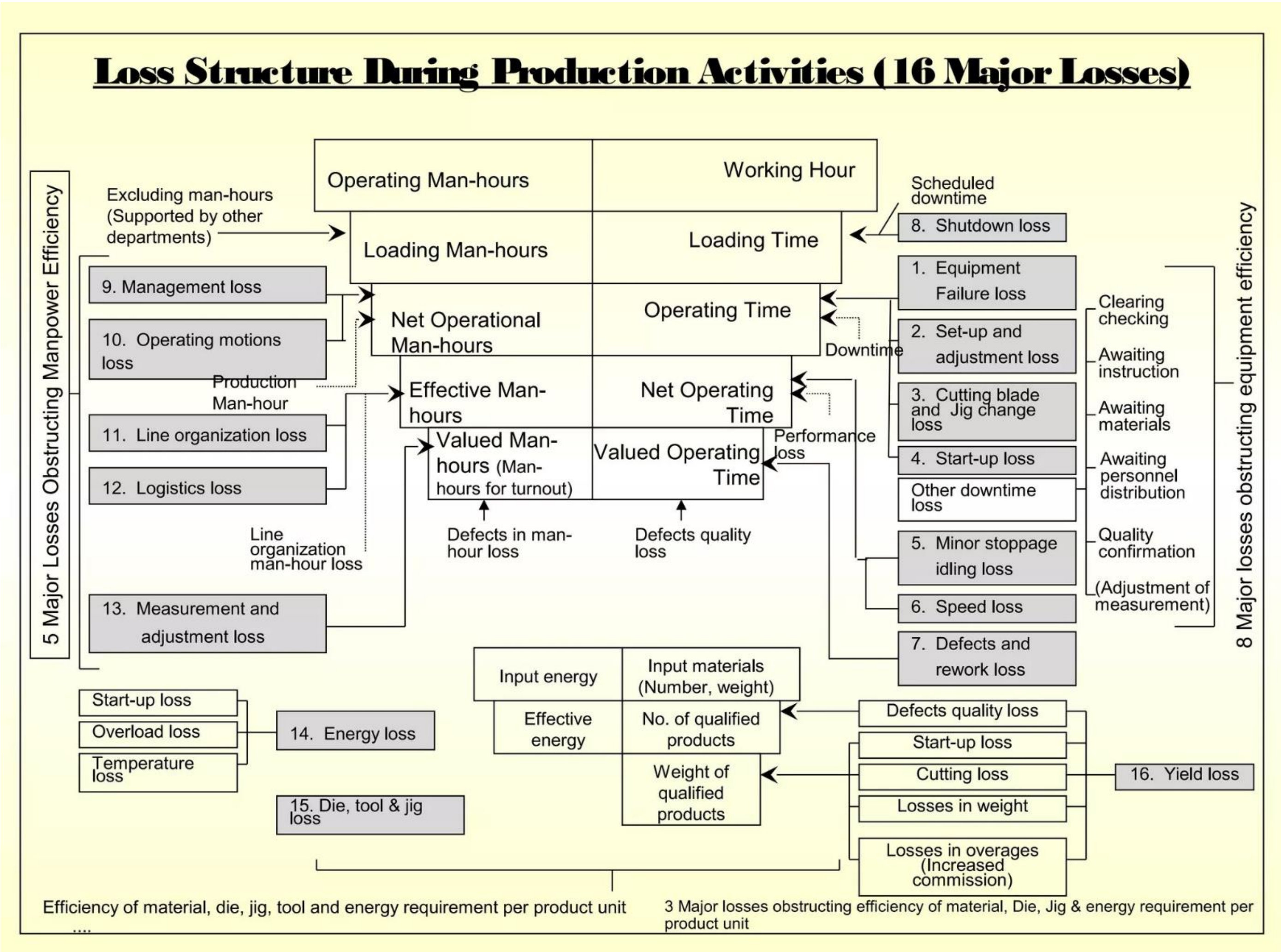


Figure 16 types of loss definition

PM (Planned Maintenance):

Targets systematic planning and scheduling of maintenance activities, optimizing resources and minimizing downtime. Planned Maintenance is a broader pillar that encompasses systematic planning and scheduling of all maintenance activities within the organization. It goes beyond equipment-specific planning (KK) to include a comprehensive approach to managing all maintenance tasks. The emphasis is on optimizing resources, preventing unplanned downtime, and ensuring that maintenance activities align with overall organizational goals.

QM (Quality Maintenance):

Integrates quality control into the maintenance process to prevent defects and ensure that equipment operates at peak performance. Quality Maintenance integrates quality control principles into the maintenance process. This pillar emphasizes preventing defects and ensuring that equipment operates at peak performance to produce high-quality products. QM involves the incorporation of quality checks and measures into routine maintenance tasks, minimizing variations in equipment performance that could impact product quality.

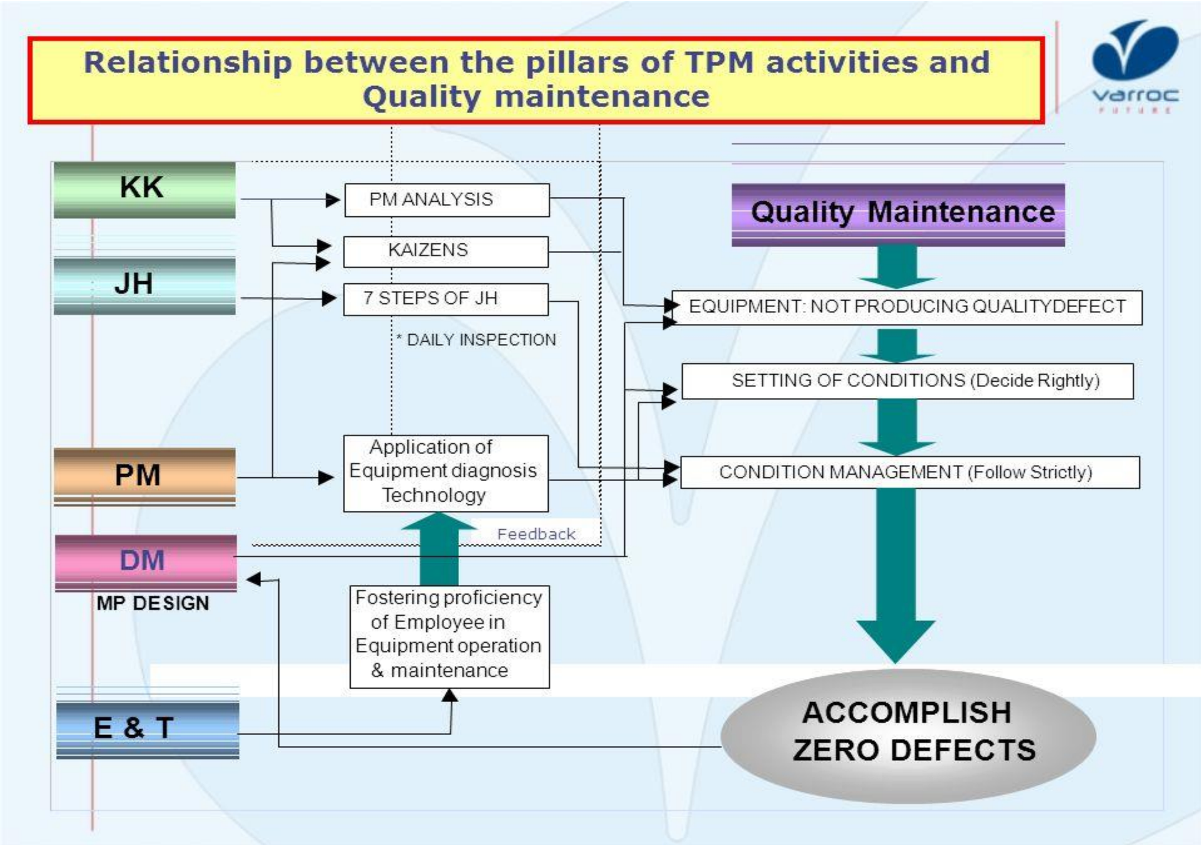


Figure 3 QM (Quality Maintenance)

Benefits of Implementing TPM:

Increased Equipment Reliability: TPM reduces breakdowns, leading to increased equipment reliability and availability.

Enhanced Productivity: Improved efficiency and reduced downtime contribute to higher overall productivity.

Cost Savings: Preventive maintenance and reduced breakdowns result in cost savings associated with repairs and emergency maintenance.

Employee Engagement: TPM fosters a sense of responsibility among employees, enhancing teamwork and collaboration.

Kick-off Strategy for Implementing TPM in Company:

Assessment and Awareness: A comprehensive evaluation of existing maintenance procedures should be executed, and staff members need to be educated on the advantages of TPM.

Training and Skill Development: Provide training sessions to employees on TPM principles and the specific requirements of each pillar. Focus on developing the necessary skills for successful implementation.

Pilot Project: Begin with a pilot project to implement one or two pillars initially. This allows for testing and refining the approach before full-scale implementation.

Continuous Improvement: Emphasize the culture of continuous improvement. Regularly review and assess the effectiveness of TPM implementation, adjusting as needed.

Communication and Feedback: Create transparent communication avenues for collecting input from employees, motivating them to express perspectives, difficulties, and accomplishments.

Recognition and Rewards: Acknowledge and reward employees for their contributions to the success of TPM implementation. Recognition boosts morale and motivates further engagement.

By adopting a systematic and phased approach, your company can successfully kick off the implementation of TPM, laying the foundation for improved equipment performance and operational excellence.

1.4 Evolution of Total Productive Maintenance (TPM):

TPM originated in Japan and evolved as a key component of the Toyota Production System, gaining prominence in the latter half of the 20th century. The philosophy of TPM shifted the paradigm from traditional reactive maintenance practices, which addressed issues only when they arose, to a more proactive and preventive approach. The core philosophy is based on the belief that everyone in the organization, from the shop floor to top management, has a role to play in equipment maintenance.

Pillars of TPM:

The success of TPM relies on a set of foundational pillars, each addressing specific aspects of maintenance and production. These pillars include:

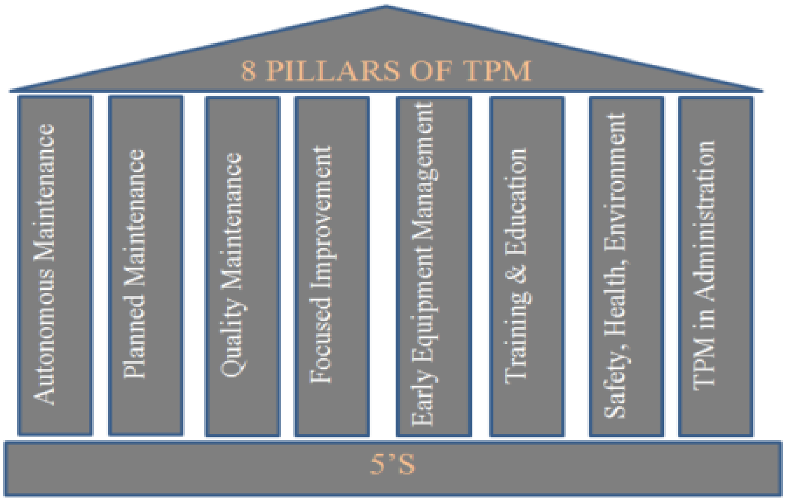


Figure 4 TPM Pillars

The 8 Pillars of Total Productive Maintenance are specific elements within the broader framework of Total Quality Management that focus on optimizing equipment effectiveness and overall organizational efficiency. Here's an explanation of each pillar:

Autonomous Maintenance:

This pillar emphasizes empowering equipment operators to assume responsibility for the task of routine repair tasks. Operators are well trained to conduct basic maintenance activities, inspect equipment, and address minor issues. The goal is to enhance equipment reliability, prevent breakdowns, and foster a culture of self-maintenance.

Planned Maintenance:

Planned Maintenance involves systematic, scheduled maintenance activities aimed at ensuring optimal equipment performance. This pillar focuses on reducing unplanned downtime by proactively addressing potential issues. It includes routine inspections, lubrication, and other planned maintenance tasks to keep equipment in peak condition.

Quality Maintenance:

Quality Maintenance integrates quality control principles into the maintenance process. The focus is on preventing defects and ensuring that equipment operates at the highest quality standards. This pillar aims to minimize variations in equipment performance that could lead to quality issues in the final product.

Focused Improvement (Kaizen):

Focused Improvement, often referred to as Kaizen, involves continuous improvement efforts within the organization. This pillar encourages employees at all levels to identify and implement small, incremental improvements in processes, equipment, and workflows. The goal is to create a culture of continuous learning and enhancement.

