

A SYSTEMATIC REVIEW OF CHALLENGES IN IMPLEMENTING TPM (TOTAL PRODUCTIVE MAINTENANCE) IN MANUFACTURING INDUSTRIES: IDENTIFYING ESSENTIAL SKILLS FOR EFFECTIVE TPM PRACTICE

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Abstract

Today in the competitive manufacturing sector, assuring reliable and efficient equipment performance is essential to achieve optimum production results. Total Productive Maintenance (TPM) provides a well-established framework for maximizing equipment efficiency which leading to numerous benefits including enhanced productivity, lower costs, and recognition through awards (TPM Excellence Award). Notwithstanding, effective implementation of TPM presents major challenges in manufacturing industries, which were identified through a systematic review. 17 Studies from various countries (India, Malaysia, Thailand etc.) and industries (heavy machinery, food processing, energy etc.) were included. Objectives of the study include: (1) Identify and categorize the main challenges critical to the success of TPM implementation; (2) Analyze industry experts' perspectives on how these challenges can be overcome; (3) Provide a skillset for individuals who aspiring to pursue careers in manufacturing that focus on TPM. The main findings underline the gaps between knowledge and skills possessed by employees, improper leadership and management styles among top management, lack of employee engagement and difficulties associated with process implementation which hinder successful deployment of TPM inside organizations. The review shows important TPM-oriented proficiencies for best practice implementation which comprise awareness of TPM pillars and other related concepts, preventative maintenance practices and OEE (Overall Equipment Effectiveness) calculations among others. The study recommends inculcation of these TPM-related skills in professional development programs and their subsequent inclusion in relevant training initiatives to improve effectiveness as TPM practitioners.

Keywords: OEE, Total Productive Maintenance, TPM Training Programs

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Introduction

The globe's spotlight on competitiveness and productivity has given birth to Total Productive Maintenance (TPM). Initially found in Japan, it is a maintenance system that involves all employees in the organization. TPM is based on eight pillars including: Autonomous Maintenance; Focused improvement; Planned Maintenance; Quality Maintenance; Early equipment management; Training and education; Safety, health and environment and Office TPM. The collective objective of these pillars is to enhance equipment reliability, reduce downtime, improve product quality and foster a culture of continuous improvement.

The literature on TPM focuses on its significance in enhancing manufacturing performance by improving equipment reliability, reducing cost of maintaining plants and striving for operational excellence (Ahuja, 2008). Notwithstanding these advantages, TPM implementation experiences many challenges. Several researchers have identified significant obstacles such as cultural resistance to change, lack of top management commitment, inadequate training and financial resources among others (Cooke, 2000). Recent research emphasizes the need for strategic approaches, robust training programs and comprehensive frameworks that can address these multiple challenges and facilitate the effective implementation of TPM (Ahuja, 2008).

Identification and development of the right skills are vital in the effective implementation of TPM. Successful application of TPM relies on understanding of the theoretical aspects of maintenance and it requires practical sets of skills and expertise that can respond to practical challenges in handling equipment to its optimum capacity. Acquiring these skills for anyone interested in TPM enhances their ability to implement TPM strategies successfully.

This research aims to conduct a systematic review on TPM implementation difficulties and how addressing these challenges can improve the essential skills anyone who interest to work in TPM focused industries. The research seeks to achieve the following:

1. Classify challenges inhibiting TPM implementation in manufacturing industries.
2. Investigate expert suggestions/recommendations for overcoming identified TPM implementation challenges.
3. Build skillset required by an individual to become successful career professionals within a manufacturing environment focusing on TPM.

Methodology

Framework

This systematic review was conducted according to 'The Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for Scoping Reviews checklist' (Tricco et al., 2018)

Search Strategy

The following databases and search engines were explored for eligible publications; SCOPUS, IEEE Xplore, ResearchGate and Google scholar using the keywords 'Total Productive Maintenance (TPM)', 'TPM Implementation Challenges', and 'TPM Training Programs'. The search was conducted from May 2024 to July, 2024.

