International Journal for Multidisciplinary Research (IJFMR)

E-ISSN: 2582-2160 ● Website: www.ijfmr.com ● Email: editor@ijfmr.com

Analysis of TPM and OEE with Case Studies

Aayush Shinde[1], Anish Shinde[2], Pravin Sambhaji Gosavi[3]

[1,2]U.G. Student, Department of Mechanical Engineering, KIT Engineering College, Kolhapur, Maharastra, India
[3]Assistant Professor, Department of Mechanical Engineering, KIT Engineering College, Kolhapur, Maharastra, India

Abstract
The primary aim of this research paper was to provide a detailed overview of Total Productive Maintenance (TPM) and Overall Equipment Effectiveness (OEE) within the manufacturing sector. We conducted a narrative research study based on existing empirical data, case studies, and literature reviews.

Equipment productivity is a pressing issue in manufacturing, directly impacting costs. TPM and OEE offer solutions to improve this productivity by addressing factors like time, materials, processes, and costs. This paper focused on TPM and OEE but acknowledged the potential for future research to explore other maintenance practices comprehensively.

In today's competitive environment, manufacturing plants must achieve world-class operational standards, including high-quality, timely production. TPM is a key approach, aiming to maximize equipment effectiveness through employee involvement. However, many plants struggle with TPM implementation due to inadequate planning and awareness.

Our research specifically examined the adoption of TPM in Small and Medium-sized Enterprises (SMEs). Results showed that 52% of SMEs surveyed had implemented TPM, while 48% had not. The study aimed to understand the extent of TPM usage and reasons behind not implementing it.

In summary, this research emphasizes the importance of TPM and OEE in enhancing equipment productivity. It also highlights the challenges SMEs face in TPM adoption, stressing the significance of planning and awareness for TPM's successful implementation.

Introduction

Total Productive Maintenance (TPM) serves as an extension of the Lean manufacturing system, aiming to achieve the ultimate goals of zero breakdowns, zero accidents, and zero losses. The reliability of machine uptime is paramount, as unpredictable downtime can significantly hinder an industry's ability to meet the velocity of sales. Therefore, the integration of a proactive system becomes imperative. By investing in proper training and implementing autonomous preventive maintenance (PM), organizations have witnessed notable enhancements in Overall Equipment Effectiveness (OEE) while concurrently reducing machine breakdowns. TPM is rooted in the continual pursuit of process and production efficiency improvement, fostering daily engagement from all individuals involved in the production process, with an unwavering focus on achieving zero defects, zero accidents, and zero stops.

In today's fiercely competitive business landscape, organizations employ various techniques and strategies to ensure their survival and growth. Successful implementation of these strategies not only reduces costs but also aligns with customer requirements. Among these strategies, Total Productive Maintenance (TPM) stands out as a widely embraced approach for optimizing maintenance activities and performance. Applicable across manufacturing, service, and process industries, TPM transcends individual and organizational perspectives by involving all levels of an organization. It effectively eliminates waste and production losses, resulting in cost reduction and heightened productivity. TPM empowers operators to assume responsibility for regular machine maintenance, instilling a sense of ownership. Additionally, it maximizes Overall Equipment Effectiveness (OEE) by enhancing equipment availability, performance efficiency, and quality standards. Recognizing the pivotal role of SMEs in the Indian industrial landscape, it is evident that TPM and similar modern technologies are essential for these enterprises to thrive amid stiff competition. While implementing TPM pillars may be simpler for SMEs compared to large-scale industries, the success of its implementation remains contingent on embracing its principles. A comprehensive analysis indicates that there is room for improvement in TPM awareness among stakeholders, with efforts needed to educate individuals about TPM's potential benefits.

The analysis of responses reveals that approximately 46% of individuals are well-informed and familiar with the TPM strategy. Furthermore, 33% of respondents expressed neutrality when queried about their awareness of TPM, while 21% acknowledged that they have not encountered TPM previously. These responses underscore the limited level of awareness among respondents regarding TPM. Consequently, there is a pressing need for educational efforts aimed at enlightening individuals about TPM and the myriad benefits it can offer.

PILLARS OF TOTAL PRODUCTIVE MAINTENANCE

PILLAR1-JISHU HOZEN (JH)

This innovative seven-step methodology is a distinctive approach designed to gradually transform an operator into a maintenance specialist capable of handling basic maintenance tasks for their machines. By breaking down the process into manageable steps, it empowers operators to develop an intimate familiarity with the machine and its components. This hands-on experience fosters a unique bond between the operator and the machine, effectively transitioning them from mere machine operators to dedicated caretakers. It is essential to recognize that operators, while not necessarily qualified engineers or experienced fitters, possess an unparalleled depth of knowledge about the specific machines they operate. This knowledge, accumulated through firsthand experience, positions them as invaluable resources for machine maintenance and upkeep.

