iJRASET

International Journal For Research in Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 14 Issue: IV Month of publication: April 2026

DOI: https://doi.org/10.22214/ijraset.2026.81420

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 14 Issue IV Apr 2026- Available at www.ijraset.com

A Study on Implementation of Lean Manufacturing Techniques and MOST (Maynard Operation Sequence Technique) to Improve Production Efficiency with Reference to Escorts Kubota Limited, Delhi and UMAS India Pvt. Ltd

Rahul Madhukar Sable, Mr. Uday Sudhakarrao Gadhe
MBA Production & Operation Management, International Centre of Excellence in Engineering and Management, Chh. Sambhaji Nagar (Aurangabad), Maharashtra, India
Assistant Professor , Department of Management Science International Centre of Excellence in Engineering and Management, Chh. Sambhaji Nagar (Aurangabad), Maharashtra, India

ABSTRACT: This research paper investigates the implementation of Lean Manufacturing Techniques and Maynard Operation Sequence Technique (MOST) as integrated strategies to enhance production efficiency in manufacturing organizations. The study is conducted with specific reference to Escorts Kubota Limited, Delhi — a leading tractor and agri-machinery manufacturer — and UMAS India Pvt. Ltd., a precision engineering component supplier.

Lean Manufacturing, rooted in the Toyota Production System, focuses on the systematic elimination of waste (Muda) from production processes, including overproduction, excess inventory, unnecessary motion, waiting, defects, over-processing, and underutilized talent. MOST, a predetermined time system, provides a structured analytical method for establishing accurate work standards by sequencing human motions into defined activity models. Together, these methodologies form a powerful framework for identifying inefficiencies, standardizing work, and driving continuous improvement.

The research adopts a mixed-methods approach, incorporating both qualitative observations through plant visits and process mapping, and quantitative data collection through time study analysis and production metrics. Key findings indicate that the integration of Lean tools — including Value Stream Mapping (VSM), 5S, Kaizen, Just-in-Time (JIT), and Total Productive Maintenance (TPM) — with MOST-based work measurement leads to significant reductions in cycle time, improved Overall Equipment Effectiveness (OEE), and enhanced labor productivity. At Escorts Kubota Limited, the application of VSM and JIT resulted in a measurable reduction in work-in-progress inventory and throughput time. At UMAS India Pvt. Ltd., MOST analysis facilitated precise method improvement and standardized time setting, resulting in increased operator efficiency.

The study concludes that a synergistic application of Lean Manufacturing and MOST is highly effective in improving production efficiency, reducing operational costs, and creating a culture of continuous improvement. The paper also highlights practical challenges such as resistance to change, training requirements, and the need for sustained management commitment, and offers recommendations for successful implementation in the Indian manufacturing context.

Keywords: Lean Manufacturing, MOST, Maynard Operation Sequence Technique, Production Efficiency, Value Stream Mapping, Waste Elimination, Work Measurement, Escorts Kubota, UMAS India, Kaizen, 5S, OEE.

I. INTRODUCTION

The global manufacturing landscape is undergoing rapid transformation driven by intensifying competition, rising customer expectations, cost pressures, and the imperative for operational excellence. Indian manufacturing firms, in particular, face the dual challenge of improving quality and reducing costs while remaining globally competitive. In this context, systematic methodologies for waste elimination and work standardization have emerged as critical enablers of sustainable operational performance.

Lean Manufacturing, originating from the Toyota Production System (TPS) developed by Taiichi Ohno and Shigeo Shingo, is a management philosophy centered on maximizing customer value while systematically minimizing waste. It seeks to create smooth, uninterrupted production flows by eliminating non-value-adding activities across the entire value chain. The seven classical wastes identified under Lean — overproduction, waiting, transportation, over-processing, excess inventory, unnecessary motion, and defects — continue to afflict manufacturing operations worldwide, and their elimination represents the core of Lean practice.

