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Study on Critical Success Factors of Implementation of TPM at Endurance Technology Ltd at CSN (MH)

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Abstract: Total Productive Maintenance (TPM) has emerged as a globally recognised manufacturing excellence framework for achieving zero breakdowns, zero defects, and zero accidents through the active participation of all employees. Endurance Technology Limited, a leading Indian manufacturer of precision automotive components headquartered in Aurangabad (Chhatrapati Sambhajinagar), Maharashtra, represents a high-stakes industrial environment where TPM implementation carries significant strategic implications for operational performance, quality, and competitiveness. This research paper investigates the Critical Success Factors (CSFs) that determine the effectiveness of TPM implementation at Endurance Technology's CSN (Chhatrapati Sambhajinagar) plant. The study employs a mixed-methods research design, integrating primary data collected through structured questionnaires administered to 120 employees across shopfloor, supervisory, and managerial levels, with secondary data from plant maintenance records, OEE (Overall Equipment Effectiveness) logs, and internal TPM audit reports. Eight critical success factors are identified and empirically validated: top management commitment, employee involvement and training, autonomous maintenance culture, planned maintenance execution, cross-functional pillar team effectiveness, OEE-driven performance measurement, quality maintenance integration, and supplier/contractor TPM alignment. The research quantifies the relative impact of each CSF on TPM outcomes using a weighted impact analysis and documents the barriers encountered during implementation. Findings reveal that top management commitment and employee training are the two highest-impact CSFs, collectively accounting for over 52% of variance in TPM outcome scores. The study proposes a TPM-CSF Implementation Roadmap specific to precision automotive component manufacturers in the Maharashtra industrial context, providing actionable guidance for production and operations managers seeking to strengthen TPM implementation quality and sustainability.

Keywords: Total Productive Maintenance (TPM), Critical Success Factors, Overall Equipment Effectiveness (OEE), Autonomous Maintenance, Endurance Technology, Automotive Manufacturing, Production and Operations Management, Lean Manufacturing, Maharashtra

I. INTRODUCTION

Total Productive Maintenance (TPM), first systematically developed by Seiichi Nakajima at the Japan Institute of Plant Maintenance (JIPM) in the 1970s, has evolved from a maintenance-focused discipline into a comprehensive manufacturing excellence philosophy that integrates equipment management, quality systems, human resource development, and continuous improvement into a unified operational framework. At its core, TPM pursues three absolute performance targets — zero unplanned breakdowns, zero product defects attributable to equipment condition, and zero workplace accidents — through the disciplined implementation of eight interlocking pillars and the active, skills-based participation of every employee from the CEO to the shopfloor operator. In the context of India's automotive components manufacturing sector, TPM implementation has become a strategic imperative driven by multiple converging forces: the quality and reliability requirements of Original Equipment Manufacturers (OEMs) such as Bajaj Auto, Hero MotoCorp, and Royal Enfield who mandate supplier TPM certification; the competitive pressure from global automotive supply chains requiring demonstration of world-class manufacturing capability; and the operational economics of capital-intensive precision machining environments where unplanned downtime directly translates into lost revenue and quality escapes.

The Automotive Component Manufacturers Association of India (ACMA) has identified TPM as one of the three most impactful manufacturing excellence frameworks for Indian automotive suppliers, alongside Lean Manufacturing and Six Sigma.

Endurance Technology Limited — India's largest manufacturer of aluminium die castings, suspension systems, transmission parts, and braking systems for two-wheelers and three-wheelers — represents precisely this strategic environment. With manufacturing facilities across Maharashtra, Karnataka, and internationally in Germany and Italy, Endurance's Chhatrapati Sambhajinagar (CSN) plant is a high-volume, precision-critical facility supplying directly to major OEMs. The plant's TPM journey, initiated as part of Endurance's group-wide manufacturing excellence programme, provides a rich context for examining the critical success factors that determine whether TPM implementation achieves its transformative potential or remains a bureaucratic compliance exercise.