Step 1: Initial Cleaning

The first step in our methodology involves a thorough initial cleaning of the machine. This process serves a dual purpose: it helps operators identify any abnormalities on the machine and reduces the potential for future breakdowns. During this cleaning, operators tag any areas where abnormalities are observed. Subsequently, an analysis of these observations is conducted, leading to appropriate actions aimed at preventing these abnormalities. Keeping the machine neat and clean is crucial for ongoing maintenance and preventing the recurrence of issues. Operators play a vital role in maintaining the cleanliness of the machine to safeguard it from premature deterioration.

Step 2: Counter Measures Against Contamination and Hard-to-Access Areas

In the second step, we address sources of contamination and hard-to-access areas within the machine. Contaminants like dust and oil can mix with lubricants or accumulate in various machine components, potentially causing abnormalities and future breakdowns. Identifying these sources, such as coolants and lubricants, is essential. While some sources cannot be eliminated entirely, containment measures can be implemented. This step involves the installation of localized guards and open-close windows, not only to maintain cleanliness but also to make previously hard-to-reach parts accessible for cleaning, inspection, lubrication, and tightening of loosened components. This attention to basic maintenance significantly reduces the likelihood of breakdowns.

Step 3: Implementation of Tentative Standards

Step three entails the creation of tentative standards in collaboration with maintenance personnel, operators, qualified engineers, and experienced fitters. Operators actively monitor and enforce these standards to ensure that identified abnormalities do not resurface.

Step 4: General Inspection

In the fourth step, trained operators perform general inspections on various subsystems of the machines, such as pneumatic systems, lubrication systems, and fasteners. This focused inspection helps identify and analyze abnormalities specific to the machine's operation, enabling prompt corrective actions.

Step 5: Autonomous Inspection

Step five introduces the use of checklists, allowing even inexperienced personnel to conduct inspections independently following predefined criteria. Autonomous inspection serves the dual purpose of implementing visual controls and preventing careless errors in maintenance activities.

Step 6: Standardization

Step six revolves around standardization. The objective here is to review the operator's role, improve ongoing activities, enhance maintenance practices, and establish a system for consistency. Implementing standards and visual control checkpoints at the workplace ensures a structured approach to machine maintenance.

Step 7: Autonomous Management

The final step, step seven, emphasizes autonomous management. When consistently applied, these activities ensure that a machine experiences minimal breakdowns due to forced deterioration. Autonomous management not only prevents breakdowns but also strives for zero failures and zero defects, aligning with the ultimate goal of maintenance excellence.

Pillar 2: Kobetsu Kaizen (KK) - Continuous Improvement

Kobetsu Kaizen, where "Kai" signifies change and "Zen" denotes continuous improvement, involves a small group of employees collaborating to enhance machine performance across several dimensions, including productivity, quality, cost, safety, delivery, and morale. This pillar aims to combat 16 chronic losses through targeted activities. These Kobetsu Kaizen initiatives focus on eliminating these chronic losses by harnessing technological, analytical, and Kaizen (continuous improvement) methodologies, ultimately striving to reduce all 16 losses within the plant to zero.

Pillar 3: Planned Maintenance (PM) - Reducing Unplanned Downtime
Planned Maintenance is a crucial pillar aimed at reducing instances of unplanned equipment downtime. During scheduled equipment shutdowns, various maintenance activities are executed to measure failure rates accurately. Six significant losses are identified within TPM, including breakdown losses, set-up and adjustment losses, minor idling stoppage losses, reduced speed losses, defect rework losses, and start-up losses. This pillar strives to minimize these losses through structured maintenance planning.

Pillar 4: Quality Maintenance (QM) - Zero Defect Philosophy
The Quality Maintenance pillar instills a zero defect/non-conformity philosophy within the organization. This pillar specifically addresses quality issues by initiating improvement projects focused on identifying and removing the root sources of defects.

Pillar 5: Initial Flow Control (IFC) - Efficient Equipment Purchase
Initial Flow Control introduces the use of Maintenance Prevention (MP) sheets and Life Cycle Costing (LCC) sheets. The LCC sheet plays a pivotal role in the equipment procurement process, helping the industry make informed purchase decisions based on the equipment's expected life cycle costs.