Early Equipment Management:

The Early Equipment Management approach concentrates on guaranteeing that new machinery is crafted, installed, and operated with an emphasis on dependability and effectiveness. This pillar aims to address potential issues early in the equipment lifecycle, reducing the likelihood of defects and optimizing performance from the outset.

Education and Training:

Education and Training are essential pillars to build the skills and knowledge of employees. This includes providing training on maintenance techniques, equipment operation, and the principles of TPM. Well-trained employees are better equipped to contribute to the success of TPM initiatives.

Safety, Health, and Environment:

This pillar recognizes the importance of Incorporating safety, health, and blend environmental considerations into maintenance procedures. It emphasizes creating a safe working environment, ensuring the well-being of employees, and minimizing the environmental impact of maintenance activities.

TPM in Administration:

TPM in Administration extends TPM principles beyond the shop floor to administrative functions. This pillar focuses on optimizing administrative processes, reducing paperwork, and improving communication and coordination within the organization.

Each of these pillars plays a main important role in the holistic TPM implementation, contributing to increased equipment reliability, enhanced quality, and overall operational excellence within an organization.

1.5 Challenges in TPM Implementation:

Implementing Total Productive Maintenance (TPM) represents a paradigm shift for organizations aspiring to optimize their maintenance practices and elevate operational efficiency. While TPM offers a wealth of benefits, the journey toward its successful implementation is fraught with several challenges that organizations must navigate.

One of the primary impediments is the inherent resistance to change. Employees and management, accustomed to traditional reactive maintenance models, may find it challenging to embrace the proactive and collaborative principles espoused by TPM. Overcoming this resistance is essential for cultivating a culture that values preventive maintenance and continuous improvement.

A lack of understanding and awareness at various organizational levels poses another significant challenge. TPM involves a holistic approach that requires a deep comprehension of its principles and methodologies. In instances where stakeholders lack comprehensive knowledge, the commitment to TPM may falter, limiting its potential impact.

Achieving a cultural shift toward a proactive maintenance mindset is a formidable task. In organizations entrenched in reactive practices, ingrained habits and established norms may resist transformation. Successfully instigating a cultural change requires concerted efforts in education, communication, and fostering a shared commitment to TPM principles.

Figure 5 The Challenges of Implementing TPM

Resource constraints, both in terms of finances and manpower, can impede the smooth execution of TPM activities. Adequate resources are essential for training, implementing new maintenance practices, and addressing unforeseen challenges. Limited resources may slow down the implementation process or compromise the quality of TPM initiatives.

The level of management commitment is crucial to the success of TPM. Without strong leadership support, the prioritization of TPM as a strategic initiative may be lacking. Leadership involvement is vital for driving cultural change, securing necessary resources, and maintaining momentum throughout the implementation process.

Inadequate training and skills development represent a pivotal challenge. TPM success hinges on the competence of the workforce, and without targeted training programs, employees may lack the necessary skills for effective TPM implementation. Addressing this challenge involves investing in comprehensive training initiatives that align with TPM principles.

Measuring and demonstrating tangible results poses another hurdle. Quantifying the financial benefits of TPM can be challenging, particularly when the impact is felt across various aspects of production. Establishing clear metrics and effectively communicating the benefits is crucial for sustaining enthusiasm and garnering ongoing support.

Integration challenges with existing systems can disrupt workflow and hinder the seamless adoption of TPM practices. Harmonizing TPM with established production and maintenance systems requires careful planning and coordination to avoid disruptions and ensure a smooth transition.

The sustainability of TPM practices is an ongoing challenge. Continuous improvement is integral to TPM, and maintaining momentum over the long term demands persistent commitment and vigilance. Organizations must embed TPM principles into their DNA to ensure sustained success.

Lastly, in industries with complex production processes, adapting TPM to fit specific operational intricacies can be particularly challenging. Tailoring TPM to suit the unique needs of the organization requires a nuanced understanding of the complexities involved and a strategic approach to customization.

In overcoming these challenges, organizations can position themselves for the full realization of TPM's potential, fostering a continuous improvement culture and achieving sustained operational excellence.

1.6 The Role of Skills in TPM Effectiveness:

The successful implementation of Total Productive Maintenance is intricately tied with the skills and workforce competencies. The role of skills in TPM effectiveness is multifaceted, influencing various aspects of the maintenance process and overall operational success. Here, we delve into the key dimensions of how skills contribute to TPM effectiveness:

Technical Proficiency:

Description: Fundamental technical skills are the bedrock of effective TPM. This includes the ability to operate and maintain machinery, conduct routine inspections, and troubleshoot basic issues.

Impact: Skilled technicians can execute tasks with precision, minimizing the risk of errors and contributing to the reliability and longevity of equipment.

Problem-Solving Abilities:

Description: TPM encourages a proactive approach to problem-solving. Individuals with very strong analytical and problem- solving skills can identify probable root causes of issues, implement corrective actions, and prevent recurring problems.

Impact: Efficient problem-solving contributes to reduced downtime, improved overall equipment effectiveness (OEE), and a more streamlined maintenance process.

Autonomous Maintenance Skills:

Description: Jishu Hozen involves operators to take on routine maintenance jobs. Skills in equipment inspection, lubrication, and minor adjustments are essential.

Impact: Well-trained operators can contribute Promoting the early identification of potential problems, averting breakdowns, or nurturing a collective sense of responsibility for equipment maintenance.

Precision in Planned Maintenance:

Description: Planned Maintenance activities require meticulous execution according to established schedules. Technical skills, attention to detail, and adherence to procedures are crucial.

Impact: Precise execution of planned maintenance ensures that equipment is consistently maintained at optimal levels, minimizing the likelihood of unplanned downtime.

Adaptability to Evolving Technologies:

Description: As technology evolves, individuals with the ability to adapt to new tools, software, and equipment are essential for successful TPM.

Impact: Adaptable skills ensure that the workforce remains current with technological advancements, maximizing the benefits of innovations in maintenance practices.

Collaboration and Communication Skills:

Description: TPM emphasizes collaboration across departments and effective communication. Strong interpersonal skills are essential for cross-functional teamwork.

Impact: Clear communication facilitates the sharing of insights, accelerates problem-solving, and ensures that everyone in the organization is aligned with TPM goals.

Continuous Learning and Training:

Description: TPM is a dynamic approach that requires a commitment to continuous learning. Training programs that keep the workforce updated on TPM principles and practices are vital.

Impact: A culture of continuous learning ensures that skills remain relevant, and that the workforce is equipped to adapt to changing maintenance requirements.

Leadership Skills:

Description: Effective TPM implementation requires leadership at all levels. Leadership skills, including the ability to motivate, inspire, and lead by example, are critical.

Impact: Strong leadership fosters a culture of TPM, secures organizational commitment, and ensures that the principles of TPM are embedded in day-to-day operations.

Analytical Skills for KPIs:

Description: TPM success is often measured through key performance indicators (KPIs) such as OEE, MTBF, and MTTR. Analytical skills are essential for interpreting and utilizing these metrics effectively.

Impact: The ability to analyze KPIs allows for informed decision-making, targeted improvements, and a more strategic approach to TPM implementation.

Proactive and Innovative Thinking:

Description: TPM encourages a proactive and innovative mindset. Skills in foreseeing potential issues, proposing improvements, and thinking creatively contribute to a culture of continuous improvement.

Impact: Proactive and innovative thinking drives the evolution of TPM practices, ensuring that the organization stays ahead of challenges and continuously enhances its maintenance processes.

In summary, the role of skills in TPM effectiveness is pivotal. A skilled workforce not only ensures the efficient execution of maintenance tasks but also contributes to a proactive and collaborative culture essential for the sustained success of TPM initiatives. Skills development, continuous training, and the cultivation of a learning-oriented environment are essential elements in unlocking the full potential of TPM in optimizing maintenance practices and achieving operational excellence.

1.7 The Significance of Total Productive Maintenance (TPM):

Total Productive Maintenance (TPM) holds paramount significance in the domain of industrial management, playing a pivotal role in enhancing operational efficiency and fostering a culture of continuous improvement. TPM goes beyond traditional maintenance practices, emphasizing a holistic and proactive approach. The significance of TPM can be discerned through several key dimensions:

Operational Excellence:

TPM's primary goal is to optimize the efficiency of production equipment. By minimizing downtime, reducing breakdowns, and enhancing overall equipment effectiveness (OEE), TPM contributes to operational excellence, ensuring a smooth and efficient production process.

Proactive Maintenance Culture:

TPM represents a shift from reactive to proactive maintenance strategies. By focusing on preventive measures, scheduled maintenance, and autonomous activities, TPM minimizes the occurrence of unplanned downtime, reducing disruptions to production schedules.

Employee Engagement and Ownership:

TPM engages the entire workforce in the maintenance process, fostering a sense of ownership and responsibility for equipment care. This active involvement empowers employees at all levels, cultivating a collaborative environment and a shared commitment to operational success.

Addressing Losses Systematically:

TPM strategically addresses the "Six Big Losses" in production, which include breakdowns, setup and adjustment time, idling and minor stops, reduced speed, defects, and start-up losses. Through the mitigation of these losses, TPM enhances efficiency and resource utilization, fostering an unpublished approach.

Autonomous Maintenance Empowerment:

The emphasis on autonomous maintenance empowers operators to take on routine tasks, promoting a sense of pride and accountability. This not only improves equipment reliability but also instills a proactive mindset throughout the organization.

Planned Maintenance for Predictability:

TPM introduces planned maintenance activities, ensuring that maintenance tasks are conducted systematically. This planned approach enhances predictability, allowing organizations to schedule maintenance during planned downtime, minimizing disruptions.

Continuous Improvement Philosophy (Kaizen):

TPM aligns with the philosophy of continuous improvement, encouraging small, incremental changes in processes. This commitment to Kaizen ensures that organizations evolve, adapt to changing conditions, and continuously refine their operational practices.

Enhanced Equipment Reliability and Lifespan:

Through preventive maintenance, quality management, and early equipment management, TPM enhances the reliability and lifespan of production equipment. This not only reduces the risk of unexpected failures but also contributes to sustained product quality.

Alignment with Lean Principles:

TPM closely aligns with lean manufacturing principles, emphasizing the elimination of waste and the efficient use of resources. This alignment results in streamlined processes, reduced lead times, and an overall improvement in operational efficiency.

Safety and Positive Work Environment:

TPM places a strong emphasis on safety, creating a work environment that encourages safe practices. A safer work environment not only protects employees but also contributes to stable operations and reduces disruptions due to accidents.

In summary, the significance of Total Productive Maintenance lies in its capacity to revolutionize maintenance practices, instill a proactive mindset, and create a workplace culture committed to continuous improvement. TPM stands as a fundamental strategy for organizations aspiring to achieve operational excellence and sustained competitiveness in the dynamic landscape of industrial operations.