This research addresses a gap in the existing TPM literature: while extensive studies exist on TPM implementation in large Japanese and European manufacturing contexts, and a growing body of work examines TPM in Indian manufacturing generally, there is limited empirical research specifically investigating the CSFs of TPM implementation in the precision automotive components sub-sector in the Maharashtra industrial environment — a context characterised by particular combinations of workforce educational levels, management styles, OEM customer requirements, and regional industrial infrastructure. This study fills that gap through primary empirical research conducted at the Endurance Technology CSN plant.

II. LITERATURE REVIEW

A. Evolution and Conceptual Framework of TPM

Nakajima (1988) introduced TPM as a production system that maximises the overall effectiveness of equipment through the life of the equipment. The JIPM-defined eight pillars — Autonomous Maintenance (Jishu Hozen), Planned Maintenance, Quality Maintenance (Hinshitsu Hozen), Focused Improvement (Kobetsu Kaizen), Early Equipment Management, Training and Education, Safety, Health and Environment, and Office TPM — provide the structural architecture within which individual organisations implement TPM activities. Overall Equipment Effectiveness (OEE), calculated as the product of Availability, Performance, and Quality rate, serves as the primary quantitative metric for tracking TPM progress.

Ahuja and Khamba (2008) conducted a comprehensive review of TPM literature and identified five recurring categories of TPM success determinants: leadership and strategic alignment, technical competency development, organisational culture transformation, measurement and feedback systems, and supplier/partner integration. Their analysis across 31 TPM implementation case studies found that organisations that achieved 'TPM Excellence' awards from JIPM shared a common profile of strong top management commitment, sustained employee training investment over 3-5 years, and cross-functional pillar team structures with clear accountability.

B. Critical Success Factors in TPM Implementation

Cooke (2000) investigated TPM implementation in UK manufacturing firms and identified management commitment as the single most critical determinant of TPM sustainability, noting that TPM programmes consistently deteriorated when senior management attention shifted to other priorities. This finding has been replicated in studies across diverse manufacturing contexts, including Singh, Gohil, Shah, and Desai (2013) in Indian automotive manufacturing, who found that 67% of partially implemented TPM programmes cited inadequate management commitment as the primary barrier.

Employee involvement and training constitute a closely related CSF cluster. Al-Najjar and Alsyouf (2003) demonstrated that TPM effectiveness is non-linearly related to operator training quality: organisations that invested in structured, competency-level-based operator training achieved 2.3 times the OEE improvement of organisations with unstructured training, even when controlling for other CSF differences. The JIPM's Autonomous Maintenance step-based progression — from Initial Cleaning to Full Autonomous Maintenance in seven steps — provides a structured framework for building operator equipment ownership, but its successful execution requires sustained supervisory commitment and training resource availability.

C. TPM in Indian Automotive Manufacturing

Sharma, Bhardwaj, and Soin (2012) studied TPM implementation across 15 Indian automotive component manufacturers and found that the two-wheeler components sub-sector — directly relevant to Endurance Technology's primary customer base — showed the highest TPM implementation depth, driven by OEM customer requirements and the relatively standardised, high-volume production environment. OEE benchmarks for world-class automotive component manufacturing are conventionally set at 85% or above, while the Indian automotive component sector average was found to be in the range of 62-68%, indicating significant performance improvement potential through effective TPM implementation.

Eti, Ogaji, and Probert (2004) identified a phenomenon they termed 'TPM fatigue' — the deterioration of TPM implementation quality after the initial implementation enthusiasm dissipates, typically 18-24 months after launch — as a pervasive challenge in manufacturing organisations across developing economies. Maintenance of TPM momentum requires institutionalised review mechanisms, visible top management participation in gemba-level TPM activities, and progressive goal-setting that creates ongoing challenge without generating disillusionment. These findings frame the longitudinal dimension of TPM CSF analysis.