Pillar 6: Office TPM (OTPM) - Extending Benefits to Administrative Functions
Office TPM is implemented after achieving the four initial pillars (JH, KK, QM, PM). This pillar extends TPM principles to administrative functions such as order processing, procurement, and scheduling. Its objective is to reduce waste and improve efficiency in office processes.

Pillar 7: Education & Training (E&T) - Building Knowledge and Skills
The Education & Training pillar emphasizes the importance of not just knowing "how" to perform tasks but also understanding "why" they are done a certain way. This pillar provides training to employees, equipping them with multi-directional skills to perform their jobs effectively.

Pillar 8: Safety, Health & Environment (SHE) - Ensuring Well-being
Safety, Health & Environment (SHE) is the final pillar, focusing on maintaining peace of mind among employees. Its core purpose is to achieve zero accidents, zero health damage, and zero pollution within the workplace. SHE ensures that employees work in a hygienic environment with peace of mind, promoting overall well-being.

Case studies

A comprehensive case study was undertaken at a prominent structural steel mill over a span of six months. The primary objective of this study was to meticulously examine breakdown occurrences within the mill, focusing on their distribution across different sections, types, and specific pieces of equipment. The intent was to identify critical areas where breakdowns were most frequent, ultimately aiming to improve operational efficiency and reduce downtime.

The research methodology employed in this case study involved a combination of data collection, analysis, and in-depth observations.

section	No of breakdowns	Percentage (%)
Mechanical	96	65.75
Electrical	9	6.16
E&I	36	24.66
Mechanical+El	5	3.42

In the course of this extensive six-month breakdown analysis, a total of 146 breakdown incidents were meticulously observed. The findings indicated that a significant proportion of these breakdowns, constituting 66% (96 out of 146 breakdowns), occurred within the Mechanical section of the manufacturing facility. Additionally, it was noted that breakdowns were most prevalent in the medium-type equipment category, totaling 87 incidents, with a cumulative downtime of 1,817 minutes. Furthermore, the equipment identified as "stacker" registered the highest number of breakdown occurrences, amounting to 13 incidents, with a cumulative downtime of 299 minutes.

Consequently, the compelling data and observations from this analysis lead us to a clear and vital conclusion: the equipment categories of "Stacker," "Cooling Bed," and "Cold Saw-2" have exhibited a notable tendency for frequent breakdown occurrences. In light of this revelation, it is imperative to embark on Corrective Action and Preventive Action (CAPA) initiatives aimed at rectifying and mitigating these issues. These actions are crucial for achieving the overarching goal of Total Productive Maintenance (TPM), which strives to optimize equipment performance, minimize disruptions, and enhance overall operational efficiency.

In summary, the data-driven insights from this six-month breakdown analysis underscore the urgency of addressing breakdowns within specific equipment categories. By implementing targeted CAPA measures in the identified areas of concern—particularly the "Stacker," "Cooling Bed," and "Cold Saw-2"—the manufacturing facility can work towards realizing its TPM objectives and ensuring the uninterrupted flow of production processes.

Autonomous maintenance groups were established to enhance equipment reliability and maintainability. Effective training programs, workshops, and seminars were conducted for employees involved in TPM activities. The plant's overall OEE was closely monitored to identify and eliminate significant losses, involving a highly motivated workforce to enhance customer satisfaction. Data on OEE, quality (customer complaints), maintenance, safety, and losses were collected and analyzed. The 5S concept was introduced to ensure a clean, organized workplace. In this study, we elaborate on TPM implementation in the industry, highlighting tangible and intangible benefits. TPM not only boosts manufacturing system efficiency but also enhances overall organizational effectiveness by fostering participation and continuous improvement in TPM key performance indicators.

In this research paper, we present a compelling case study of the significant improvements achieved through the implementation of Total Productive Maintenance (TPM) initiatives within a manufacturing organization. The data analysis reveals a remarkable surge in two-wheeler production compared to the benchmark year. It illustrates a substantial increase from an average monthly production of 78,442 units to an impressive 232,200 units, showcasing the tangible impact of TPM on productivity enhancement. Concurrently, it showcases a substantial reduction in customer complaints, plummeting from 64 to a mere 10. This marked decrease signifies a noteworthy enhancement in product quality, achieved through TPM activities, encompassing improvements in raw materials, semi-finished and finished products.