Study selection

The study selection was performed using the Covidence platform (covidence, n.d.). The citations were imported to Covidence for screening. Quantitative, qualitative and mixed- method research conducted

on Challenges in implementing TPM in manufacturing industries, which were reported in English language were included in this review.

Two independent reviewers conducted the title/abstract screening and full text screening. The conflicts were resolved by consensus. The eligible articles were retrieved for full text review. Full texts were assessed in detail against the inclusion criteria such as,

1. Studies focusing on TPM implementation in manufacturing industries.
2. Research published in peer-reviewed journals and conference proceedings
3. Articles that discuss challenges and barriers to implementing TPM.
4. Research conducted since 2014.

The studies that did not meet the inclusion criteria were excluded. The reasons for exclusions were noted.

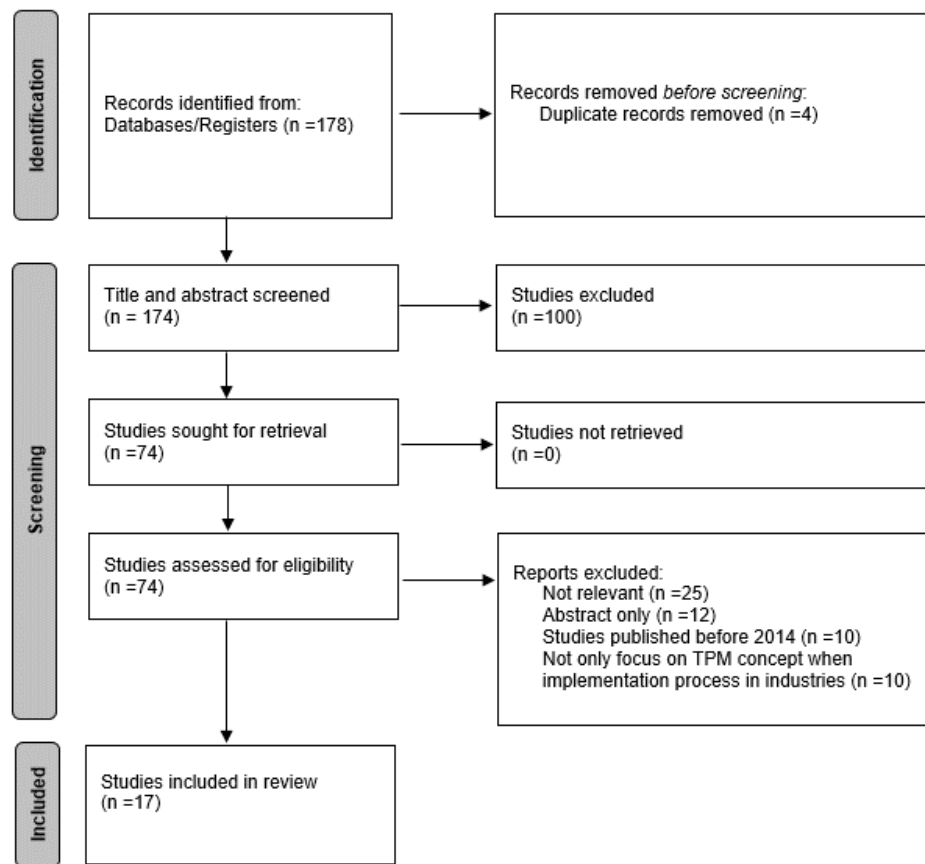
Data extraction and synthesis

Two reviewers independently extracted the data using customized tables. Data items used during the extraction were as follows; author/s, year of publication, title, challenges, suggestions/recommendations and required skills. After the extraction the discrepancies were resolved via consensus. A formal assessment of quality of the methodologies was not performed as this review aimed to provide an overview of existing evidence regardless of quality.