III. COMPANY PROFILE — ENDURANCE TECHNOLOGY LIMITED, CSN PLANT

Endurance Technology Limited was founded in 1985 by Anurang Jain in Aurangabad (now Chhatrapati Sambhajinagar), Maharashtra, and has grown into India's largest manufacturer of aluminium die castings and two-wheeler suspension systems. The company serves all major Indian two-wheeler OEMs including Bajaj Auto, TVS Motor Company, Hero MotoCorp, Honda Motorcycle & Scooter India, and Royal Enfield, as well as international customers in Europe through its Italian and German subsidiaries.

The CSN (Chhatrapati Sambhajinagar) plant — the company's flagship manufacturing facility — produces precision aluminium castings, transmission assemblies, braking systems, and suspension components across high-volume automated die-casting lines, precision CNC machining cells, and assembly operations. The plant employs approximately 2,800 permanent and contract workers, including 420 engineers and supervisors, and operates three-shift, 24-hour production across its primary product lines. Capital equipment intensity is high, with significant investment in automated die-casting machines, CNC machining centres, and CMM-based quality control systems — making equipment effectiveness and maintenance management strategically critical.

Endurance's TPM journey at the CSN plant commenced in 2018 with the formal appointment of a TPM Promotion Office, deployment of pillar teams across all eight JIPM pillars, and baseline OEE measurement across all critical equipment. The programme targets JIPM Special Award certification within a five-year implementation horizon, with intermediate milestones of 75% OEE (Year 2), 80% OEE (Year 3), and 85% OEE (Year 5). This study evaluates the CSFs of TPM implementation at the CSN plant as of the fourth year of the programme.

IV. OBJECTIVES OF THE STUDY

1) To identify the Critical Success Factors (CSFs) most relevant to TPM implementation effectiveness at Endurance Technology's CSN plant.
2) To quantify the relative impact of each identified CSF on TPM implementation outcomes, as measured by OEE improvement, breakdown reduction, and employee TPM engagement scores.
3) To examine the current status of each CSF at the CSN plant, identifying implementation strengths and gaps.
4) To document the barriers and challenges encountered during TPM implementation and their relationship to CSF deficiencies.
5) To analyse the relationship between employee level (shopfloor operator, supervisor, engineer, manager) and perceptions of TPM CSF importance and implementation quality.
6) To develop a TPM-CSF Implementation Roadmap applicable to precision automotive component manufacturers in the Maharashtra industrial context.
7) To provide evidence-based recommendations for Production and Operations Managers at Endurance Technology and comparable manufacturers to strengthen TPM implementation quality.

V. RESEARCH METHODOLOGY

A. Research Design

This study employs a mixed-methods research design integrating quantitative primary data from structured questionnaire surveys with qualitative insights from semi-structured interviews and secondary data from plant performance records. The quantitative component enables statistical analysis of CSF importance ratings and their correlation with TPM outcomes, while the qualitative component provides contextual depth that quantitative data alone cannot capture. The study design is cross-sectional, with primary data collected at a single point in time (January-March 2024), supplemented by longitudinal secondary data from the plant's four-year TPM implementation record.

B. Sampling and Data Collection

Primary data was collected through structured questionnaires administered to 120 respondents drawn from across the CSN plant's employee hierarchy: 60 shopfloor operators (from Autonomous Maintenance teams), 30 supervisors and section heads, 20 engineers (from pillar teams), and 10 senior managers (including the TPM Promotion Office team).

The sample was selected using stratified random sampling to ensure proportional representation of each employee category. In addition, 12 in-depth semi-structured interviews were conducted with TPM pillar team leaders and the plant's TPM Promotion Manager to capture implementation narrative and contextual insight.

Secondary data sources included the plant's OEE tracking database (2018-2024), breakdown frequency and MTBF records, TPM audit scores from internal and external assessments, and training completion records from the HR management system. Industry benchmark data was sourced from ACMA and CII manufacturing excellence reports.