Furthermore, our study underscores the economic benefits of TPM. The cost of operations, initially at 62 million, saw a significant reduction to 50 million during successful TPM implementation. The rigorous monitoring of the six big losses, aimed at enhancing Overall Equipment Effectiveness (OEE), led to increased production yield within the same timeframe. The paper also highlights the vital aspect of delivery adherence, as depicted in data. Delivery adherence catapulted from 75% to a commendable 96% after TPM interventions, attributed to improvements in logistics, addressing issues related to loading, unloading, labor, raw materials, and transportation. Additionally, the study emphasizes the importance of safety, health, and the environment within TPM. It underscores the creation of a safe and clean working environment, reducing accidents caused by unsafe conditions and underscoring the significance of safety measures and pollution control.

Moreover, the research paper delves into the role of motivation in TPM implementation. Motivation strategies, such as banners, signs, newsletters, and awards to contributing employees and shifts, played a pivotal role in maintaining enthusiasm and fostering a positive work culture. The paper emphasizes that effective human resource management practices and a motivated, well-trained workforce are critical factors in achieving the high-level TPM performance evident in the study. This research paper provides valuable insights into the multifaceted benefits and transformative potential of TPM, making a compelling case for its adoption in manufacturing organizations striving for operational excellence and enhanced customer satisfaction.

Over a targeted three-year period, the organization achieved significant improvements across various key performance indicators. Notably, the average monthly production volume surged from 78,442 units to an impressive 232,200 units due to the successful implementation of TPM initiatives. This increase was attributed to enhanced Overall Equipment Effectiveness (OEE), autonomous maintenance, and the consequent reduction in breakdowns and failures.

Customer satisfaction also saw a substantial boost, with customer complaints dropping from 64 to just 10, showcasing the improved product quality resulting from TPM efforts. Furthermore, operational costs witnessed a notable decrease, decreasing from 62 million to 50 million, thanks to diligent monitoring and elimination of the six major sources of losses.

TPM's positive impact extended to delivery adherence, which improved by 16%, and workplace safety, with accidents reduced by 100%. Additionally, employee morale received a significant uplift, evident through a substantial increase in kaizens from 320 to 6,042 and a remarkable reduction in absenteeism from 15% to zero. These achievements were attributed to the systematic implementation of the 5S methodology, reduced accidents, and skill-enhancing training on the shop floor.

In conclusion, the organization's continued commitment to TPM, coupled with a positive team spirit, has been instrumental in achieving and sustaining growth across multiple facets of its operations.

In this research paper, we present a comprehensive assessment of the Overall Equipment Effectiveness (OEE) of CNC Table Type Boring and Milling Machines within a Heavy Machinery Manufacturing Plant. Employing a case study methodology, we collected both primary and secondary data to conduct a thorough analysis. The investigation revealed that the CNC machines in question were operating significantly below the proposed world-class OEE standard, highlighting ample room for improvement.

During our observations, we identified a critical issue involving tool selection and tool insert availability, resulting in prolonged equipment downtime, sometimes lasting up to 60 minutes. To address this challenge, we recommend the recruitment of experienced personnel and the implementation of a systematic tool insert classification system.

Furthermore, we propose the provision of an Operation Process Sheet (OPS) and component drawings to operators before commencing their tasks. This initiative aims to facilitate a clearer understanding of the machining sequence, ultimately enhancing efficiency.

In addition, we noted deficiencies in the arrangement of clamps during the loading process, coupled with insufficient training for operator assistants, leading to unnecessary setup time increases. To mitigate this, we advocate for improved clamp arrangement and enhanced training for operator assistants.

Upon implementing these recommendations, we observed a notable improvement in the OEE score of the CNC table machines, rising from a mere 62% to a commendable 75%. However, it's important to acknowledge that this figure still falls short of the world-standard OEE. Hence, there remains substantial room for further enhancement.

In conclusion, our research underscores the critical importance of addressing these operational inefficiencies to achieve higher OEE levels, ultimately contributing to improved productivity and competitiveness within the heavy machinery manufacturing sector.

In this study, data was collected from daily production reports to assess the Equipment Effectiveness of four Injection Molding Facilities. The results revealed that two out of the four facilities fell short in Equipment Effectiveness by as much as 10% when compared to the world-class OEE standard. Conversely, the remaining two facilities operated optimally and even exceeded the suggested OEE standard of 85%.

In addition to computing the OEE scores, we conducted a Pareto Analysis to identify the most frequent causes contributing to lower OEE scores. Furthermore, a 5 Why Analysis was undertaken to pinpoint the root causes of breakdowns, with Operator Breaks and Setup and Adjustment Times emerging as the most significant contributing factors.