Results

Overview

The flow of the studies through the search and selection process is presented in Fig. 1. The search retrieved 178 records, and among those, 04 were duplicates. Of the 178 studies, 74 studies were selected for full-text review after the title and/or abstract screening. At the end of the full-text review, 17 studies were included in this review.



**Fig.1 Preferred Reporting Items for Systematic Reviews and Meta-Analyses
Flowchart for the Article Search**

Study Characteristics

The review consists of 17 studies conducted in various manufacturing industries categorized into 03 types, on the Challenges of implementing TPM. These data present a comprehensive picture of the difficulties faced and the strategies employed, with several significant trends and concerns emerging from the analysis.

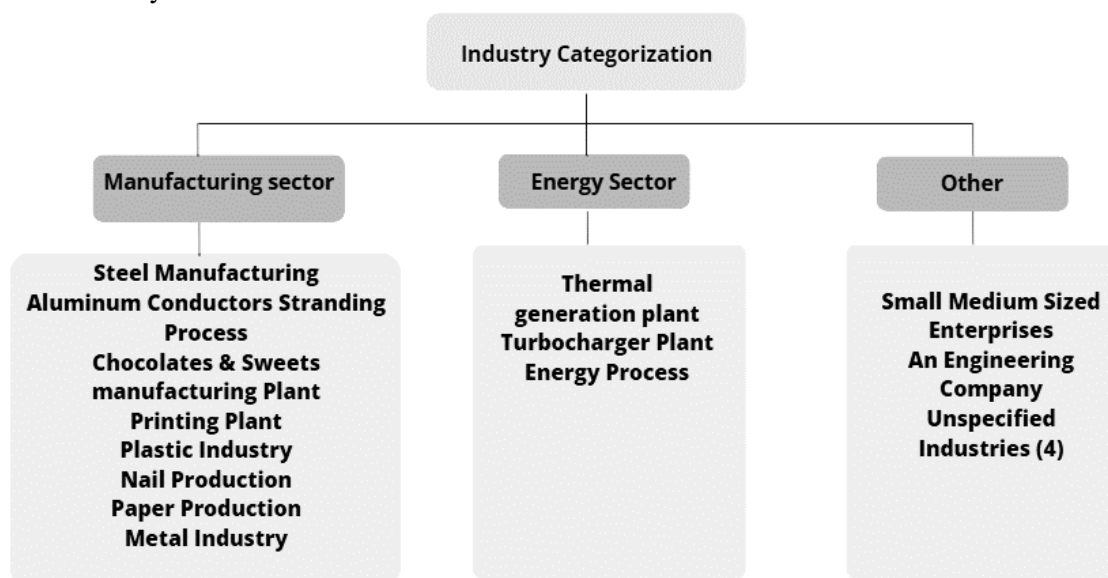


Fig. 2 Industry categories explored in the review..

The 17 studies included data published from 2014 to 2024 across various countries. India leads with the highest number of publications, accounting for 07 papers. Malaysia contributes 03 papers. The remaining countries—Thailand, Pakistan, Bosnia & Herzegovina, Ethiopia, Tanzania, South Africa and Czech Republic—each have one paper. This diverse geographic distribution highlights the global interest in understanding and addressing the challenges of TPM implementation in different manufacturing contexts.

Out of the 17 research papers, 13 are case studies which provide detail into how TPM works in specific situational contexts. The other 04 papers are of different research types such as review articles, descriptive studies and other methodologies.

Moreover, one notable study features a company awarded the TPM Excellence Award in 2013, highlighting successful implementation and industry recognition within the field.

Summary of the 17 studies considered in this review are shown in Table 1.