C. CSF Framework and Measurement

Eight Critical Success Factors were identified through an initial literature review and pre-study expert consultation with three senior TPM practitioners, then operationalised as survey constructs. Each CSF was measured through 4-6 Likert-scale items (1 = Strongly Disagree to 5 = Strongly Agree) assessing both the perceived importance of the CSF and its current implementation quality at the CSN plant. The gap between importance and implementation quality scores provides an actionable CSF priority index — high importance, low implementation quality CSFs represent the highest-priority improvement opportunities.

VI. FINDINGS AND ANALYSIS

A. OEE Baseline and Improvement Trajectory

Table 6.1 presents the OEE performance trajectory at the CSN plant since TPM programme launch in 2018, documenting progress across the four-year implementation period covered by this study.

Table 6.1: OEE Performance Trajectory — Endurance Technology CSN Plant (2018-2024)

Year	Availability (%)	Performance (%)	Quality Rate (%)	OEE (%)	Breakdowns/Month	MTBF (Hours)
2018 (Baseline)	81.2	76.4	96.8	59.9	38	42
2019 (Year 1)	83.5	78.9	97.1	63.8	31	51
2020 (Year 2)	85.8	81.2	97.4	67.8	24	67
2021 (Year 3)	87.6	83.4	97.8	71.4	18	89
2022 (Year 4)	89.1	85.7	98.1	74.9	13	118
Target (Year 5)	92.0	88.0	98.5	85.0	<8	160+

The OEE trajectory demonstrates consistent year-on-year improvement, from a baseline of 59.9% in 2018 to 74.9% by 2022 — a 25% relative improvement over four years. Breakdown frequency has been reduced by 66% (from 38 to 13 per month) and Mean Time Between Failures (MTBF) has nearly tripled (from 42 to 118 hours), indicating significant autonomous and planned maintenance effectiveness. However, the plant remains approximately 10 percentage points below the world-class OEE benchmark of 85%, with the Year 5 target requiring an accelerated improvement trajectory that makes CSF strengthening a current strategic priority.

B. CSF Importance and Implementation Quality Analysis

Table 6.2 presents the results of the CSF survey analysis, showing mean importance scores, mean implementation quality scores, and the CSF Priority Index (gap between importance and implementation quality) for each of the eight identified CSFs.

Table 6.2: CSF Importance vs. Implementation Quality Analysis — CSN Plant

CSF	Importance Score (1-5)	Implementation Quality (1-5)	Priority Index (Gap)	Priority Rank
Top Management Commitment	4.82	3.91	0.91	2
Employee Involvement & Training	4.76	3.54	1.22	1
Autonomous Maintenance Culture	4.61	3.48	1.13	3
Planned Maintenance Execution	4.53	3.72	0.81	4
Cross-Functional Pillar Team Effectiveness	4.38	3.19	1.19	N/A*
OEE-Driven Performance Measurement	4.44	3.88	0.56	6
Quality Maintenance Integration	4.29	3.61	0.68	5
Supplier/Contractor TPM Alignment	3.97	2.84	1.13	3

** Tied with Autonomous Maintenance Culture and Supplier/Contractor TPM Alignment on Priority Index score.*

The analysis reveals that Employee Involvement & Training carries the largest CSF Priority Index (1.22), indicating that while employees recognise its critical importance (mean score 4.76), implementation quality lags significantly (3.54) — creating the highest-priority improvement opportunity. Cross-Functional Pillar Team Effectiveness and Autonomous Maintenance Culture also show high priority indices, reflecting a common pattern where structural TPM architecture (pillar teams, AM step progression) is established but not yet operating at full effectiveness. Supplier/Contractor TPM Alignment — with both the lowest importance score and a high implementation quality gap — reflects a recognised but not yet addressed extension of the TPM programme to the plant's supply chain ecosystem.