It is important to note that this study's scope was delimited to evaluating the current equipment scores rather than delving into OEE score improvement. The focus was primarily on assessing the existing performance of the equipment. Enhancements in OEE are considered as potential areas for future research and investigation.

In conclusion, this study sheds light on the varying Equipment Effectiveness levels within the Injection Molding Facilities and identifies key contributing factors to lower OEE scores. The prospects for OEE improvement are left as an avenue for future research endeavors.

This research provides a comprehensive guideline for enhancing the production rate of a tire curing press while concurrently reducing downtime and maintenance costs, emphasizing the pivotal role of a maintenance management strategy grounded in Overall Equipment Efficiency (OEE). The study employs a methodology that evaluates the OEE of the tire curing press both before and after addressing the root causes of failures. To identify these causes, the Failure Mode and Effect Analysis (FMEA) technique, in conjunction with risk priority numbers, is employed.

The outcomes of this research showcase a substantial improvement in OEE values following the rectification of recurring failures identified through the FMEA technique. Consequently, it is affirmed that the integration of OEE and FMEA serves as a powerful mechanism for bolstering industrial efficiency and bolstering the competitive edge of the production facilities under investigation. It's important to note that this research concentrates exclusively on evaluating the OEE of individual machines within a manufacturing setup rather than assessing the entire production process. Given the unique operational contexts of manufacturing facilities, it would not be judicious to make direct comparisons between different production facilities based solely on OEE values.

This research is highly adaptable and can be readily applied in the tire industry or any sector where optimizing equipment downtime, enhancing efficiency, and reducing maintenance costs are strategic imperatives. The novel perspective presented in this paper, which focuses on pinpointing bottlenecks within the tire production line, demonstrates its originality and promising results. This approach can serve as a blueprint for improving manufacturing efficiency and productivity across various production equipment, lines, and factories within the studied organization, ultimately driving sustainable competitive advantages.

The research aimed to optimize Production Planning and Process Improvement within an impeller manufacturing facility. The approach involved a comprehensive review of current Planning and Scheduling techniques, identification of process bottlenecks, streamlining changeover processes, and reducing process inventory. The research employed SMED principles derived from Lean manufacturing and utilized the Preactor APS Scheduling Software developed by Siemens. The outcomes were notable, with a 4.4% enhancement in Delivery Performance and a substantial 47% reduction in setup times for specific impellers.

In addition to this research, an extensive OEE evaluation was conducted, encompassing 23 different companies and 884 devices. The research determined that the average OEE stood at 65%. However, it was observed that nearly half of the reported OEE losses could not be adequately categorized due to incomplete or insufficient definitions of loss categories. Furthermore, a striking 90% of the identified downtime was attributed to support tasks performed by workers rather than issues within the automated process itself. Consequently, this study emphasizes the need for a comprehensive exploration of automated data acquisition systems to extract reliable OEE measures, which can significantly contribute to enhancing production efficiency.

In conclusion, the research underscores the critical role of optimizing production planning and processes, as evidenced by the substantial improvements achieved. It also highlights the challenges in categorizing OEE losses accurately and emphasizes the importance of refining data acquisition systems to drive efficiency enhancements in manufacturing operations.

The study was conducted with the primary objective of investigating the impact of total productive maintenance (TPM) and total quality management (TQM) approaches on organizational efficiency within the pharmaceutical industry, while also exploring their interdependence. This analysis encompasses three fundamental concepts: TPM, TQM, and operational efficiency in the pharmaceutical sector. Extensive literature review guided the identification of four key factors within TPM: disciplined maintenance, information monitoring, housekeeping, and worker participation. Similarly, within the scope of TQM, four frameworks were considered: quality data and monitoring, innovative products, research and development (R&D) management, and technology leadership.

In this research review, a total of 254 responses were collected from a pool of 410 Indian pharmaceutical companies that were approached for participation. Various statistical techniques such as factor analysis, path modeling, and structural equation modeling were employed to evaluate the proposed framework. The findings from alternative models were meticulously analyzed, assessed, and subsequently published. The study culminated in a comprehensive examination of the overt and covert impacts of both TPM and TQM on operational efficiency, validating and refuting pertinent theories in the process. Ultimately, this research provides valuable insights for executives operating in the pharmaceutical industry.