1.8 The Role of Skills in TPM Implementation:

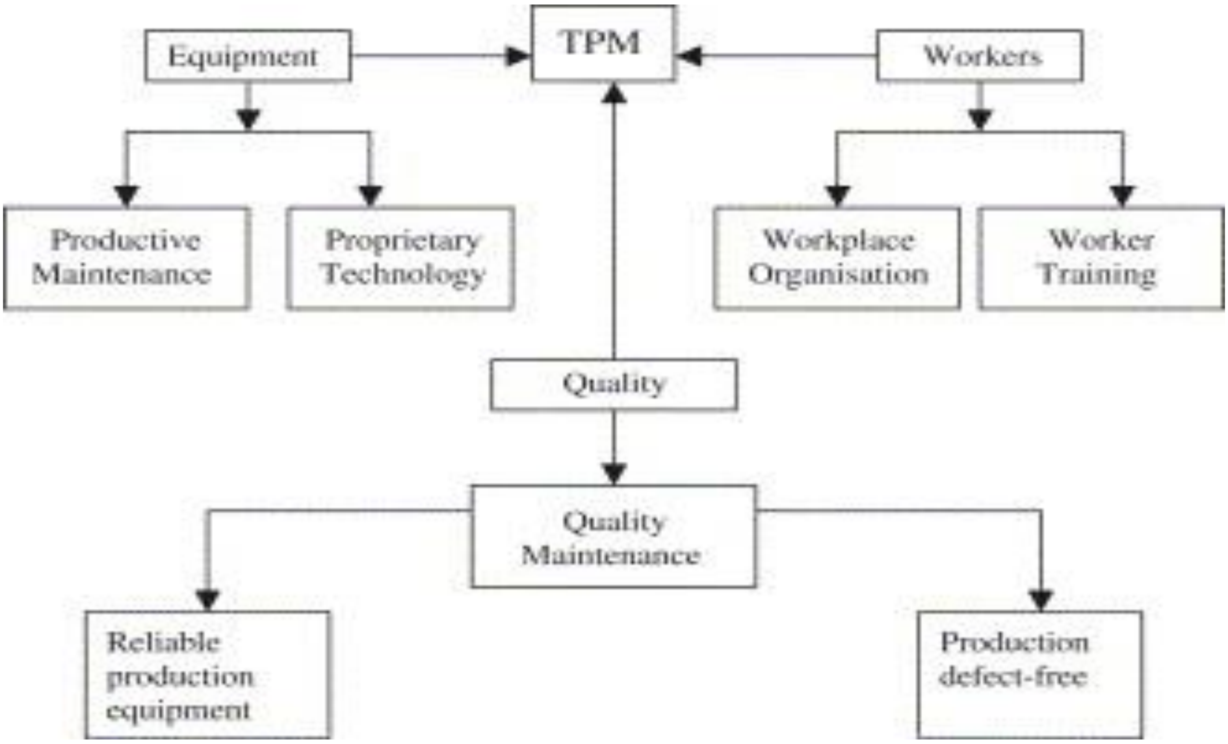


Figure 6 Implementation of TPM

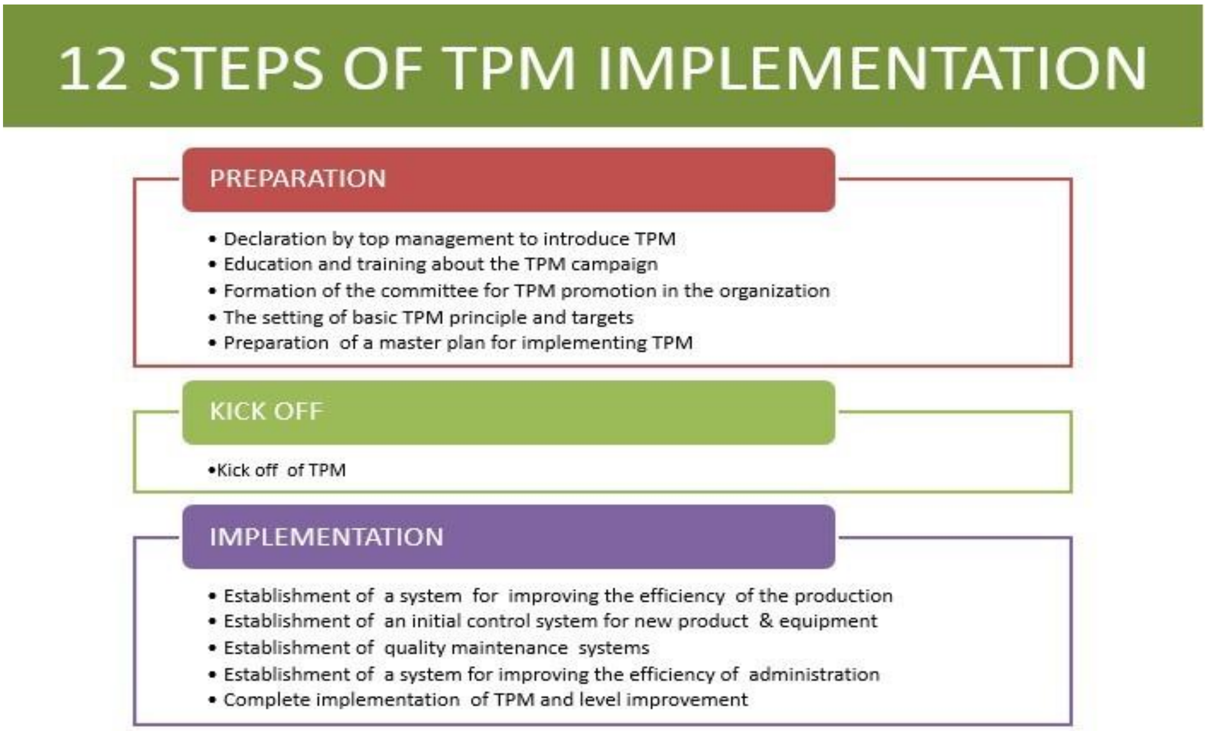


Figure 7 TPM preparation, Kick off and Implementation.

The skill roll in TPM implementation is very important, as it enables the employees to perform their tasks effectively, identify and solve problems, and continuously improve the processes and equipment. TPM is a holistic approach that involves all levels of the organization, from top management to operators, in the maintenance and improvement of the production system. Therefore, the skills required for TPM implementation are not only technical, but also managerial, communication, and problem-solving skills.

Some of the skills that are essential for TPM implementation are:

Machine operation and maintenance skills: These skills allow the operators to operate the machines safely and efficiently, and to perform routine maintenance tasks such as cleaning, lubricating, inspecting, and adjusting the machines. These skills also help the operators to detect and report any abnormal conditions or defects in the machines, and to participate in improvement activities such as kaizen and poka-yoke.

Quality control and assurance skills: These skills enable the operators to monitor and control the quality of the products and processes, and to prevent and eliminate any defects or errors. These skills also involve the use of various quality tools and techniques, such as statistical process control, 5S, 7QC tools, and FMEA.

Safety and environmental skills: These skills ensure the safety and health of the employees and the environment and comply with the relevant regulations and standards. These skills include the knowledge and practice of safety rules and procedures, the use of personal protective equipment, the identification and elimination of hazards and risks, and the prevention and management of accidents and emergencies.

Communication and teamwork skills: These skills facilitate the collaboration and coordination among the employees and the departments, and the sharing of information and feedback. These skills also involve the use of effective communication tools and methods, such as visual management, standard work, and Gemba walks.

Problem-solving and decision-making skills: These skills enable the employees to analyze and solve the problems that arise in the production system, and to make informed and timely decisions. These skills also involve the use of various problem-solving tools and techniques, such as PDCA, A3, fishbone diagram, and 5 whys.

Leadership and management skills: These skills are required for the managers and supervisors who are responsible for planning, organizing, directing, and controlling the TPM activities. These skills also involve the ability to motivate and empower the employees, to set and monitor the goals and targets, to evaluate and improve the performance, and to manage the change and innovation.

The Education and Training Pillar in TPM concentrates on imparting essential skills and knowledge to employees, enabling effective job performance and continual enhancement of their capabilities. This encompasses training across diverse domains like machine operation, maintenance, quality control, and safety1. This Pillar adheres to fundamental principles including ongoing learning and improvement, active employee participation, standardization, data-informed decision-making, and the development of leadership and culture, maintaining a yet unpublished approach.

The skills role in TPM implementation is crucial, as it determines the success and sustainability of the TPM program. Organizations that have successfully implemented TPM provide comprehensive training and education to all employees involved in the process. They also create a culture of learning and improvement, where the employees are encouraged and rewarded for developing and applying their skills.

1.9 Selected Factors of TPM Effectiveness:

In evaluating the effectiveness of Total Productive Maintenance (TPM) implementation, several key factors play a crucial role. These selected factors offer insights into the overall health and success of TPM practices within an organization:

Overall Equipment Effectiveness - OEE:

OEE serves as an all-encompassing metric, amalgamating availability, performance, and quality to gauge the efficiency of equipment utilization. Elevated OEE signifies proficient TPM implementations.

Mean Time Between Failures - MTBF:

Mean Time Between Failure measures the average time an equipment operates without a failure. Longer M T B F values suggest improved equipment reliability due to successful TPM strategies.

Mean Time to Repair – MTTR:

MTTR evaluates the average actual time taken to repair equipment and machines post a failure. Diminished MTTR values indicate streamlined maintenance procedures and reduced downtime.

Equipment Availability:

This factor quantifies the percentage of time during which equipment is accessible for production. High equipment availability reflects effective TPM in ensuring equipment readiness.

Rate of Defects or First Pass Yield:

Evaluates the percentage of products meeting quality standards on the first production run. A low defect rate signifies the success of TPM in improving product quality.

Percentage of Planned Maintenance vs. Unplanned Maintenance:

Compares the ratio of maintenance activities designated as planned versus unplanned. A heightened percentage of planned maintenance signifies proactive TPM.

Utilization of Autonomous Maintenance:

Measures the extent to which operators engage in autonomous maintenance tasks. Increased utilization reflects a cultural shift and successful TPM implementation.

Reduction in Breakdowns:

Tracks the decrease in the frequency of unexpected equipment breakdowns. A reduction in breakdowns demonstrates the preventive nature of TPM.

Employee Engagement and Training Levels:

Assesses the level of employee involvement in TPM activities and the success of training programs. High engagement and well-executed training contribute to TPM effectiveness.

Safety Performance:

Evaluates safety records and incidents related to equipment. Successful TPM is often associated with a safer work environment and fewer incidents.

Rate of Continuous Improvement (Kaizen) Initiatives:

Measures the frequency and success of continuous improvement initiatives. A high rate of Kaizen initiatives indicates a culture of ongoing improvement fostered by TPM.

Alignment with Production Targets:

Examines how well TPM practices align with and contribute to achieving production targets. Successful TPM directly supports the organization in meeting or exceeding production goals.

These factors collectively provide a comprehensive picture of TPM effectiveness, enabling organizations to identify strengths, address weaknesses, and continuously improve their maintenance and operational strategies. Regular monitoring of these factors is essential for ensuring the sustained success of TPM initiatives.

1.10 Objectives of the Study

In evaluating the effectiveness of Total Productive Maintenance (TPM) implementation, several key factors play a crucial role. These selected factors offer insights into the overall health and success of TPM practices within an organization.

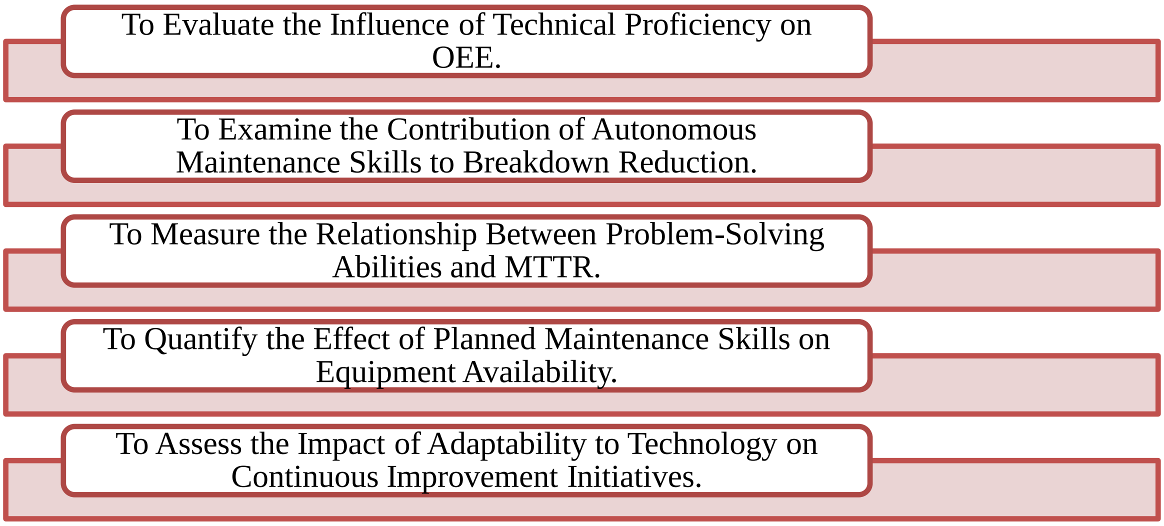


Figure 8 Objectives of The Study

1.11 Expected Contributions

This research needs to provide insights into nuanced relationships in between skills, TPM effectiveness. The findings may guide organizations in optimizing their workforce development strategies, fostering a culture of continuous improvement, and ultimately improving the overall performance of TPM initiatives in industrial settings. Through a careful assessment of these dynamics, the research seeks to contribute to the advancement of maintenance practices and operational excellence.

1. Skills in Autonomous Maintenance:

Skills in autonomous maintenance are the abilities and knowledge that machine operators need to perform minor maintenance tasks on their equipment and machinery, instead of relying on maintenance technicians. Skills in autonomous maintenance are essential for improving the performance and reliability of the production system, as well as promoting a culture of quality and safety. Some of the skills in autonomous maintenance are:

Machine operation and maintenance skills: These skills allow the operators to operate the machines safely and efficiently, and to perform routine maintenance tasks such as cleaning, lubricating, inspecting, and adjusting the machines. These skills also help the operators to detect and report any abnormal conditions or defects in the machines, and to participate in improvement activities such as kaizen and poka-yoke.

Quality control and assurance skills: These skills enable the operators to monitor and control the quality of the products and processes, and to prevent and eliminate any defects or errors. These skills also involve the use of various quality tools and techniques, such as statistical process control, 5S, 7QC tools, and FMEA.