Table 1: Summary of the Studies on the Challenges of implementing TPM in Manufacturing Industries

Reference (Author(s) - year)	Title	Challenges identified	Suggestions/recommendations	Skills identified
Chandrashekar G1, Dr. N. V. R. Naidu - 2014	Study and Implementation of Total Productive Maintenance in Turbocharger Plant	- Identifying bottleneck machines. - TPM team implementation for the solution of issues. - Standardizing 5S activities across the cell. - Lack of knowledge regarding machines.	- Implement TPM techniques [5S, Poka-yoke, Preventive Maintenance, and Kaizen] effectively on the machines in the cell. - Comprehensive operator training.	- Knowledge about Visual control techniques, 5S, Poka yoke, Preventive Maintenance, and Kaizen. - Overall Equipment Efficiency (OEE) calculations. - Root cause analysis, Cause & Effect diagram - Team work
Pardeep Gupta - 2015	Upgrading Operational Capabilities with the Implementation of TPM Initiatives in an Indian Industry: A Case Study	- There is no quality improvement in the product/equipment - Lower employee engagement - There is no preventive & predictive maintenance system. - Unsafe working environment.	- Focus on developing autonomous maintenance teams. - TPM awareness programs for all employees. - Structured approach for change of mindset of employees, showing visible changes in work culture. - Achieve zero breakdowns, losses, defectives, and accidents.	- Understanding of TPM pillars. - Equipment maintenance Skills - Training for Individual Excellence. - Technical Knowledge - Understanding of PQCDSP (Productivity, Quality, Cost, Delivery, Safety and Morale) concept. - OEE calculations
Ignatio Madanhire, and Charles Mbohwa - 2015	Implementing Successful Total Productive Maintenance (TPM) in a Manufacturing Plant	The bad housekeeping conditions add to the high defect rate and demotivate the operators.	Integrated Management System: Information sharing, core decision making and transparency that the	- On-the-job training for operators - Knowledge on TPM - OEE calculations

		• Losses because of efficiency deterioration of machines and defects in products.	technicians and operators should also follow. • Efficient human resource management practices should be ensured.	• Identification of machine issues (e.g., oil leakage, dirty areas, abnormal noise/vibration) • Root-cause analysis • Lean manufacturing structures
Pradeep Kumar Shetty, Lewlyn L. R. Rodrigues - 2016	Optimizing a production system using tools of total productive maintenance	• Identifying losses and failures • Employee empowerment • Achieving an OEE comparable to world-class manufacturing systems. • Reduction of losses from breakdowns, maintenance-related problems, start-up defects, process defects, and totally defective output.	• Improve OEE. • Maintain 5S practices. • Adopt lean manufacturing systems. • Promote continual improvement. • Empower employees.	• Knowledge of TPM, TQM, Lean, 5S principles and practices, preventive and predictive maintenance. • Ability to identify and analyze various types of equipment losses & failures. • OEE calculations • Teamwork & leadership skills
O. Joochim ¹ and J. Meekaew - 2016	Applying Total Productive Maintenance in Aluminum Conductor Stranding Process	• Waste reduction, downtime reduction, and quality improvement. • Identifying critical equipment and implementing corrective actions. • Increasing OEE and productivity.	• Arrange extended periods for autonomous maintenance due to few operators for a big machine. • Implement focused improvement to reduce losses in the workplace.	• Knowledge in Autonomous maintenance and focused improvement. • Knowledge in TPM pillars • OEE calculations