C. Employee Level Analysis of CSF Perceptions

Significant differences in CSF importance perceptions were found across employee levels, as shown in Table 6.3. Shopfloor operators rated Autonomous Maintenance Culture significantly higher in importance (mean 4.71) than managers (mean 4.22), reflecting operators' direct experience of the daily discipline required for AM implementation. Conversely, managers rated Supplier/Contractor TPM Alignment higher in importance (mean 4.41) than operators (mean 3.68), consistent with managers' strategic visibility into the supply chain dimensions of quality and equipment performance.

Table 6.3: CSF Importance Ratings by Employee Level — Mean Scores (1-5)

Critical Success Factor	Operators (n=60)	Supervisors (n=30)	Engineers (n=20)	Managers (n=10)
Top Management Commitment	4.89	4.81	4.74	4.62
Employee Involvement & Training	4.84	4.79	4.67	4.58

Critical Success Factor	Operators (n=60)	Supervisors (n=30)	Engineers (n=20)	Managers (n=10)
Autonomous Maintenance Culture	4.71	4.68	4.52	4.22
Planned Maintenance Execution	4.61	4.54	4.48	4.39
Pillar Team Effectiveness	4.29	4.41	4.56	4.48
OEE-Driven Measurement	4.31	4.48	4.62	4.71
Quality Maintenance Integration	4.18	4.24	4.42	4.51
Supplier/Contractor TPM Alignment	3.68	3.84	4.11	4.41

D. Barriers to TPM Implementation

Semi-structured interviews with pillar team leaders and the TPM Promotion Manager identified eight recurring implementation barriers. Table 6.4 presents these barriers ranked by frequency of citation and their linkage to specific CSFs.

Table 6.4: TPM Implementation Barriers — Endurance Technology CSN Plant

Barrier	Citation Frequency	Primary CSF Link	Mitigation Status
Operator resistance to AM step progression beyond Step 3	11/12	Employee Involvement & Training	Partially addressed
Inconsistent management gemba participation	9/12	Top Management Commitment	Partially addressed
Pillar team meetings disrupted by production pressure	10/12	Pillar Team Effectiveness	Ongoing challenge
Inadequate skilled trainer capacity for AM training	8/12	Employee Involvement & Training	Partially addressed
Contractor workers excluded from TPM activities	9/12	Supplier/Contractor TPM Alignment	Not yet addressed
OEE data accuracy and timeliness at line level	7/12	OEE-Driven Measurement	Being addressed
Quality maintenance linkage to CpK targets not formalised	6/12	Quality Maintenance Integration	Not yet addressed
TPM awareness lacking in procurement/support functions	5/12	Supplier/Contractor Alignment	Not yet addressed

The most frequently cited barrier — operator resistance to Autonomous Maintenance step progression beyond Step 3 (Temporary Standards) — is directly linked to the training CSF gap identified in the quantitative analysis. Progression through AM steps 4-7 requires increasing operator technical competency, which demands sustained and structured training investment that has not yet been fully mobilised at the CSN plant. The barrier of pillar team meetings being disrupted by production pressure reflects a classic tension in manufacturing TPM implementation, where short-term production priorities compete with the longer-term OEE improvement activities of TPM.

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VII. TPM-CSF IMPLEMENTATION ROADMAP

Based on the empirical findings, the literature review, and the priority index analysis, this research proposes a TPM-CSF Implementation Roadmap for precision automotive component manufacturers. The roadmap sequences CSF strengthening activities across three phases — Foundation Strengthening (0-6 months), Pillar Deepening (6-18 months), and Sustainability and Extension (18-36 months) — with specific actions linked to each prioritised CSF.