Safety and environmental skills: These skills ensure the safety and health of the employees and the environment and comply with the relevant regulations and standards. These skills include the knowledge and practice of safety rules and procedures, the use of personal protective equipment, the identification and elimination of hazards and risks, and the prevention and management of accidents and emergencies.

Communication and teamwork skills: These skills facilitate the collaboration and coordination among the employees and the departments, and the sharing of information and feedback. These skills also involve the use of effective communication tools and methods, such as visual management, standard work, and Gemba walks.

Problem-solving and decision-making skills: These skills enable the employees to analyze and solve the problems that arise in the production system, and to make informed and timely decisions.

2. Skills in PM:

PM within the Total Productive Maintenance framework requires a specific set of skills to ensure its effective implementation. Technical proficiency is at the core of these skills, as maintenance tasks often involve intricate procedures such as equipment inspections, lubrication, and component replacements. The ability to execute these tasks with precision is paramount, as it minimizes the risk of errors and contributes to the longevity and optimal performance of equipment.

Time management skills are equally crucial in planned maintenance. Adhering to schedules is essential to minimize disruptions to production. Effective time management ensures that maintenance tasks are carried out in a timely manner, preventing unexpected downtime, and maintaining overall production schedules.

Accurate documentation of planned maintenance activities is another skill of significance. Maintaining detailed records facilitates data-driven decision-making by allowing for the analysis of maintenance trends and the optimization of future maintenance plans. This documentation is vital in tracking equipment history and performance over time.

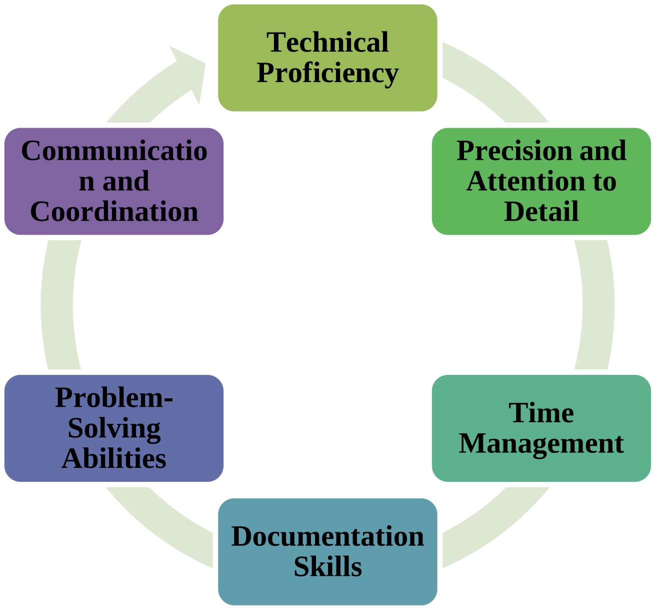


Figure 9 Skills in Planned Maintenance

Communication skills play a pivotal role in coordinating planned maintenance activities. Effective communication ensures that all relevant stakeholders, including production teams and other maintenance personnel, are aligned with the maintenance schedule. This coordination is essential to reduce the likelihood of operational disruptions.

Planned maintenance may also uncover issues that require problem-solving skills for resolution. The ability to identify root causes and implement corrective actions is crucial for proactive problem-solving, contributing to the success of planned maintenance by addressing potential issues before they escalate.

Adherence to Standard Operating Procedures (SOPs) is a fundamental skill in planned maintenance. Following established SOPs maintains consistency and ensures that planned maintenance tasks are carried out in accordance with best practices, enhancing the reliability and effectiveness of these activities.

Risk assessment and mitigation skills are also vital in planned maintenance. The ability to assess potential risks associated with maintenance activities and implement mitigation strategies ensures the safety of personnel and equipment during planned maintenance tasks.

Continuous learning and adaptability round out the skill set for planned maintenance. A willingness to learn and adapt to new technologies, methodologies, and best practices ensures that maintenance personnel stay abreast of advancements, optimizing planned maintenance processes.

Finally, teamwork and collaboration are essential skills in planned maintenance, which often involves coordination with cross-functional teams. Collaborative efforts contribute to a cohesive approach, fostering a culture of shared responsibility for equipment care.

In conclusion, skills in planned maintenance are diverse, encompassing technical expertise, precision, effective communication, problem-solving, and a commitment to continuous improvement. A skilled workforce is indispensable for the successful execution of planned maintenance tasks, contributing to the overall effectiveness of the TPM framework.

3. Skills in Focused Improvement (Kaizen):

The successful implementation of Focused Improvement, commonly known as Kaizen, within the Total Productive Maintenance (TPM) framework requires specific skills from the workforce. These skills are pivotal for identifying, analyzing, and implementing continuous improvement initiatives. Key skills in Focused Improvement include:

Root Cause Analysis: Proficiency in identifying the root causes of inefficiencies or problems within the production process. This skill is crucial for addressing issues at their source, ensuring sustained improvement.

Data Analysis: The ability to collect, analyze, and interpret data related to production processes. Analytical skills enable the identification of trends, patterns, and areas for improvement.

Creativity and Innovation:
A mindset that cultivates inventive problem-solving and the creation of innovative solutions to challenges. Creative thinking is essential for proposing improvements that go beyond conventional approaches.

Collaboration: Effective collaboration among team members is crucial for the success of Kaizen initiatives. This includes communication, idea sharing, and collective problem-solving.

Continuous Learning: Kaizen is rooted in continuous improvement. Individuals engaged in Focused Improvement should have a commitment to ongoing learning, staying informed about new methodologies and best practices.

4. Impact on Key Performance Indicators (KPIs):

Assessing the impact of Total Productive Maintenance on Key Performance Indicators is a critical aspect of gauging its effectiveness. This involves understanding how TPM practices influence various performance metrics. Key objectives related to the impact on KPIs include:

OEE Improvement: Measure the extent to which TPM contributes to enhancing Overall Equipment Effectiveness, reflecting increased equipment efficiency, and minimized downtime.

Reduction in Breakdowns: Evaluate the impact of TPM on reducing the frequency of unexpected breakdowns, contributing to improved equipment reliability.

Quality Metrics: Assess the influence of TPM on product quality, examining metrics such as first pass yield and defect rates.

Cost Reduction: Measure the financial impact of TPM on maintenance costs, including a reduction in emergency maintenance and associated expenses.

Cycle Time Reduction: Evaluate how TPM practices contribute to the reduction of cycle times in production processes, enhancing overall operational efficiency.

5. Training and Development Programs:

Training and development programs within the Total Productive Maintenance (TPM) framework are designed to equip the workforce with the essential skills and knowledge required for the effective implementation and sustained upkeep of TPM practices in our area. These programs typically encompass a range of technical skills, including equipment maintenance and troubleshooting, as well as soft skills such as teamwork, communication, and problem-solving. Specific training initiatives often focus on autonomous maintenance, empowering operators to take on routine tasks and fostering a proactive mindset. Continuous learning is emphasized, ensuring that employees stay abreast of evolving TPM principles and best practices. The goal of these programs is not only to enhance individual competencies but also to cultivate a culture of continuous improvement where the workforce actively contributes to the success of TPM initiatives. Effective training and development programs play a vital role in creating A proficient and committed workforce capable of steering TPM success and attaining operational excellence. The objectives related to training and development include:

Skill Enhancement: Provide training programs to enhance technical skills related to maintenance tasks, ensuring that the workforce is equipped for the demands of TPM.

Autonomous Maintenance Training: Implement training initiatives to empower operators with the skills needed to perform autonomous maintenance tasks, fostering a proactive mindset.

Continuous Learning and Culture: Establishing an environment of continual learning through regular training programs, ensuring that employees stay updated on TPM principles and best practices.

6. Organizational Culture and Leadership:

The impact of organizational culture and leadership on TPM effectiveness is substantial. Objectives in this domain include:

Leadership Commitment: Ensure leadership commitment to TPM principles and practices, fostering a culture where TPM is integrated into the organization's core values.

Employee Engagement: Foster an organizational culture that encourages active employee participation in TPM initiatives, creating a sense of ownership and responsibility.

Change Management: Provide leadership with the skills to effectively manage and communicate change, ensuring smooth TPM implementation and acceptance across the organization.

Continuous Improvement Culture: Instill a culture of continuous improvement where every member of the organization is encouraged to contribute ideas and participate in TPM-related improvement initiatives.

These objectives collectively contribute to the holistic success of TPM, ensuring that the workforce is equipped with the necessary skills, organizational culture aligns with TPM principles, and leadership provides the necessary support for effective implementation.

CHAPTER 2

LITERATURE REVIEW

Sayid Muhammad Muhajir(2021) Concrete manufacturing equipment includes welding equipment, concrete mixer equipment, spinning equipment, and mobile hopper equipment. Batching mixer machines are among the equipment in the production area that has faced disruptions. Sand, coral, and cement raw material mixing is done with batching mixers. Due to frequent issues or equipment damage, problems frequently arise in batching mixer machines. The batching mixer, which is frequently damaged, is the final component of the batching plant machine that serves as a machine for mixing and combining raw materials for concrete. In the nine months from January to September 2022, mixer batching machines frequently face downtime and breakdowns totaling 865 minutes and 265 minutes, respectively.

Farkhan Fajar Nurdin(2023) Improper handling and maintenance can cause a decrease in the level and effectiveness of a machine, which will have an impact on the output of the products produced. Machines that are used continuously certainly affect the efficiency of the machine. To increase the productivity of the machine, the Total Productive Maintenance (TPM) method is used using the calculation of Overall equipment Effectiveness (OEE). This discussion is expected to provide information on an explanation of the explanation of machine repair with a calculation method that also provides an overview of how to apply the method, with data attached through references from journals that analyze the efficiency of a machine. The research was conducted by means of Literature Review, namely analyzing relevant journals or articles and focusing on improving the efficiency of a machine. After this research is carried out the results, we can find out the purpose of TPM is to prevent the occurrence of six Big Losses. while OEE is a value expressed as a ratio between actual output divided by the maximum output of equipment at the best performance conditions.

Guilherme Luz Tortorella(2022) This paper analyzes the joint adoption of Industry 4.0 (I4.0) technologies and Total Productive Maintenance (TPM) practices in manufacturing firms. For that, we surveyed 335 practitioners from firms currently implementing TPM and I4.0, located in sixteen countries. The collected dataset was analyzed using sets of partial correlation analyses, obtained when controlling the effect of three contextual variables, all assessed at the firm level: (i) socio-economic context, (ii) technological intensity, and (iii) size. Pairs of TPM practices and I4.0 technologies with significant positive correlations in all partial correlation sets indicate positive trends in the adoption of elements in the pairs, regardless of context, and may be viewed as indicators of TPM practices and I4.0 technologies more prone to be integrated. Our results identified 67 pairs of I4.0 technologies and TPM practices meeting the significance criterion. This research investigated the relationship between the adoption of TPM practices and I4.0 technologies in a large sample of manufacturing firms. Based on commonalities found in six sets of partial correlation analyses controlling the effects of socio-economic context, technology intensity, and company size, 67 positive partial correlations stood out regardless of the company's context, indicating some synergistic relationships between TPM and I4.0. Four TPM practices and two I4.0 technologies were found to be more frequently present in joint implementations of TPM and I4.0 in our sample of firms. Our findings contributed to both theory and practice on Maintenance digitalization.

D. I. Sukma(2022) The Jakarta Government Hospital provides cancer services with several available types of equipment, one of which is the Linear accelerator (LINAC) Synergy Platform (SP) machine. The phenomenon of this machine experiencing a low effectiveness value because it is not able to handle the patient queue, so it is not able to reduce the severity of cancer. The purpose of this study was to determine the factors.
causing the low value of Overall Equipment Effectiveness (OEE) and provide suggestions for improvement to increase the OEE value. The new approach of this research is using the Total Productive Maintenance (TPM) approach with OEE analysis as a success parameter because TPM is more identical in the manufacturing industry. Another update is using Failure Mode and Effect Analysis (FMEA) through Focus Group Discussions (FGD) with experts. The results of the study found that the factors that influenced the low OEE value on the LINAC SP machine were caused by breakdown loss of 76.29%, setup loss of 9.59%, idling and minor stop of 8.80%, and a decrease in speed of 5.29%. The continuous and consistent implementation of the TPM Pillar has increased the OEE value of the LINAC SP machine. Based on the analysis in the previous section, several conclusions were obtained. The conclusions obtained in this study include finding that there are factors that affect the low OEE value on the LSP machine, namely the breakdown loss factor of 76.29% setup loss of 9.59%, idling and minor stops of 8.80%, and reduced speed of 5.29%. Based on the FGD with the experts, the improvement in this research is to apply the pillars of sustainable TPM.