Munyaradzi Kapuyanyika, Kinjal Suthar - 2018	Review on the Implementation of Total Productive Maintenance	• Lack of managerial support. • Engineers are technically skilled but need more training in economics and corporate finance. • Transformation of work culture.	• Value Driven Maintenance (VDM) is suggested to identify the best maintenance strategy and justify the need for management to invest in maintenance strategies. • OEE should be used . • Effective communication of goals, intertwining TPM with goal setting, and actively managing cultural change are proposed to enhance TPM program success.	• Technical skills in maintenance & operations. • Economic and financial skills . • Skills in using VDM. • OEE calculations
Srikrishna Baskar Rao, Asuthosh Pattanaik - 2019	A Paper on Total Productive Maintenance	• Conflict about organizational culture. • Lack of enthusiasm for a new system inadequate training and education. • Lack of expertise in productivity and quality. • TPM objectives not being in line with shop floor operations. • Teamwork is lacking. • Insufficient expertise and experience. • Insufficient involvement of all employees.	• Use the OEE as a tool to examine the present condition and determine where the improvement process should begin. • Change the preventive maintenance plan for all machines. • Maintain commonly problematic spare parts in stock. • Establish a quality system and department. • Provide periodic training for operators.	• Maintenance and repair skills • Operational skills • Inspection and Monitoring skills • OEE calculations

		Relationship roadblock between manufacturing and maintenance departments.	Utilize the maintenance system to create a more reliable and stable production system.	
S. Salmi, M.Z. Nazrin, H. Norlena - 2019	Applied of Total Productive Maintenance Concepts in Energy Industry: Organizations Practices	- Communication gaps regarding TPM policies. - Safety concerns with critical equipment. - Cultural barriers and resistance from senior employees. - Staff faced difficulties adapting and adopting TPM as a new tool at the workplace. - Realizing the need for TPM requires support from top management, community, and all staff levels.	- Collecting improvement suggestions from all interviewees to understand their perspectives on TPM. - Developing a proactive approach to TPM rather than a reactive one. - Create career paths based on TPM ranking. - Implement a reward system for proactive employees. - Integrate TPM with other initiatives. - Ensure active management participation.	- Top management roles - TPM Activities - Operator involvement - Technical skills. - Leadership and motivation. - Communication skills. - Problem-solving skills. - OEE calculations
Zhang Tian Xiang , Chin Jeng Feng - 2020	Implementing Total Productive Maintenance in a Manufacturing Small or Medium-Sized Enterprise	- Shop floor resistance - Need for leader-driven activities - Financial and human resource burden - Low initial employee awareness - Poor production arrangements	- Establish a steering committee - Conduct a prudent pilot run of TPM. - Implement initial 5S and focused improvement. - Use public free sources and internet for resources and training.	- Knowledge in TPM - Ability to conduct training sessions - Data collection and monitoring - Leadership and management skills - Problem-solving

		• Equipment performance issues	• Introduce a sustained system (standards, visualization, routinization, patrol system, continuous improvement)	• Communication and teamwork skills • OEE calculations
Vladimíra SCHINDLEROVÁ, Ivana ŠAJDLEROVÁ, Václav MICHALČÍK, Jan NEVIMA, Lucie KREJČÍ - 2020	Potential of Using TPM to Increase the Efficiency of Production Processes	• Technical downtime and unplanned shutdowns of manufacturing devices due to failures, unplanned repairs, and maintenance. • Maintaining the perfect condition of new devices from the beginning of their delivery.	• Detailed monitoring and data collection at individual workplaces. • Designing new shift and weekly maintenance plans in a well-arranged and user-friendly way to be used by operators. • Direct implementation of all principles and improvement actions on new devices to maintain their perfect condition from the start.	• Ability to analyze technical downtime and unplanned shutdowns. • Competence in detailed monitoring and data collection. • Proficiency in designing and implementing maintenance plans. • Skill in early detection and documentation of abnormalities. • Application of autonomous maintenance principles. • OEE calculations
Ahmad Nur Aizat Ahmad, Md Fauzi Ahmad, Norhadilah Abdul Hamid, Nor Aziati Abdul Hamid, Rumaizah Ruslan, Edwin Lamani, Gusman Nawanir, Adnan Bakri, Mustaqqim Abdul Rahim - 2020	TPM: Factors and Barrier Analysis Towards Maintenance efficiency in Manufacturing Industry	• Resistance by employees • Lack of tools and instruments. • Lack of top management commitment. • Lack of training. • Lack of maintenance training.	• Proper training programs for employees. • Provision of necessary tools and instruments. • Top management commitment and monitoring. • Encourage collaboration between maintenance and production staff.	• Technical skills for maintenance • Training and development skills • Collaborative skills • Problem-solving skills • OEE calculations • Analytical skills (Ex: SPSS software)