Scholarly sources have asserted that TQM serves as an enforcer of TPM practices. TPM, in turn, plays a pivotal role in ensuring operational consistency and product quality. High-quality products, in reciprocity, contribute to enhanced operational efficiency by reducing in-process inventory, minimizing defective products, and reducing waste. The TPM activities of an organization can significantly expedite the pace of product development and efficiency enhancements, which are critical in the context of the pharmaceutical industry. Continuous monitoring of TPM procedures aids organizations in meeting their routine operational and maintenance obligations for each machine, ensuring sustained productivity.

This study elucidates the multifaceted relationship between TPM, TQM, and operational efficiency within the dynamic and technologically advanced pharmaceutical sector. Beyond personnel, the quality of machinery and equipment stands as a pivotal determinant of an enterprise's capability. These machines necessitate regular maintenance and upgrading to meet the stringent requirements of pharmaceutical production. The meticulous implementation of TPM procedures empowers factories to enhance operational efficiency while maintaining process quality, as highlighted by Modgil and Sharma (2016).

In their research article, Hooi & Leong (2016) stated that their primary objective was to conduct an in-depth analysis of the multifaceted nature of total productive maintenance (TPM) within the Malaysian manufacturing sector and its correlation with the enhancement of production efficiency. Specifically, their study aimed to evaluate the significance of the success factors associated with individual TPM programs in driving improvements in production efficiency.

To substantiate their research model, the authors collected input from a total of 89 employees who actively participated in the survey. To contextualize their findings within the Malaysian context, they utilized a standardized questionnaire borrowed from Ahuja and Khamba (2006).

The empirical results of their research indicated that both conventional maintenance practices and TPM deployment programs had a substantial impact on operational performance. However, it's important to note that these factors did not demonstrate a similar influence on upper management and leadership within maintenance organizations. This emphasizes the critical role of top management in the early stages of TPM implementation, where their responsibilities and dedication are pivotal in defining the strategic plan and ensuring the successful execution of the entire project.

Interestingly, the study highlighted that conventional maintenance practices and TPM deployment programs progressively fostered commitment, meticulous planning, precise implementation, and a commitment to continuous improvement. Over time, these elements significantly contributed to the improvement of various metrics associated with production efficiency. Nevertheless, the results also suggested that TPM might not be a viable long-term strategy for manufacturing industries in Malaysia.

This research holds significant relevance for senior managers within manufacturing organizations, particularly those that have already implemented TPM or are considering its adoption. It sheds light on the need for a nuanced approach, recognizing the evolving dynamics of TPM's impact on production efficiency within the specific context of Malaysia's manufacturing landscape.

Conclusion

A comprehensive literature review was undertaken to explore the prominent lean tools in maintenance management, specifically Total Productive Maintenance (TPM) and Overall Equipment Effectiveness (OEE), with a focus on their application and implementation across various manufacturing sectors. It was observed that a majority of contemporary manufacturing and automotive companies, including some SMEs, food, and construction firms, have successfully integrated these lean maintenance management tools, namely TPM and OEE, into their operations.

However, despite their proven effectiveness, there remains a notable lack of awareness regarding the impact and benefits of TPM and OEE among certain companies, leading to reluctance in their adoption. Additionally, resistance from both employees and top management has emerged as a significant barrier to the implementation of these tools.

In response to these challenges, some researchers have suggested that comprehensive training is essential for all employees, from the bottom to the top of the organizational hierarchy, to ensure the proper implementation of TPM and OEE. This approach recognizes the crucial role of machine operators as the primary link in performing routine maintenance and identifying faults. By empowering employees at all levels with the necessary knowledge and skills, organizations can foster an autonomous flow of maintenance activities.

It is worth noting that while TPM concepts have gained recognition in Indian manufacturing industries, their full-scale implementation remains incomplete. This limitation is primarily attributed to inadequate planning and a lack of awareness within these industries. In some cases, maintenance functions are undervalued and seen as unprofitable endeavors.

For small and medium-sized enterprises (SMEs), which must adapt swiftly to evolving customer demands and maintain flexibility in their operations, the adoption of modern maintenance management techniques such as TPM becomes imperative. Implementing TPM in SMEs requires a concerted effort, driven by a significant cultural shift and unwavering commitment from top management. It is essential to recognize that the benefits of TPM are not immediately apparent but rather accrue gradually over time.

In conclusion, this literature review underscores the importance of raising awareness about TPM and OEE's effectiveness, addressing resistance within organizations, and promoting comprehensive training as critical steps toward successful implementation. Furthermore, it highlights the significance of TPM adoption, especially for SMEs seeking to thrive in an ever-changing business environment through improved maintenance management practices.

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