CHAPTER 3

RESEARCH TECHNIQUE

3.1 Introduction

In undertaking assessment of skills, their impact on selected factors of Total Productive Maintenance (TPM) effectiveness, a robust and systematic methodology is paramount. The methodology employed seeks to delve into the intricate relationship between the skills possessed by the workforce and key factors influencing the success of TPM initiatives. By employing a multifaceted approach, this methodology aims to identify, measure, and analyse the proficiency levels of essential skills, ranging from technical expertise to problem-solving and collaboration. Through comprehensive data collection, including interviews, surveys, and performance metrics, the methodology aims to quantitatively and qualitatively assess the influence of these skills on factors such as (OEE) Overall Equipment Effectiveness , mean time to repair, planned versus unplanned maintenance. By adopting a structured and analytical methodology, this assessment endeavours to provide valuable insights into the dynamic interplay between workforce skills and the effectiveness of TPM practices in optimizing industrial maintenance and operational efficiency.

3.2 Research and design:

The research and design crafted for assessing impacts of skills on selected factors of Total Productive Maintenance (TPM) effectiveness adopts a meticulous and multi-faceted approach. Employing a mixed-methods research design, this study combines quantitative and qualitative methodologies to offer a thorough comprehension of the intricate relationship between workforce skills and TPM outcomes. The sampling strategy involves stratified random sampling to ensure diverse representation from various organizational departments and skill levels, facilitating a nuanced analysis. In the quantitative phase, structured surveys and questionnaires will be administered to quantify the skills possessed by the workforce, utilizing Likert scales and numerical assessments. Concurrently in the qualitative phase, in-depth interviews and focus group discussions are conducted to capture contextual insights and individual experiences related to TPM practices. Variables such as technical proficiency and problem-solving abilities are considered independent, while TPM factors like Overall Equipment Effectiveness and MTBF serve as dependent variables. Statistical analyses, including correlation and regression, will be employed for quantitative data, while thematic analysis will uncover patterns within qualitative data. Ethical considerations, a well-defined timeline, and measures for validation and reliability ensure the integrity of the research. The triangulation of data sources and a clear plan for disseminating results further enhance the robustness of this research design.

3.3 Data collection:

The collection of data process for assessing impact of skills on selected factors of Total Productive Maintenance (TPM) effectiveness involves a strategic and systematic approach to gather both quantitative and qualitative information. The following outlines key components of the data collection process:

Figure 10 Data Collection

1. **Quantitative Data Collection:**

Surveys and Questionnaires: Designing structured surveys and questionnaires that focus on assessing specific skills, including technical proficiency, problem-solving abilities, and collaboration skills. Likert scales and numerical assessments will be utilized to quantify responses.

Skill Assessment Tools: Implementing standardized skill assessment tools to objectively measure the technical competencies of the workforce. These tools may include practical assessments or knowledge tests tailored to TPM-related skills.

TPM Performance Metrics: Collecting quantitative data on TPM performance metrics, including Overall Equipment. Effectiveness, mean time to repair, the percentage of planned maintenance versus unplanned maintenance. This data provides a quantitative measure of TPM effectiveness.

2. **Qualitative Data Collection:**

In-Depth Interviews: Conducting in-depth interviews with key stakeholders, including maintenance personnel, supervisors, and managers. These interviews will explore qualitative insights into the impact of skills on TPM factors, capturing individual experiences and perceptions.

Focus Group Discussions: Organizing focus group discussions to facilitate interactive conversations among participants. This qualitative method allows for the exploration of shared perspectives, group dynamics, and in-depth insights into the cultural aspects of skill utilization in TPM.

Document Analysis: Reviewing relevant documents, reports, and records related to TPM activities. This includes analysing incident reports, maintenance logs, and training records to gain additional context and insights into the practical application of skills in the TPM framework.

3. Sampling Strategy:

Implementing a stratified random sampling strategy to ensure representation from different departments, skill levels, and roles within the organization. This approach aims to capture a diverse range of perspectives and experiences related to TPM practices.

4. Data Management:

Establishing a secure and organized data management system to handle both quantitative and qualitative data. This includes an unitizing responses to ensure participant confidentiality and employing data coding for qualitative analysis.

3.4 Data analysis:

1. Qualitative Data Analysis:

Thematic Analysis:

Thematic analysis will be utilized to recognize, analyse, and report patterns (themes) within qualitative data. This method involves systematically coding and categorizing data to identify recurring themes related to the impact of skills on TPM factors. Themes will be derived from the content of interviews, focus group discussions, and document analysis.

Content Analysis:

Content analysis will be applied to scrutinize the content of documents and reports associated with TPM practices. This method entails systematically categorizing and interpreting textual data to identify key patterns, trends, and insights. It provides a structured approach to analysing qualitative content within the context of the research objectives.

Constant Comparative Method:

The constant comparative method will be employed during the analysis of qualitative data, particularly in interviews and focus group discussions. This iterative process involves comparing new data with previously collected data, refining categories and themes as the analysis progresses. It enhances the depth and richness of the qualitative findings.

Coding and Categorization:

Qualitative data, including interview transcripts and qualitative survey responses, will be coded, and categorized based on emerging themes and patterns. This systematic approach ensures that relevant information is organized for subsequent analysis and interpretation.

Figure 11 Data Analysis

Quantitative Data Analysis:

Descriptive Statistics: Descriptive statistics, including measures of central tendency (mean, median) and variability (standard deviation), will be used to summarize and describe quantitative data from surveys and skill assessments. This provides an overview of the distribution of skills and performance metrics within the sample.

Correlation Analysis: Correlation analysis will be conducted to examine the relationships between different skills and TPM factors. For example, assessing the correlation between technical proficiency scores and Overall Equipment Effectiveness (OEE). This statistical method helps identify potential associations and dependencies.

Regression Analysis: Regression analysis will be employed to explore the impact of skills on selected TPM factors while controlling for potential confounding variables. This method allows for the identification of specific skills that significantly contribute to variations in performance metrics, such as mean time to repair or breakdown reduction.

Comparative Analysis: Comparative analysis will be used to compare the performance metrics of different groups within the organization based on skill levels. This includes comparing the TPM effectiveness of high-skill groups versus low-skill groups, providing insights into the differential impact of skills on selected factors.

Data Visualization: Graphical representations, such as charts and graphs, will be used to visually present quantitative data. This includes visualizing the distribution of skills, performance metrics, and any identified patterns or trends. Visualization enhances the clarity and interpretability of quantitative findings.

Statistical Software: Statistical software, such as SPSS or R, will be utilized for quantitative data analysis. These tools facilitate the application of advanced statistical techniques and ensure the accuracy and efficiency of the analysis process.

By integrating both qualitative and quantitative data analysis methods, the research aims to provide a comprehensive and nuanced understanding of how skills impact selected factors of Total Productive Maintenance (TPM) effectiveness within the organizational context. Triangulating findings from these analyses enhances the robustness and validity of the research outcomes.

3.5 Research Method and Analysis

The research methodology for investigating the impact of skills on selected factors of Total Productive Maintenance (TPM) effectiveness employs a mixed-methods approach to comprehensively explore the intricate dynamics within organizational contexts. The study utilizes a stratified random sampling strategy, combining qualitative methods such as in-depth interviews, focus group discussions and document analysis with quantitative tools like surveys and skill assessments. Thematic and content analysis, along with statistical techniques including correlation and regression analysis, will be applied to both qualitative and quantitative data, respectively. This dual-method approach enhances the depth and breadth of understanding, allowing for a nuanced exploration of individual experiences and statistical trends. The integration of qualitative and quantitative findings ensures a robust and holistic interpretation of the impact of skills on TPM effectiveness, contributing valuable insights to both academic and industrial domains. Ethical considerations, encompassing participant confidentiality and informed consent, are strictly adhered to throughout the research process.

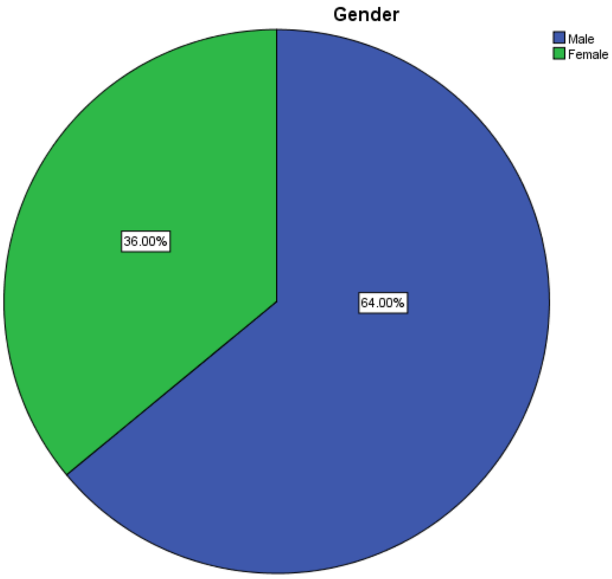
CHAPTER 4

ANALYSIS, DISCUSSION AND RECCOMENDATIONS

4.1 Analysis

Table 1 Gender

		Frequency	Percent
Valid	Male	32	64.0
	Female	18	36.0
	Total	50	100.0



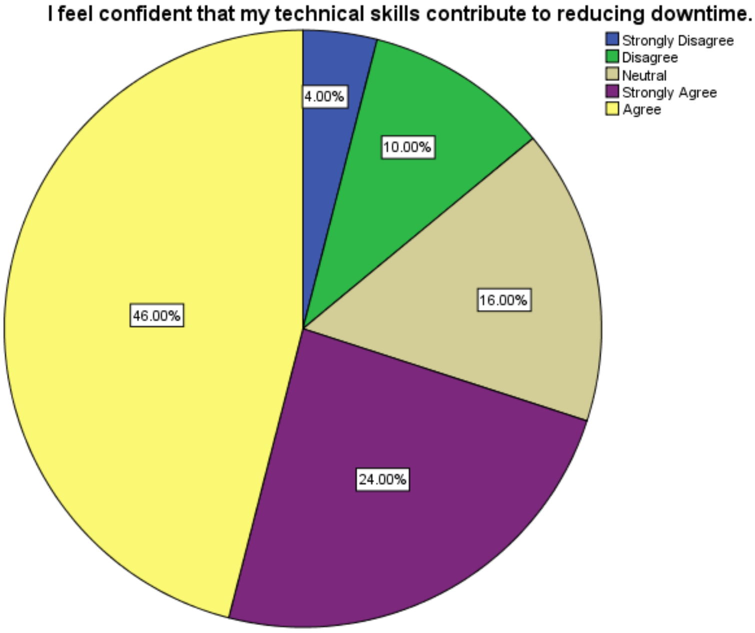
Graph 1 Gender

The table presents the gender distribution of a sample group consisting of 50 individuals. According to the data, males constitute the majority, with 32 participants, accounting for 64% of the total sample. In contrast, females make up 36% of the sample, with 18 participants. This indicates that the sample is predominantly male, with nearly two-thirds of the participants being male compared to a little over one-third being female.

Table 2 I feel confident that my technical skills contribute to reducing downtime.

		Frequency	Percent
Valid	Strongly Disagree	2	4.0
	Disagree	5	10.0

		Frequency	Percent
	Neutral	8	16.0
	Strongly Agree	12	24.0
	Agree	23	46.0
	Total	50	100.0



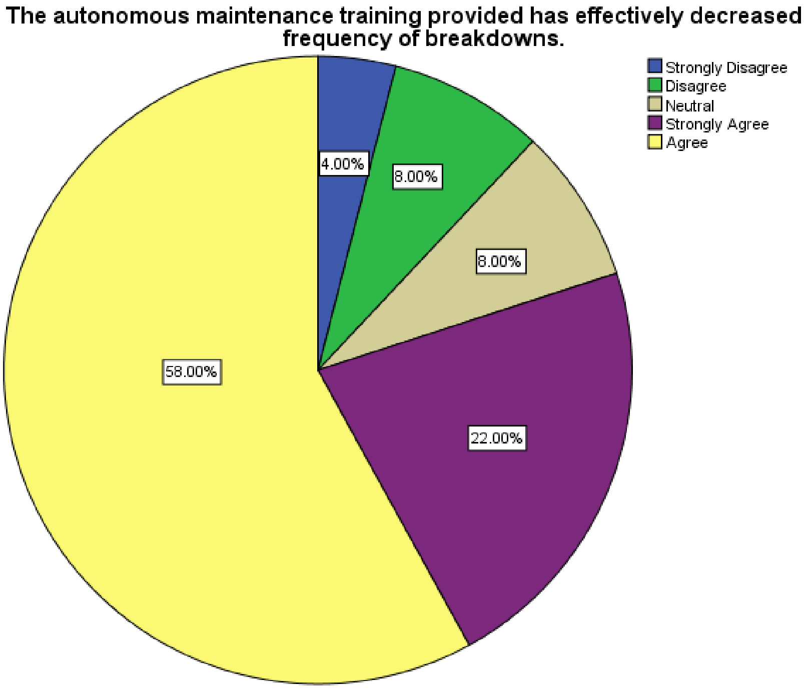
Graph 2 I feel confident that my technical skills contribute to reducing downtime.