Tauseef Aized - 2021	Analysis and Implementation of TPM in Plastic Industry	• Machine breakdown and waste reduction • Implementation of Total Productive Maintenance strategy • Evaluate the existing maintenance system of the plant to identify areas for improvement.	• Implement TPM strategy. • Conduct scheduled maintenance (weekly, monthly, and yearly). • Involve operators and maintenance teams in training. • Implement the Eight Pillar Strategy (EPS).	• Qualitative and quantitative evaluation methods • Maintenance skills/techniques • Knowledge on TPM concept • OEE calculations
Issa H. Danguche and Ismail W. R. Taifa - 2022	Factors Influencing Total Productive Maintenance Implementation for Thermal Generation Plants	• Machine breakdowns, and customer dissatisfaction. • Lack of appropriate maintenance approaches in thermal generation plants.	• Implementing effective TPM. • Technical factors like planned maintenance, autonomous maintenance, quality maintenance, and early equipment management should also be prioritized.	• Management support • TPM awareness • Employee participation • Strategic planning • TPM pillars • Root cause analysis
Dejan Brankovic and Zdravko Milovanovic - 2022	The Role and Significance of TPM Concept Application in Industrial Systems Maintenance	• Cultural Resistance • Training and Education • Resource Allocation • Sustaining Improvements • Integration with Other Systems • Measuring Effectiveness • Safety Considerations	• Ensure comprehensive training and education programs for all employees. • Allocate sufficient resources and support from top management. • Integrate TPM practices seamlessly with other operational systems. • Develop and implement robust data collection and analysis systems to continuously monitor and improve maintenance performance. • Prioritize worker safety.	• Technical competency • Problem-solving abilities • Attention to detail • Communication skills • Adaptability and flexibility • Safety awareness • Continuous learning • OEE calculations

Sukhpreet Singh, Ashish Agrawal, Deepak Sharma, Vishnu Saini, Abhinav Kumar, and Seepana Praveenkumar - 2022	Implementation of Total Productive Maintenance Approach: Improving Overall Equipment Efficiency of a Metal Industry	• Employee resistance • Management commitment • Skill deficiencies • Resource constraints • Operational challenges	• Enhance management commitment. • Employee involvement and training. • Structured maintenance system. • Improving work environment • Continuous improvement	• Technical skills • Problem-solving skills • Training and development • Leadership and teamwork • Health and safety awareness • OEE calculations
Mudit M. Saxena - 2022	Total Productive Maintenance (TPM); As a Vital Function in Manufacturing Systems	• Need for management support for new philosophy. • Commitment to cultural change required by management. • Trust issues between workforce and management. • Potential for low morale and frustration with management. • The challenge of integrating new systems with existing ones.	• Management should understand and support the new TPM viewpoint. • Training programs should be developed and funded for everyone. • Improvement areas should be identified. • Performance goals should be formulated. • An implementation plan should be developed. • Independent work groups should be established. • Benchmarking with successful firms for valuable insights. • Top management should spend significant time encouraging the system. • Full commitment from management is necessary.	• Autonomous maintenance. • Predictive and preventative maintenance. • Continuous improvement. • Employee involvement and motivation. • Data and statistical tool usage. • Cross-functional teamwork.