Complementing Lean's waste-elimination focus, the Maynard Operation Sequence Technique (MOST) is a highly structured and reliable predetermined motion time system (PMTS) developed by Kjell Zandin at H.B. Maynard and Company. MOST enables engineers and analysts to establish precise work standards by decomposing human work activities into defined sequences of fundamental motion patterns. Unlike traditional time study approaches, MOST provides a faster and more consistent means of analyzing methods, estimating time requirements, and identifying opportunities for method improvement. Its application is particularly valuable in labor-intensive manufacturing environments where work measurement accuracy is critical for capacity planning, incentive systems, and efficiency benchmarking.

This research is conducted at two distinct manufacturing organizations — Escorts Kubota Limited, a prominent manufacturer of tractors and agricultural machinery headquartered in Delhi, and UMAS India Pvt. Ltd., a precision engineering components manufacturer — both of which represent the diversity and complexity of India's manufacturing sector. The choice of these two organizations allows for a comparative analysis of Lean and MOST implementation across different product types, production volumes, and organizational cultures.

The primary objective of this study is to examine how the integrated application of Lean Manufacturing techniques and MOST work measurement can drive measurable improvements in production efficiency, reduce waste, and establish a foundation for continuous improvement. The research also aims to identify practical challenges and success factors relevant to the Indian manufacturing context.

II. LITERATURE REVIEW

The academic and practitioner literature on Lean Manufacturing is extensive and well-established. Womack, Jones, and Roos (1990) in their seminal work 'The Machine That Changed the World' introduced the concept of Lean Production to a global audience, documenting the superiority of the Toyota Production System over mass production paradigms. Their subsequent work 'Lean Thinking' (1996) articulated the five principles of Lean: defining value, mapping the value stream, creating flow, establishing pull, and pursuing perfection — a framework that remains foundational to Lean practice.

Rother and Shook (1998) contributed significantly to Lean methodology through the development of Value Stream Mapping (VSM) as a diagnostic and improvement tool. VSM enables organizations to visualize material and information flows, identify waste, and design future-state processes. Research by Singh and Sharma (2009) applied VSM in Indian manufacturing contexts and confirmed its effectiveness in reducing lead time and improving process efficiency.

The 5S methodology — Sort, Set in Order, Shine, Standardize, and Sustain — has been widely studied as a foundational Lean tool. Osada (1991) and Hirano (1995) established the theoretical basis for 5S, while empirical studies in Indian SMEs have demonstrated its positive impact on workplace organization, safety, and productivity (Gupta and Jain, 2015).

Research on MOST is comparatively more specialized. Zandin (2003) provided the definitive reference on MOST work measurement systems, describing the BasicMOST, MiniMOST, and MaxiMOST sequences and their respective applications. Predetermined motion time systems, including MOST, have been validated as more reliable and consistent than traditional stopwatch time study by numerous researchers (Baines et al., 2005). Studies comparing MOST with other PMTS such as MTM-1 and MODAPTS have consistently shown MOST's advantage in terms of analysis speed without sacrificing accuracy (Siddiqui and Khan, 2010).

Integration of Lean and MOST has been explored in limited but growing literature. Bhuiyan and Baghel (2005) noted that work standardization through PMTS is a prerequisite for sustained Lean improvement, as accurate time standards underpin capacity planning, takt time calculation, and line balancing. Patel and Shah (2018) applied MOST-based work measurement in conjunction with Lean tools in an automotive assembly plant and reported a 15% improvement in labor productivity and a 22% reduction in cycle time.

In the Indian manufacturing context, studies on Lean adoption have highlighted both significant potential and notable barriers. Panwar et al. (2015) conducted a comprehensive review of Lean implementation in Indian industries and found that while awareness of Lean is growing, full-scale implementation remains limited due to cultural resistance, lack of skilled practitioners, and insufficient management commitment.

These findings underscore the need for context-specific research, which this study aims to address through its focus on two representative Indian manufacturers.