The table illustrates the respondents' confidence in their technical skills contributing to reducing downtime. Out of 50 participants, the largest group, comprising 46%, agree that their technical skills help reduce downtime. Following this, 24% strongly agree with the statement, indicating a high level of confidence among nearly a quarter of the respondents. A smaller portion, 16%, remains neutral on the matter. On the other end of the spectrum, 10% disagree, and a mere 4% strongly disagree, reflecting a minority who lack confidence in their technical skills' impact on reducing downtime. Overall, the majority of respondents (70%) express confidence in their technical skills in this regard.

Table 3 The autonomous maintenance training provided has effectively decreased the frequency of breakdowns.

		Frequency	Percent
Valid	Strongly Disagree	2	4.0
	Disagree	4	8.0
	Neutral	4	8.0
	Strongly Agree	11	22.0

	Agree	29	58.0
	Total	50	100.0



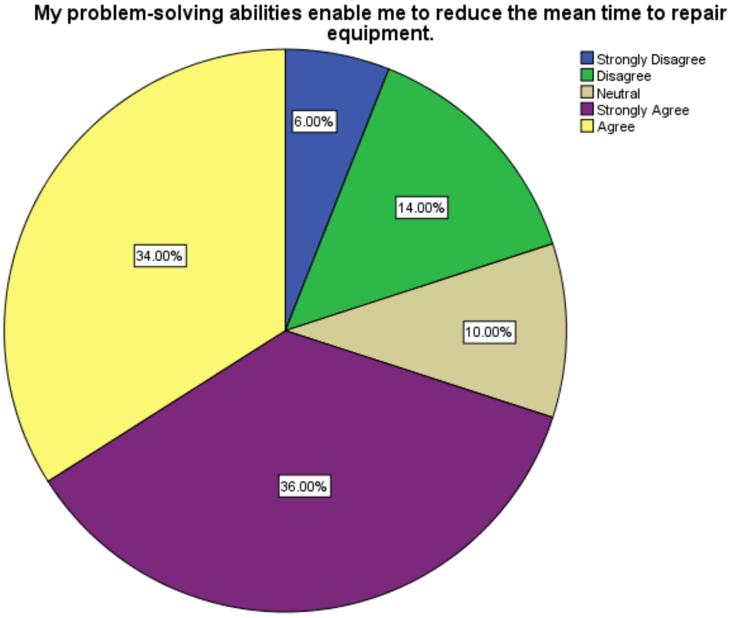
Graph 3 The autonomous maintenance training provided has effectively decreased the frequency of breakdowns.

The table displays the respondents' views on the effectiveness of autonomous maintenance training in decreasing the frequency of breakdowns. Among the 50 participants, a significant majority, 58%, agree that the training has been effective. Additionally, 22% strongly agree, indicating a high level of perceived effectiveness among nearly a quarter of the respondents. A smaller group, comprising 8%, remain neutral. Conversely, 8% of respondents disagree, and a small minority of 4% strongly disagree, suggesting some skepticism about the training's impact. Overall, the data reveals that 80% of the respondents believe the autonomous maintenance training has successfully reduced breakdowns.

Table 4 My problem-solving abilities enable me to reduce the mean time to repair equipment.

		Frequency	Percent
Valid	Strongly Disagree	3	6.0
	Disagree	7	14.0
	Neutral	5	10.0
	Strongly Agree	18	36.0
	Agree	17	34.0

	Total	50	100.0

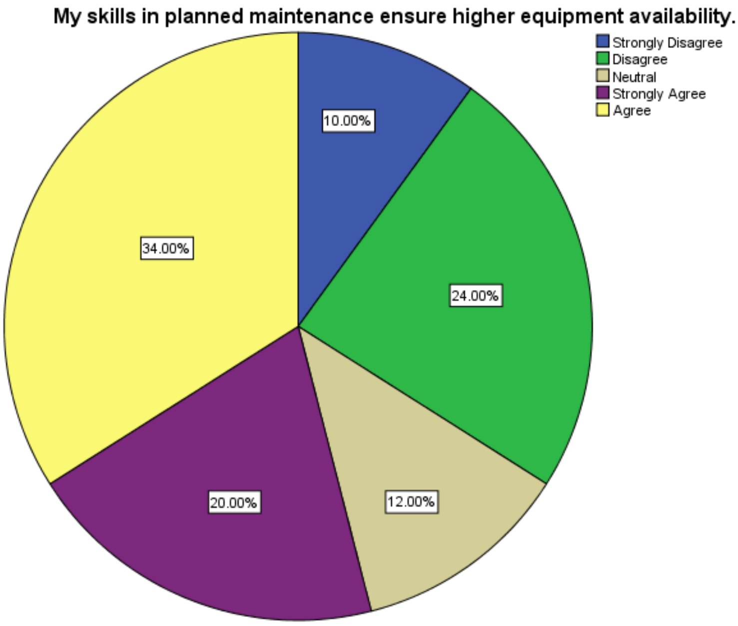


Graph 4 My problem-solving abilities enable me to reduce the mean time to repair equipment.

The table presents the respondents' perceptions of their problem-solving abilities in reducing the mean time to repair equipment. Among the 50 participants, 36% strongly agree that their problem-solving skills are effective in this regard, while 34% agree, collectively indicating that 70% of respondents have confidence in their abilities to reduce repair times. A smaller portion, 10%, remains neutral. On the opposing side, 14% disagree, and 6% strongly disagree, reflecting a minority who do not believe their problem-solving skills contribute significantly to reducing repair times. Overall, the majority of respondents (70%) feel positively about their problem-solving abilities in this context.

Table 5 My skills in planned maintenance ensure higher equipment availability.

		Frequency	Percent
Valid	Strongly Disagree	5	10.0
	Disagree	12	24.0
	Neutral	6	12.0
	Strongly Agree	10	20.0
	Agree	17	34.0
	Total	50	100.0

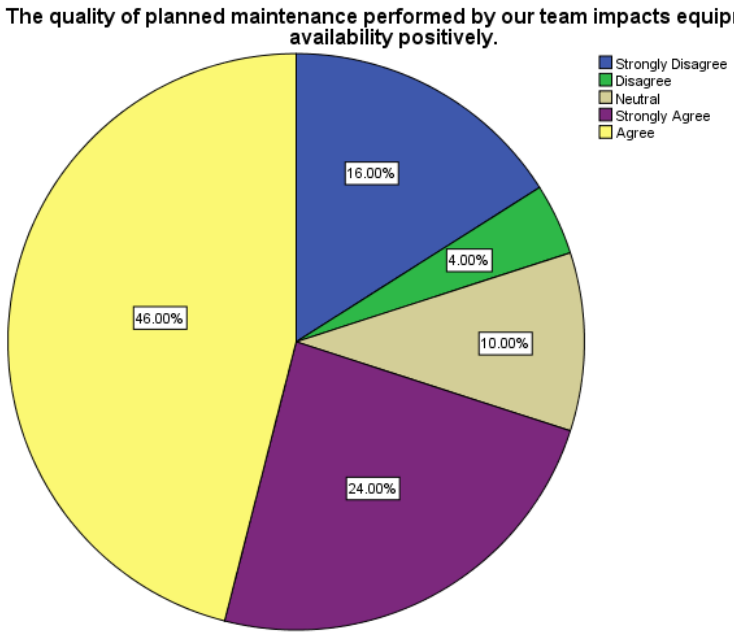


Graph 5 My skills in planned maintenance ensure higher equipment availability.

The table provides insights into respondents' views on the impact of their skills in planned maintenance on equipment availability. Out of 50 participants, 34% agree that their skills ensure higher equipment availability, while 20% strongly agree, making a combined total of 54% who hold a positive view of their maintenance skills. Meanwhile, 12% of respondents are neutral. On the other hand, 24% disagree, and 10% strongly disagree, indicating that a notable minority, 34% in total, do not believe their skills in planned maintenance contribute significantly to higher equipment availability. This shows a divided perspective, with a slight majority confident in their abilities but a substantial portion expressing doubts.

Table 6 The quality of planned maintenance performed by our team impacts equipment availability positively.

		Frequency	Percent
Valid	Strongly Disagree	8	16.0
	Disagree	2	4.0
	Neutral	5	10.0
	Strongly Agree	12	24.0
	Agree	23	46.0
	Total	50	100.0

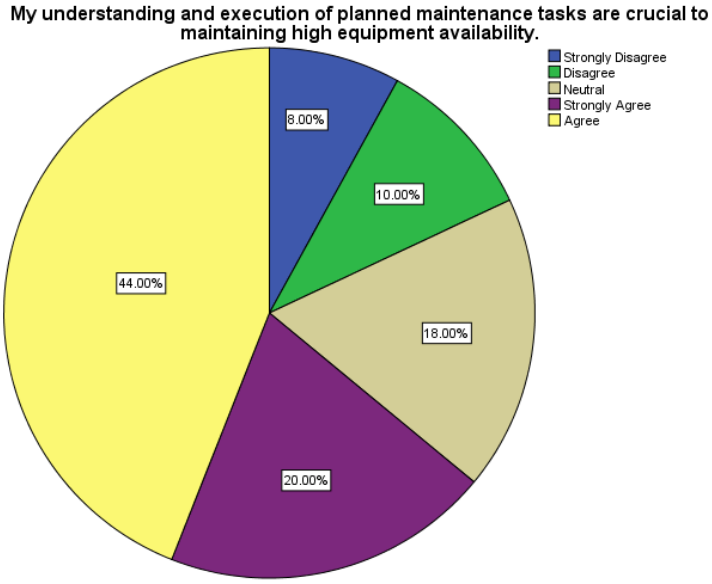


Graph 6 The quality of planned maintenance performed by our team impacts equipment availability positively.

The table assesses respondents' opinions on whether the quality of planned maintenance performed by their team positively impacts equipment availability. Among the 50 participants, 46% agree with this statement, while an additional 24% strongly agree, indicating that a substantial majority of 70% believe in the positive impact of their team's maintenance quality on equipment availability. A smaller group, 10%, remains neutral. Conversely, 4% of respondents disagree, and 16% strongly disagree, reflecting a minority of 20% who do not perceive a positive impact. Overall, the data suggests that the majority of respondents (70%) view their team's maintenance quality as beneficial for equipment availability, despite some differing opinions.

Table 7 My understanding and execution of planned maintenance tasks are crucial to maintaining high equipment availability.

		Frequency	Percent
Valid	Strongly Disagree	4	8.0
	Disagree	5	10.0
	Neutral	9	18.0
	Strongly Agree	10	20.0
	Agree	22	44.0
	Total	50	100.0

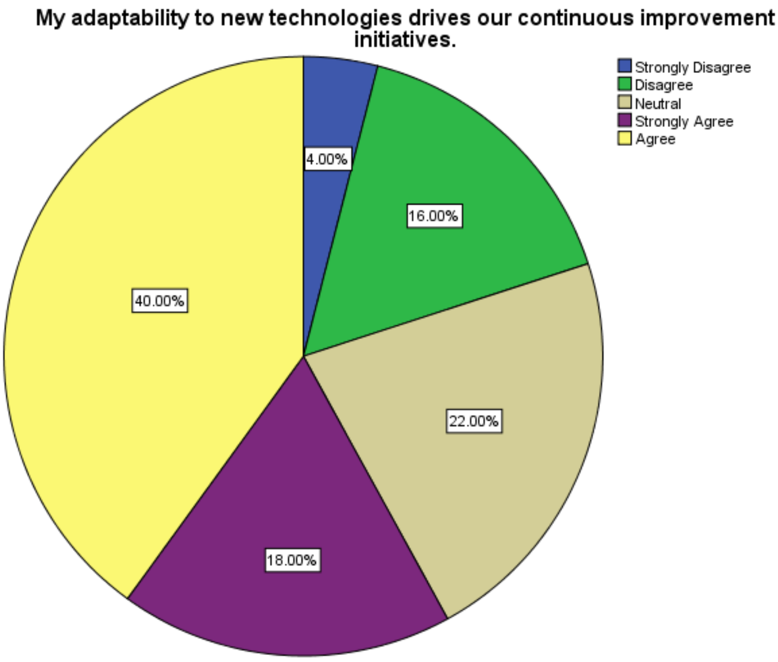


Graph 7 My understanding and execution of planned maintenance tasks are crucial to maintaining high equipment availability.