Fasikaw Fasikaw Kibrete and Ashenafi Ashenafi Abuye. -2023	Implementation of Total Productive Maintenance (TPM) in a Nail Production Process: A Case Study	• Improper cleaning and lubrication of machine components leading to machine breakdowns. • Maintenance technicians performing tasks without manuals causing machine failures. • Frequent tool breakage due to operator inefficiency impacting performance. • Lack of a planned maintenance schedule.	• Focus on continuous improvements. • Encourage operators to take responsibility for routine maintenance tasks to free up skilled maintenance staff for more technical repairs. • Consider implementing the remaining TPM pillars. • Develop and implement CLIT tools for cleaning, lubrication, inspection, and tightening standards.	• Multi-skilled revitalized operators and maintenance workers who are efficient in performing all required activities without support. • OEE calculations
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Discussion

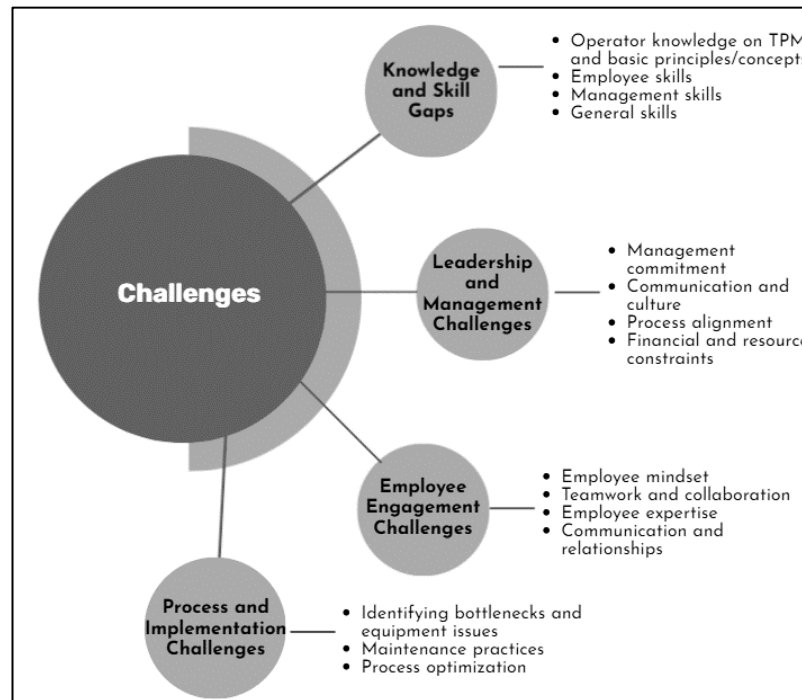
This systematic review aimed to address the issues of TPM implementation in manufacturing sectors, which often results in less reliable equipment and operational shortcomings and review industry experts' suggestions and provide essential skills that required for anyone who interest to work in an industrial sector which focuses TPM. The review examined 17 studies from different countries offering a thorough insight into the worldwide interest in TPM and the abilities needed to put it into action.

The results of this review highlight the vital role of both particular technical and soft skills in coping with the challenges that arise in the course of the implementation of TPM. The study has made a contribution to the existing knowledge of TPM by identifying the crucial competencies for its implementation and thereby developed the insight about the practical skills required for successful TPM implementation.

Studies have found that TPM has a huge positive impact on the production process in terms of productivity improvement and equipment downtime reduction. TPM has been shown to be a successful method to increase productive capacity and quality (McKone, 1999). This analysis of the evidence validates these conclusions and goes further by presenting a comprehensive description of the vital skills necessary to overcome the TPM implementation problems. Contrasting to previously conducted studies that concentrated on the results of TPM only, this review addresses the skills that are needed to achieve these results, and thus offers a more practical framework for the industry and academia.

The number of inclusions and possible publication bias, however, set a limit to this review. In addition, variations in the quality and scope of the included researches might influence the generalizability of the findings. In the future, research can focus on longitudinal studies in order to establish long-term effects of TPM training programs on labor productivity and industry performance.

Classification of challenges reported in studies on implementing TPM within manufacturing organizations.



Categorized challenges and corresponding expert suggestions for successful TPM implementation

Fig. 3 Classification of challenges reported in the review.