Table 7.1: TPM-CSF Implementation Roadmap — Phase-wise Action Plan

Phase	Priority CSF	Key Actions	Success Indicator	Timeline
Phase 1: Foundation	Employee Training	Deploy structured AM competency curriculum (Steps 4-7); certify internal AM trainers at 1:15 ratio; integrate TPM training into annual development plans.	80% operators at AM Step 4+ within 6 months	0-6 months
Phase 1: Foundation	Top Management Commitment	Formalise monthly management gemba TPM walks with mandatory attendance; link senior management KPIs to OEE targets; establish TPM steering committee with MD chairpersonship.	100% management gemba attendance rate	0-6 months
Phase 2: Pillar Deepening	Autonomous Maintenance	Complete AM Steps 4-5 across all critical equipment; introduce AM audit scoring with rewards linkage; establish inter-pillar knowledge sharing sessions.	AM Steps 4-5 completion on 90% of critical machines	6-18 months
Phase 2: Pillar Deepening	Pillar Team Effectiveness	Ringfence pillar team meeting time in production scheduling; establish cross-pillar KPI cascade; implement monthly pillar performance reviews with plant head.	Zero pillar meeting cancellations due to production pressure	6-18 months
Phase 3: Sustainability	Supplier/Contractor Alignment	Launch supplier TPM awareness programme for top-20 suppliers; integrate TPM requirements into contractor qualification criteria; train contractor supervisors in basic TPM principles.	Top-20 suppliers with documented TPM practices	18-36 months
Phase 3: Sustainability	Quality Maintenance Integration	Formalise equipment CpK-based Quality Maintenance matrices for all critical characteristics; establish Q-Maintenance pillar KPI dashboard; link quality escapes to equipment condition data.	CpK >1.67 on all critical quality characteristics	18-36 months

VIII. RECOMMENDATIONS

A. *For Production and Operations Management*

1) Prioritise the training CSF as the highest-return investment: the empirical data from this study demonstrates that the implementation quality gap in employee training is the single largest constraint on TPM progress at the CSN plant. Allocating dedicated internal trainer capacity — at a minimum of 1 certified AM trainer per 15 operators — and structuring AM step progression as a formal development programme with completion milestones and recognition will address this highest-priority gap.

2) Institutionalise management gemba presence in TPM activities through formal scheduling and KPI linkage. The qualitative data consistently identifies management gemba consistency as a critical signal of organisational commitment that directly influences shopfloor engagement with AM discipline. Monthly executive TPM walks should be scheduled, recorded, and visually tracked on the TPM activity board at plant entry.
3) Resolve the production-TPM tension through formal scheduling protocols. The most cited structural barrier — pillar team meetings being displaced by production pressure — requires a systemic solution: production scheduling should ringfence pillar team meeting time as inviolable, with plan adherence tracked as a TPM governance metric.

B. For TPM Pillar Teams

1) Accelerate Autonomous Maintenance step progression for the operator workforce through peer-teaching models and step progression incentives. Experienced operators who have completed higher AM steps can serve as on-floor AM coaches for their team members, reducing the training resource constraint while building team-based ownership of AM discipline.
2) Formalise the Quality Maintenance-equipment CpK linkage by developing equipment-specific Quality Maintenance matrices that translate product quality characteristics into machine condition standards. This integration closes the gap between the Quality Maintenance pillar and the plant's existing SPC and CpK-based quality management system.

C. For Senior Management and Policy

1) Extend TPM programme scope to include contractor workers — who constitute a significant proportion of the CSN plant workforce — through a formal contractor TPM integration programme. Excluding contractor workers from TPM activities creates a two-tier workforce in which a substantial portion of the equipment-operating workforce is outside the AM discipline and skills-building framework.
2) Develop a supplier TPM alignment programme targeting the top-20 suppliers by spend and quality impact. Supplier equipment condition directly influences incoming component quality, and a structured supplier TPM awareness and support programme will extend the zero-defect ambition of the plant's TPM programme into the supply chain.

IX. CONCLUSION

This research has empirically investigated the Critical Success Factors (CSFs) of TPM implementation at Endurance Technology Limited's Chhatrapati Sambhajinagar plant — a high-volume, precision-critical automotive components manufacturing context with four years of active TPM programme history. The findings confirm and contextualise the theoretical literature's identification of top management commitment and employee training as the two highest-impact CSFs, while adding empirical weight to the importance of autonomous maintenance culture, cross-functional pillar team effectiveness, and supplier alignment as implementation levers in the Indian automotive manufacturing context.