The table explores respondents' beliefs regarding the importance of their understanding and execution of planned maintenance tasks in maintaining high equipment availability. Out of 50 participants, 44% agree that their skills are crucial, and 20% strongly agree, indicating that 64% hold a positive view of their contribution to equipment availability. Meanwhile, 18% remain neutral on the matter. On the other hand, 10% disagree and 8% strongly disagree, showing that 18% of respondents do not perceive their role in planned maintenance as essential for maintaining high equipment availability. Overall, the data reveals that a majority of respondents (64%) consider their understanding and execution of planned maintenance tasks to be vital in ensuring high equipment availability.

Table 8 My adaptability to new technologies drives our continuous improvement

		Frequency	Percent
Valid	Strongly Disagree	2	4.0
	Disagree	8	16.0
	Neutral	11	22.0
	Strongly Agree	9	18.0
	Agree	20	40.0
	Total	50	100.0

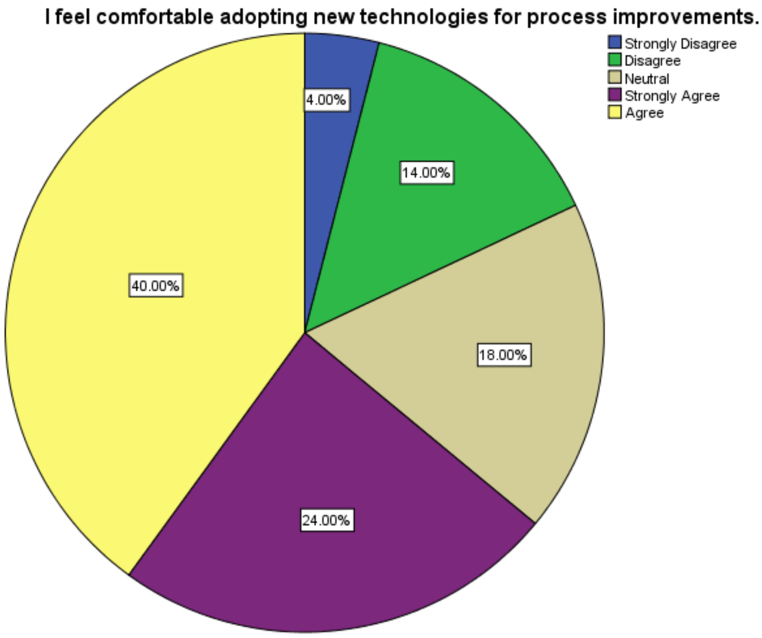


Graph 8 My adaptability to new technologies drives our continuous improvement

The table examines respondents' views on whether their adaptability to new technologies drives continuous improvement within their organization. Among the 50 participants, 40% agree with the statement, and 18% strongly agree, indicating that 58% believe their adaptability is a significant driver of continuous improvement. Conversely, 22% remain neutral, suggesting some uncertainty or mixed feelings on the matter. On the opposing end, 16% disagree, and 4% strongly disagree, revealing that 20% do not view their adaptability as a major factor in continuous improvement. Overall, the majority of respondents (58%) feel that their adaptability to new technologies contributes positively to ongoing improvements in their organization.

Table 9 I feel comfortable adopting new technologies for process improvements.

		Frequency	Percent
Valid	Strongly Disagree	2	4.0
	Disagree	7	14.0
	Neutral	9	18.0
	Strongly Agree	12	24.0
	Agree	20	40.0
	Total	50	100.0

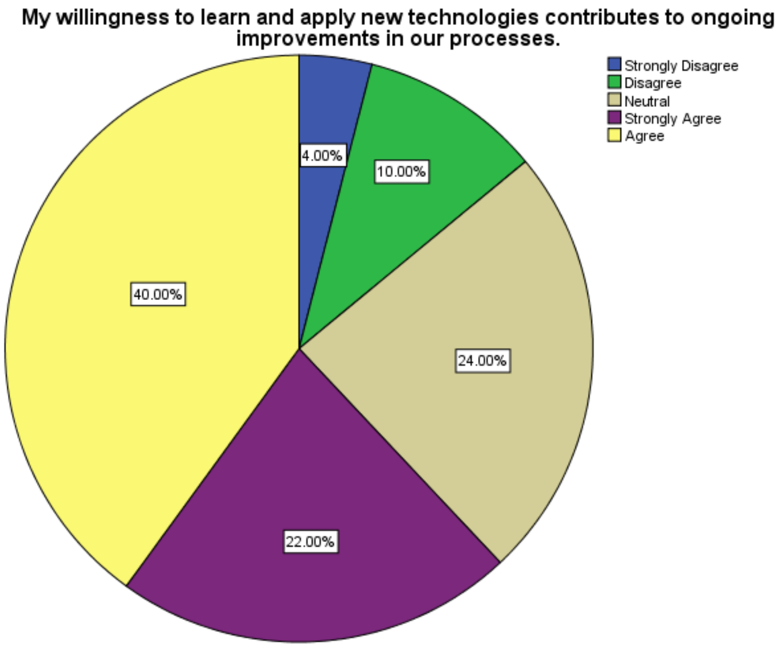


Graph 9 I feel comfortable adopting new technologies for process improvements.

The table presents respondents' comfort levels with adopting new technologies for process improvements. Out of 50 participants, 40% agree that they feel comfortable with this adoption, and 24% strongly agree, indicating that 64% of respondents are comfortable with incorporating new technologies for improving processes. Meanwhile, 18% are neutral, showing some ambivalence. On the other side, 14% disagree, and 4% strongly disagree, suggesting that 18% of respondents are not comfortable with adopting new technologies. Overall, the majority (64%) of respondents feel at ease with using new technologies to enhance process improvements.

Table 10 My willingness to learn and apply new technologies contributes to ongoing

		Frequency	Percent
Valid	Strongly Disagree	2	4.0
	Disagree	5	10.0
	Neutral	12	24.0
	Strongly Agree	11	22.0
	Agree	20	40.0
	Total	50	100.0



Graph 10 My willingness to learn and apply new technologies contributes to ongoing improvements in our processes.

The table assesses respondents' perceptions regarding how their willingness to learn and apply new technologies contributes to ongoing processes. Among the 50 participants, 40% agree that their willingness contributes positively, and 22% strongly agree, collectively indicating that 62% view their readiness to embrace new technologies as beneficial to ongoing processes. Meanwhile, 24% remain neutral, implying some uncertainty or mixed feelings on the subject. Conversely, 10% disagree, and 4% strongly disagree, suggesting that 14% of respondents do not see their willingness to learn and apply new technologies as contributing significantly. Overall, the majority (62%) of respondents believe that their willingness to adopt new technologies positively impacts ongoing processes.

Setting the Basic Policy and Goals of Total Productive Maintenance

Total Productive Maintenance is a comprehensive approach to equipment maintenance aiming to attain flawless production. The basic policy and goals of TPM are as follows:

1. Strive to achieve production excellence with no breakdowns, no small stops or slow running, no defects, and no accidents.
2. Improve the machine`s effectiveness.
3. Improve the machine`s efficiency, reliability and effectiveness of maintenance process.
4. Schedule repair to avoid early repair.

5. Engage the operation team in minor maintenance tasks, including machine checklist inspections before starting and after closing the machines.

The conclusive phase in the TPM process involves incorporating proactive maintenance techniques, targeting minor losses that can eventually contribute to substantial productivity gains. Various proactive maintenance techniques exist, with some of the most prevalent being condition-based, predictive, and preventive maintenance.

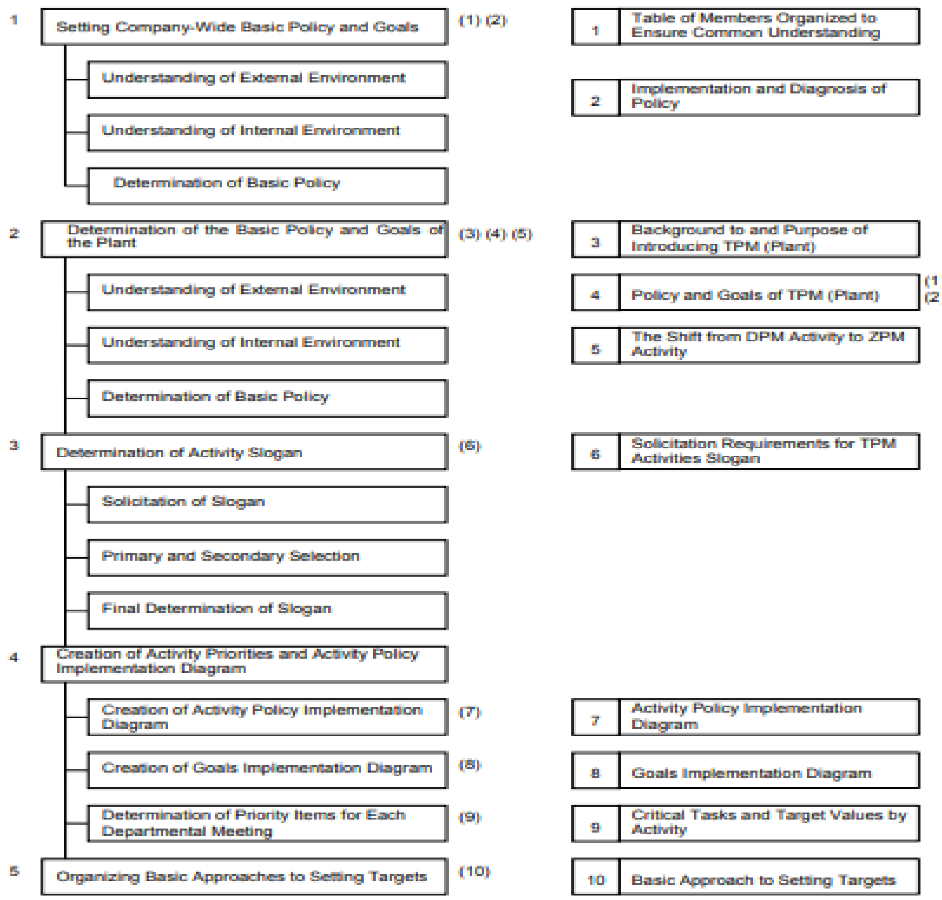


Fig 12 Basic Policy and Goals of TPM

Source – secondary data

The three major losses category that impede efficient use of production resources are typically categorized as follows:

Availability Losses: These are losses due to equipment failures, planned maintenance time loss, setup loss, tool change loss, and start-up loss. For example, breakdown loss (failure losses) are losses due to failures. Another example is setup and adjustment losses which refer to time losses from the end of the production of a previous item through product-change adjustment to the point where the production of the new item is completely satisfactory.

Performance Losses: These are losses due to minor stoppages and reduced speed. For instance, minor stoppage loss occurs when the equipment temporarily stops or idles due to sensor actuation or jamming of the work. Speed loss is the loss caused by the difference between the designed speed and the actual working speed.

Quality Losses: These are losses due to defects and reworks. Defect and rework loss is the loss caused when defects are found and must be reworked. These losses can significantly impact the efficiency of production subsidiary resources and are often the focus of improvement initiatives in manufacturing environments.

4.2 Findings:

The survey findings highlight several key insights into the perceptions of maintenance personnel regarding the relationship between skills and various aspects of Total Productive Maintenance (TPM) effectiveness. Notably, there is a prevalent consensus on the positive impact of technical proficiency, autonomous maintenance skills, problem-solving abilities, and planned maintenance skills on different performance metrics, such as (OEE), breakdown reduction, MTTR, equipment availability. Additionally, respondents emphasize the critical role of adaptability to technology in the success of continuous improvement initiatives within the maintenance domain. These findings provide valuable insights for organizations seeking to optimize TPM practices by focusing on skill development and technological integration.

To summarize the findings from all the questions presented in Tables 1 through 10:

1. Gender Distribution (Table 1):

- Majority of the sample group are male (64%), with females comprising 36%.

2. Confidence in Technical Skills (Table 2):

- A significant majority (70%) express confidence in their technical skills contributing to reducing downtime.

3. Effectiveness of Autonomous Maintenance Training (Table 3):

- The majority (80%) believe that autonomous maintenance training has effectively reduced breakdowns.

4. Problem-Solving Abilities and Repair Time (Table 4):
   - A majority (70%) feel positively about their problem-solving abilities' impact on reducing repair times.

5. Skills in Planned Maintenance and Equipment Availability (Table 5):
   - Opinions are divided, with 54% expressing confidence in their skills contributing to higher equipment availability.

6. Quality of Planned Maintenance and Equipment Availability (Table 6):
   - The majority (70%) perceive the quality of planned maintenance as positively impacting equipment availability.