Table 2: Categorized Challenges and Corresponding Expert Suggestions for Successful TPM Implementation

Type of challenge	Summarized suggestions
Knowledge and Skill Gaps: Unskilled workers, skill variety limitations, skill gaps.	Organize training sessions/workshops (machines, 5S, basic maintenance practices, TPM pillars, Kaizen, etc.) for all levels.
Leadership and Management Challenges: Lack of managerial support, ineffective communication, cultural resistance, process misalignment.	The commitment and active involvement of top management, improve management communication, using Value Driven Maintenance (VDM) to justify investment, make use of OEE as a performance measure, pilot trial TPM to establish the resource requirement.
Employee Engagement Challenges: Rigid mindset, lack of teamwork, insufficient expertise/experience, limited employee involvement	Roll out TPM Awareness and Focused Improvement activities for validation of benefits, collect employee suggestions, establish TPM-skills based career paths, rewards for proactive employees, integrate TPM with other initiatives to compliment culture.
Process and Implementation Challenges: Bottlenecks issues identification, no formal maintenance program, lack of safe work environment, identifying losses/failures, waste	Implement TPM related techniques (5S, Poka-Yoke, and preventive maintenance), introduce Kaizen and Just-In-Time systems, drive out all breakdowns/losses/defects/accidents, implement OEE, implement Lean Manufacturing principles, focus on improving the performance of planned maintenance,

reduction/downtime, quality improvement, critical equipment issues, low OEE/productivity.	implement changes to the Preventive maintenance schedule, create a quality system/department.
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Skills framework for TPM-focused careers

Outlined are essential TPM-focused skills designed to prepare careers for effective implementation of TPM in manufacturing industries from the reviewed papers.

Table 3: Skills framework for TPM-focused careers

Type of skill	Key skills
Technical Knowledge and Skills	1. Knowledge of TPM pillars, Lean, TQM, Kaizen, 5S principles, and practices 2. Preventive and predictive maintenance 3. Equipment-related technical skills 4. OEE (Overall Equipment Efficiency) calculations
Analytical and Problem-Solving Skills	1. Root cause/ 5 why analysis 2. Data analysis and statistical tool usage (e.g., SPSS) 3. Ability to identify and analyze equipment losses and failures.
Health, Safety, and Environmental Awareness	1. Awareness of health, safety, and environmental standards.
Economic and Financial Skills	1. Understanding of economic and financial characteristics of maintenance and operations
Teamwork and Leadership	1. Effective communication 2. Teamwork 3. Leadership & management skills 4. Ability to conduct training sessions

Conclusions and Recommendations

This systematic review identified and classified the most prominent challenges in the implementation of TPM within manufacturing industries: knowledge and skill gaps, management and leadership barriers, employee engagement issues, and process implementation challenges. Analysis outlined that technical and soft skills are important for implementing an effective TPM practices in industries. These desired skills must be led by in-depth knowledge of TPM pillars, preventive maintenance, and calculation of OEE, and development of in-depth root cause analysis skills.

The competencies mentioned in this paper can greatly benefit for those who aspiring to practice TPM in the industrial sector. They can develop into expert TPM practitioners by identifying the gaps in their skills and knowledge. These results present an actual, practical framework of insight into the vital proficiencies for TPM implementation success, which offers valuable guidance on career development in this field.

Considering the challenges that have been identified, there is a requirement for systematic combination of TPM-related skills into the professional development programs of any individual with a desire to pursue TPM and related industries. These need to orient with practical-oriented training, constant skill development assessment, and strong links between educational institutions, training providers, and industry partners. This will empower future TPM employees with relevant expertise to contribute meaningfully within organizations.

Acknowledgment

It is with much appreciation and gratitude that we acknowledge those whose tireless efforts have contributed to filling the literature relating to TPM. Their work provided invaluable insights that greatly inform this systematic review.

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