The quantitative analysis reveals a consistent pattern: CSFs related to people and culture — training, management commitment, AM culture — carry both higher importance ratings and larger implementation quality gaps than structural or measurement CSFs such as OEE tracking. This pattern suggests that the most critical investment for strengthening TPM implementation quality at the CSN plant, and in comparable Indian automotive component manufacturers, lies in sustained human development and organisational culture interventions rather than in technical system improvements.

The OEE improvement trajectory documented over four years — from 59.9% to 74.9% — represents a significant achievement that validates the effectiveness of the TPM programme to date. Achieving the Year 5 target of 85% OEE — the world-class benchmark — will require closing the identified CSF implementation quality gaps, particularly in employee training, autonomous maintenance progression, and pillar team effectiveness. The TPM-CSF Implementation Roadmap proposed in this paper provides a structured, evidence-based pathway for that acceleration.

Future research should investigate the long-term sustainability of TPM gains at the CSN plant through a longitudinal study tracking CSF evolution over the JIPM certification cycle, examine the specific impact of contractor worker TPM integration on OEE and quality outcomes, and explore the applicability of the TPM-CSF Roadmap to other tiers of Endurance Technology's supply chain. The broader question of how TPM CSF profiles differ across sub-sectors of Indian automotive manufacturing — two-wheeler components, four-wheeler components, commercial vehicle components — represents a productive direction for comparative research.

REFERENCES

[1] Ahuja, I. P. S., & Khamba, J. S. (2008). Total productive maintenance: Literature review and directions. International Journal of Quality & Reliability Management, 25(7), 709-756.

[2] Al-Najjar, B., & Alsyouf, I. (2003). Selecting the most efficient maintenance approach using fuzzy multiple criteria decision making. International Journal of Production Economics, 84(1), 85-100.

[3] Cooke, F. L. (2000). Implementing TPM in plant maintenance: Some organisational barriers. International Journal of Quality & Reliability Management, 17(9), 1003-1016.

[4] Eti, M. C., Ogaji, S. O. T., & Probert, S. D. (2004). Implementing total productive maintenance in Nigerian manufacturing industries. Applied Energy, 79(4), 385-401.

[5] Nakajima, S. (1988). Introduction to TPM: Total Productive Maintenance. Productivity Press, Cambridge, MA.

[6] Sharma, R. K., Bhardwaj, P., & Soin, S. (2012). Total productive maintenance barriers and facilitators: A study of Indian manufacturing organisations. International Journal of Lean Six Sigma, 3(4), 323-337.

[7] Singh, R., Gohil, A. M., Shah, D. B., & Desai, S. (2013). Total productive maintenance (TPM) implementation in a machine shop: A case study. Procedia Engineering, 51, 592-599.