7. Understanding and Execution of Planned Maintenance Tasks (Table 7):
   - Most respondents (64%) consider their understanding and execution of planned maintenance tasks crucial for maintaining high equipment availability.

8. Adaptability to New Technologies and Continuous Improvement (Table 8):
   - The majority (58%) believe their adaptability to new technologies drives continuous improvement.

9. Comfort with Adopting New Technologies for Process Improvements (Table 9):
   - A significant majority (64%) feel comfortable adopting new technologies for process improvements.

10. Willingness to Learn and Apply New Technologies (Table 10)
   - The majority (62%) perceive their willingness to learn and apply new technologies as contributing to ongoing processes.

Overall, the findings suggest a general confidence in technical skills, maintenance practices, and adaptability to new technologies among respondents, with some variations in specific areas and a few divergent opinions.

4.3 Limitations:

While the survey provides valuable perspectives, it is important to acknowledge certain limitations. Firstly, the findings are based regarding self-reported perceptions, which may be subject to bias or subjective interpretation. Assessment also assumes certain level on understanding and uniformity in interpreting terms like "technical proficiency" or "autonomous maintenance skills," which might vary among respondents. The sample size and composition may not represent the entire diversity of maintenance personnel in different industries. Additionally, the survey does not delve into specific industries or organizational contexts, limiting the generalizability of findings. Future research could address these limitations by conducting more in-depth qualitative studies, considering diverse industry contexts, and incorporating objective performance metrics.

Brings the types of maintenance used by the companies. A balanced distribution can be observed among predictive, with 20%, preventive, 22.2%, planned corrective, 24.4% and unplanned corrective maintenance, 24.4%. It is emphasized that the expectation for the last type of maintenance is from a lower rate due to the expected technological evolution and the development of professionals in the implemented process.

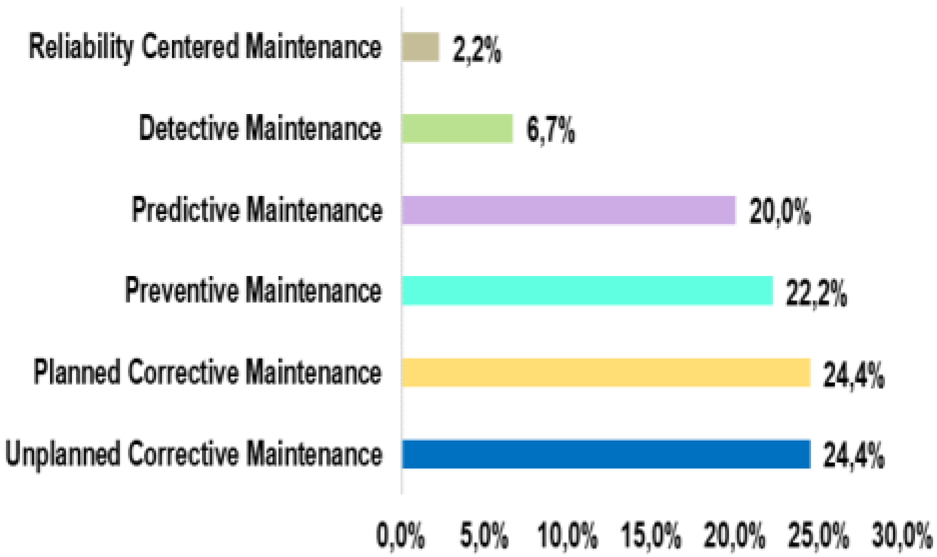


Fig. 13 Maintenance types used by the companies.

Figure 4 shows the implemented TPM pillars, highlighting the pillars of Focused Improvement, with 17.7%, concentrated on the global improvement of business, and Planned Maintenance, with 17.7%, aiming to plan, execute and control the maintenance program.

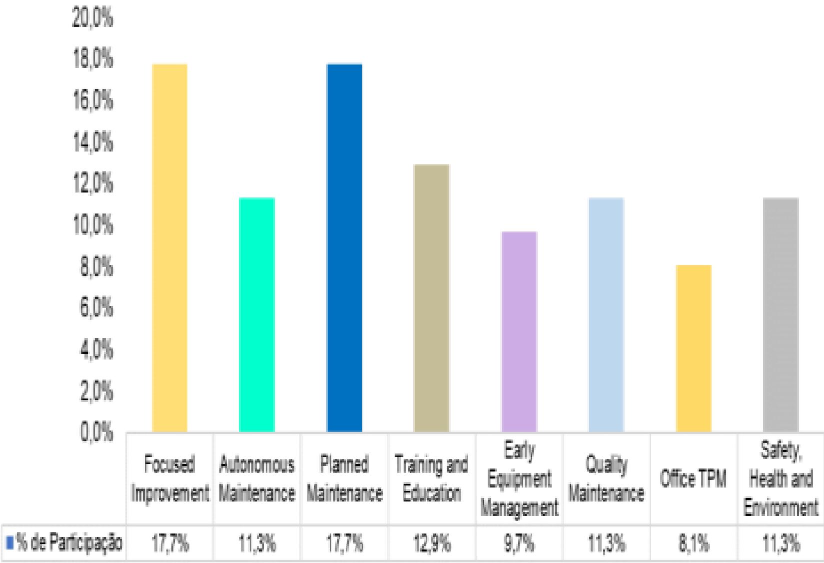


Figure 14: Incidence of implemented TPM pillars

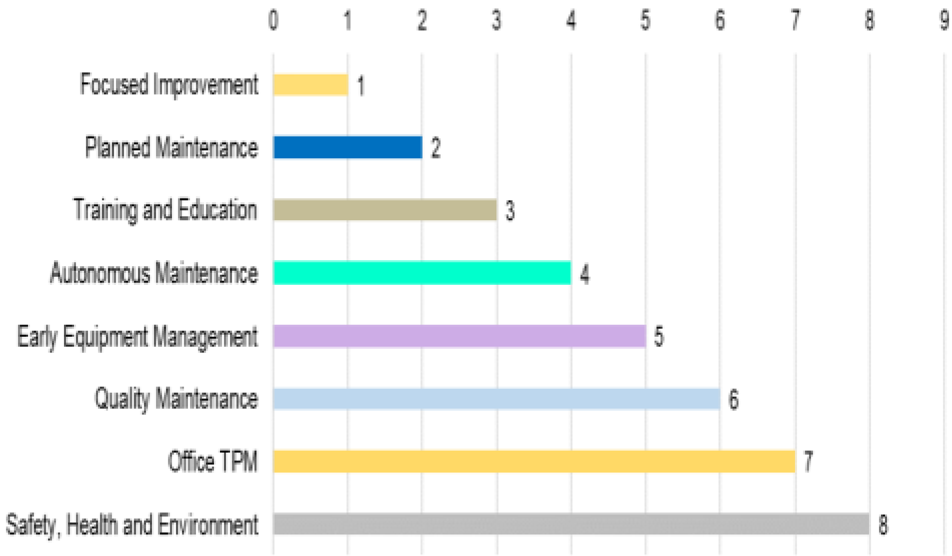


Figure 15: Sequence of TPM pillars' implementation.

Table 1 compares the implementation sequence suggested by the literature and the sequence implemented by the responding companies. To analyze the implementation evolution of the TPM method, the companies were numbered from 1 to 11, to maintain the confidentiality of the respondent companies. The monitoring of the implementation performance evolution of the TPM method was defined by the OEE metric, according to the following statements.

TPM Methodology for Sustainable Profit Growth in the Indian Process Industry

Introduced in the year 1969 in Nippon Denso, Japan, the primary focus of Total Productive Maintenance is to establish the concept of Zero Failure of Equipment extending to Production

Efficiency Enhancement. Adopted in 1991 by the Cement Industry in India, CII in collaboration with Japan Institute of Plant Maintenance (JIPM) created a focused CII TPM Club in the CII Institute of Quality to propagate and support the Indian Industry.

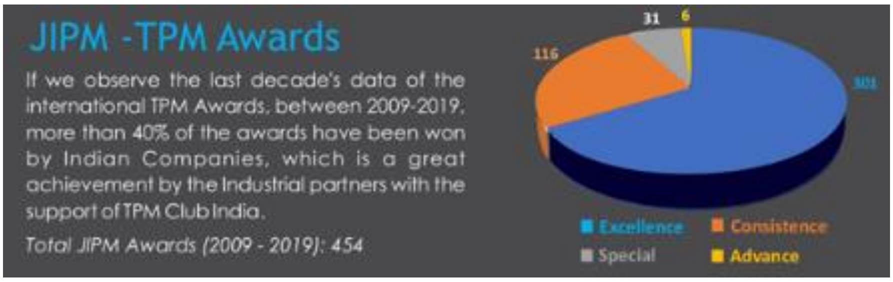


Fig. 16 TPM award

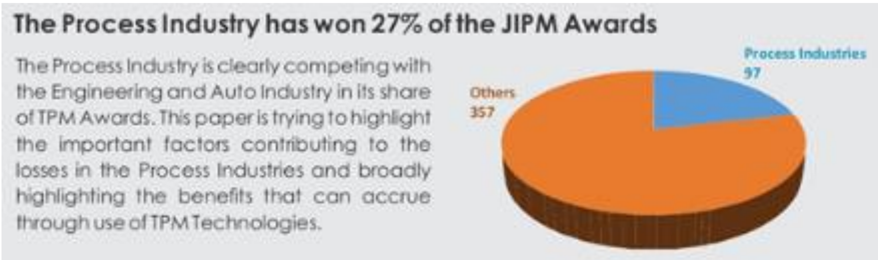


Fig. 17 TPM award

The Batch process and Continuous process industries are unique, in the sense that, the business challenges of raw material availability, Raw material price, raw material yield, the operating style, Losses inside the plant, people knowledge, power consumption. In process industry, types of defects are totally different from the other type of industries. Also, in the scope for improvement in profitability i.e. the possibility of achieving exponential growth is very high.

The Process Industry, by its nature, exhibits the following features:

- Continuous production.
- Prioritizing the process over individual equipment.
- The complexity of the material properties being handled.
- A substantial amount of energy consumption.
- Operators are required to manage a diverse array of parameters and equipment.

The Challenges

Numerous processes span the entire facility, encompassing crystallization, distillation, refining, and furnaces equipped with both static and rotary equipment. The Destroyment

Approximately 7 to 10 percent of the total downtime is devoted to equipment maintenance; preventive maintenance contributes an additional 10 to 12 percent; and shut-down maintenance presents yet another formidable obstacle.

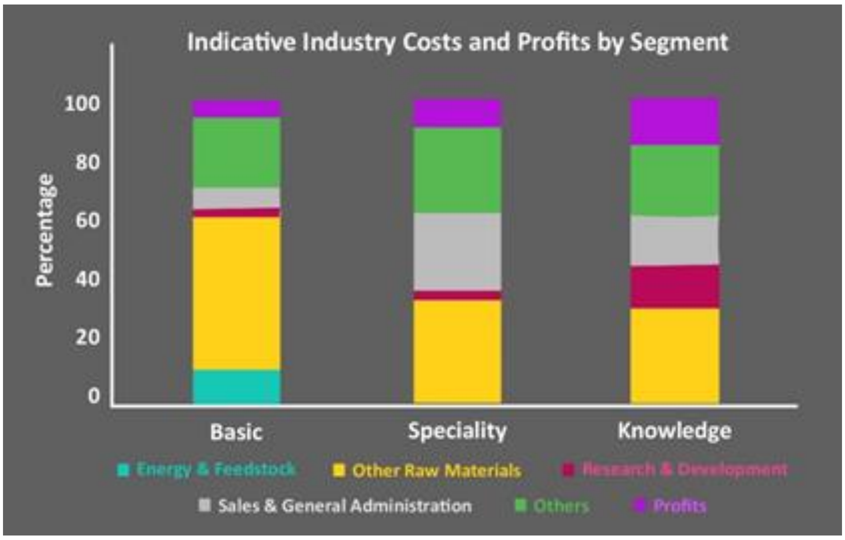


Fig.18 Cost and profit segment

4.4 Future Research:

Building on these findings, future research could explore the specific mechanisms through which skills impact TPM effectiveness by conducting in-depth interviews or case studies within different industries. Investigating the role of organizational culture in skill development and TPM implementation could provide a richer understanding. Furthermore, longitudinal studies could assess the sustainability of the observed relationships over time and explore how evolving technologies influence the skill sets required for effective maintenance practices. Exploring the impact of external factors, such as regulatory changes or advancements in maintenance technologies, on the perceived effectiveness of TPM practices could also be an avenue for future research. Overall, there is a need for more nuanced and context-specific investigations to advance our understanding of the interplay between skills and TPM effectiveness in diverse organizational settings.

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