

## LITERATURE REVIEW

Total Productive Maintenance (TPM) is a proactive maintenance technique designed to increase production, reduce downtime, and maximize equipment performance. All team members, from operators to management, are involved in equipment maintenance to avoid breakdowns rather than respond to them. TPM integrates maintenance into everyday operations with the goal of zero equipment failures, problems, and accidents. Planned maintenance, staff instruction, continual improvement, and autonomous maintenance are important components. These practices not only enhance equipment performance but also extend its lifespan and reduce operational costs (Nakajima, 1988).

TPM is required for the maintenance of CNC (Computer Numerical Control) equipment, which is important for precise machining in the manufacturing sector. To guarantee precision and reliability, CNC machines need to have regular maintenance performed, such as lubrication, maintenance, and calibration. By allowing operators to conduct routine inspections, autonomous maintenance lowers unexpected breakdowns and improves output. In addition, predictive maintenance techniques, like vibration testing and thermal scanning, support identifying defects before they cause serious breakdowns. Implementing TPM in CNC machine operations leads to higher efficiency, better product quality, and lower maintenance costs (Smith & Mobley, 2008).

Figure 3 below shows Total Productive Maintenance (TPM) as a comprehensive system of equipment maintenance that involves every employee, from management down to frontline staff, with the objective to improve machinery output and reduce downtime. TPM places a high priority on preventative maintenance practices to avoid equipment breakdowns and performance loss. Manufacturers implement preventive maintenance programs to ensure that manufacturing equipment is regularly inspected, maintained, and adjusted to maintain optimal performance. TPM encourages frontline staff to participate in equipment maintenance by assigning them independent maintenance tasks. Operators in the manufacturing sector receive instruction to do routine inspections, maintenance, lubrication, and small fixes to keep equipment in good running condition. Continuous attempts to improve manufacturing processes and address equipment-related issues are supported by TPM.



Pillar of TPM

- i. Autonomous Maintenance: Every machine operator has their own responsibility for equipment maintenance, which goes from simple operations to include standard maintenance procedures like lubrication and inspection. This proactive strategy maintains production equipment in excellent condition and provides early problem discovery.
- ii. Focused Improvement: This TPM pillar supports departments to work together to promote continuous improvement. Each unit has an "improvement team" that works together to improve equipment maintenance and safety using a kaizen (improvement) methodology similar to current internal audits.
- iii. Planned Maintenance: Operators can decide when maintenance is required with autonomous maintenance, and preventative maintenance is scheduled using machine indicators and breakdown rates in planned maintenance. Availability of replacement parts, workforce planning, and effective resource allocation are all guaranteed by this method.
- iv. Quality Management: Machine breakdowns are frequently caused by structural problems rather than human mistakes. Failures may result from bad maintenance, inadequate documentation, and lack of interaction. When these are fixed, efficiency increases, downtime decreases, and dependability is improved.
- v. Early Equipment Management: Focuses on ensuring that new equipment is designed, installed, and commissioned with reliability and maintainability in mind (Mishra, 2005). Organizations can reduce the probability of future breakdowns or performance problems by taking maintenance requirements into account throughout the planning and setting-up processes.
- vi. Training and Education: Trains managers on TPM concepts and management of assets, maintenance teams planning and regulation, and operators on machine maintenance. It guarantees that everyone has the abilities required for efficient equipment maintenance.
- vii. Safety, Health, and Environment (SHE): TPM requires a structured workplace where everything has a home. Removing clutter, improving visibility, and maintaining maintenance equipment within easy reach are all benefits of proper housekeeping. This improves the effectiveness and security of maintenance procedures.
- viii. Administrative Aspects of TPM: The standard of office-based operations influences field events. The last TPM pillar is to improve local operations through the reduction of waste in administrative tasks, such as minimizing errors in receiving maintenance work requests and approving work procedure permits to accelerate the start of maintenance operations.