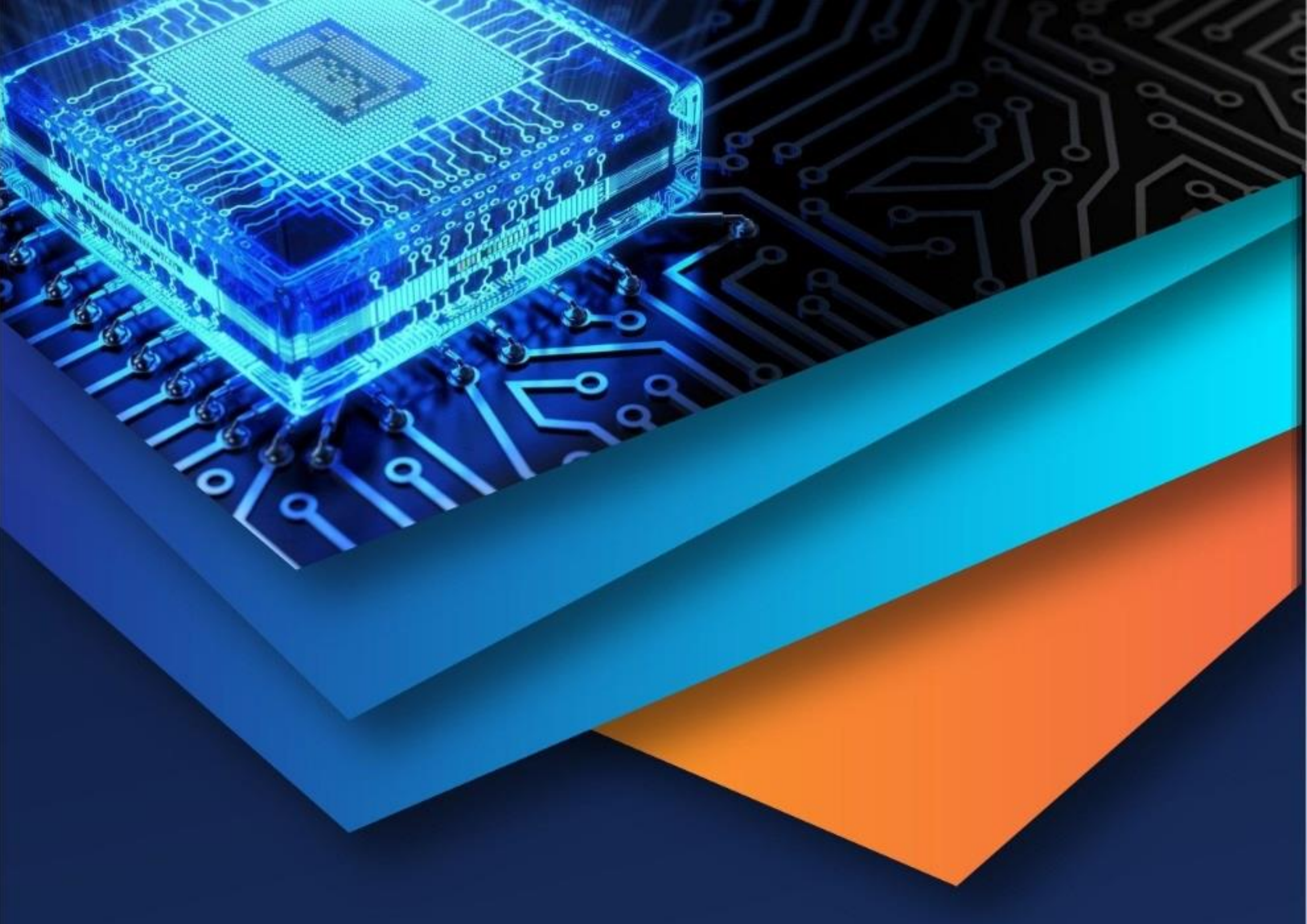
[8] Automotive Component Manufacturers Association of India (ACMA). (2023). Manufacturing Excellence in Indian Auto Components: Benchmarks and Best Practices. ACMA Publications, New Delhi.

[9] Japan Institute of Plant Maintenance (JIPM). (2019). TPM Award Evaluation Criteria and Implementation Framework. JIPM Press, Tokyo.

[10] Confederation of Indian Industry (CII). (2023). Manufacturing Excellence Report: Lean, TPM and Six Sigma Adoption in Indian Industry. CII Publications, New Delhi.

[11] Endurance Technology Limited. (2023). Annual Report 2022-23. Endurance Technology Limited, Aurangabad, Maharashtra.

[12] Dogra, M., Sharma, V. S., Sachdeva, A., & Dureja, J. S. (2011). TPM — A key strategy for productivity improvement in process industry. Journal of Engineering Science and Technology, 6(1), 1-16.



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