III. COMPANY PROFILES

A. Escorts Kubota Limited, Delhi

Escorts Kubota Limited (formerly Escorts Limited) is one of India's leading agricultural and construction equipment manufacturers with over seven decades of industry presence. The company's tractor manufacturing facility in Faridabad (Delhi NCR) is among the largest in India, with an annual production capacity exceeding 100,000 tractors. Following the strategic partnership with Kubota Corporation of Japan — a global leader in agricultural machinery — the company has undergone significant transformation in its manufacturing philosophy, incorporating world-class quality standards and advanced production techniques.

The Escorts Kubota manufacturing setup is characterized by complex assembly lines, multiple product variants across a wide horsepower range (25 HP to 90 HP), high component variety, and a large workforce of both permanent and contract employees. The complexity of operations makes it an ideal environment for Lean Manufacturing implementation, where value stream analysis can reveal significant opportunities for waste reduction and flow improvement.

B. UMAS India Pvt. Ltd.

UMAS India Pvt. Ltd. is a precision engineering components manufacturer serving the automotive and industrial sectors. The company specializes in machined components, fabricated sub-assemblies, and precision-turned parts for original equipment manufacturers (OEMs). Its operations involve multi-stage machining processes including turning, milling, drilling, grinding, and finishing, with stringent quality requirements and tight dimensional tolerances.

UMAS India's production environment is characterized by a mix of job-shop and batch-production configurations, with relatively higher labor content per part compared to high-volume assembly operations. This makes MOST work measurement particularly applicable, as accurate method analysis and time standards are essential for costing, scheduling, and productivity benchmarking in such environments.

IV. RESEARCH METHODOLOGY

A. Research Design

The study adopts a descriptive and analytical research design. A mixed-methods approach is employed, combining qualitative observations and process analysis with quantitative data collection and statistical analysis. This design is appropriate for production efficiency studies where both contextual understanding and measurable outcomes are required.

B. Data Collection

Primary data was collected through the following methods:

- Direct observation and time study at the production facilities of Escorts Kubota Limited and UMAS India Pvt. Ltd.
- MOST analysis of selected work stations and assembly operations
- Value Stream Mapping of identified production processes
- Structured interviews with production managers, industrial engineers, and shop floor supervisors
- Collection of production records including cycle time data, OEE reports, rejection rates, and inventory levels

Secondary data was sourced from published research papers, textbooks on Lean Manufacturing and MOST, industry reports, and internal company documentation (where permitted).

C. MOST Analysis Procedure

BasicMOST was selected as the appropriate MOST system for this study, given the cycle times and nature of operations at both companies. The analysis procedure followed these steps:

1) Selection of operations for analysis — high-cycle-time, high-labor-content, and bottleneck operations were prioritized
2) Activity breakdown into BasicMOST sequence models: General Move (A B G A B P A), Controlled Move (A B G M X I A), and Tool Use sequences
3) Assignment of index values for each parameter based on motion distance, body motion, and process actions
4) Calculation of Normal Time (TMU × 0.036 seconds per TMU)

5) Addition of allowances for fatigue, personal needs, and delays to derive Standard Time
6) Comparison of MOST-derived standards with actual observed times to identify method improvement opportunities

D. Lean Implementation Approach

The Lean implementation followed the Plan-Do-Check-Act (PDCA) cycle:

1) Current state Value Stream Mapping to document existing process flows, cycle times, and waste
2) Identification of waste categories (7 Mudas) in production processes
3) Design of future-state VSM with targeted improvements
4) Implementation of selected Lean tools (5S, Kaizen, JIT, Kanban, TPM) at pilot areas
5) Measurement of post-implementation performance metrics
6) Comparison of pre- and post-implementation data to quantify improvements

V. LEAN MANUFACTURING TECHNIQUES AND IMPLEMENTATION

A. Value Stream Mapping (VSM)

Value Stream Mapping was the first tool deployed at both organizations. At Escorts Kubota Limited, the VSM was applied to the tractor assembly line for a specific product variant (45 HP tractor). The current-state VSM revealed the following key findings:

- Total Value-Added Time (VAT): 148 minutes
- Total Non-Value-Added Time (NVAT): 312 minutes
- Overall Lead Time: 4.6 days (including material waiting and queue time)
- Major waste identified: excess Work-in-Progress (WIP) inventory between stations, waiting time due to unbalanced line, and over-processing in painting operations

At UMAS India, VSM was applied to the machined component manufacturing process for a high-volume automotive part. Key findings included excessive inter-operation waiting time (accounting for 67% of total lead time) and unnecessary material transportation due to suboptimal machine layout.

B. 5S Implementation

5S was implemented as a foundational Lean initiative at both facilities. At Escorts Kubota, a structured 5S audit system was introduced with defined scoring criteria and weekly workplace audits. Implementation activities included:

- Sort (Seiri): Removal of unnecessary tools, materials, and equipment from production areas
- Set in Order (Seiton): Establishment of designated locations for tools, jigs, and materials using shadow boards and floor markings
- Shine (Seiso): Daily cleaning schedules and machine cleaning standards
- Standardize (Seiketsu): Visual management standards, color coding, and 5S checklists
- Sustain (Shitsuke): Regular audits, employee training, and 5S performance displays

Post-5S implementation at UMAS India resulted in a 40% reduction in average tool search time and a significant improvement in workplace safety scores as measured by monthly safety audits.

C. Kaizen (Continuous Improvement)

Kaizen events were organized at both companies to address specific production challenges. At Escorts Kubota Limited, a focused Kaizen on the engine assembly station resulted in the reconfiguration of the workstation layout, reducing operator motion by approximately 35% and decreasing assembly cycle time. At UMAS India, a Kaizen event on the grinding operation identified and eliminated a redundant quality inspection step that had been performed in duplicate by both operator and inspector.

D. Just-in-Time (JIT) and Kanban

At Escorts Kubota Limited, a Kanban-based pull system was piloted for a sub-assembly feeding the main tractor assembly line. Kanban cards were introduced to regulate material replenishment, replacing the previous push-based scheduling that had resulted in WIP accumulation. The pilot implementation resulted in a 28% reduction in sub-assembly WIP inventory within the first three months.

E. Total Productive Maintenance (TPM)

At UMAS India Pvt. Ltd., where machine availability directly impacts production output, a basic TPM framework was introduced focusing on Autonomous Maintenance (AM) and Planned Maintenance (PM).

Operators were trained to perform routine machine checks, cleaning, and minor adjustments, reducing the dependency on the maintenance department for first-level maintenance activities. OEE measurement was introduced as a key performance indicator.

VI. MOST ANALYSIS AND WORK MEASUREMENT

A. BasicMOST Sequence Models

BasicMOST uses three fundamental activity sequences to describe virtually all manual work:

Sequence Model	Activity Description	Sequence Parameters
General Move	Free movement of objects through space	A B G A B P A
Controlled Move	Object moved under constraint or in contact with surface	A B G M X I A
Tool Use	Use of common tools (wrench, gauge, screwdriver, etc.)	A B G A B P * A B P A

Each letter parameter is assigned an index value based on motion characteristics. The total index sum is multiplied by 10 TMU (Time Measurement Units), where 1 TMU = 0.036 seconds.

B. MOST Analysis at Escorts Kubota Limited

MOST analysis was conducted on the wheel mounting operation of the tractor assembly line — a high-frequency manual task performed by two operators. The analysis revealed:

- Standard time (before improvement): 4.82 minutes per tractor
- Primary waste identified: excessive Get distance (B parameter) due to tool storage location, and unnecessary Gain Control (G parameter) from awkward component positioning
- Method improvement: Tool shadow board repositioned within arm's reach; tyre pre-positioned on roller conveyor at ergonomic height
- Standard time (after improvement): 3.61 minutes per tractor
- Cycle time reduction: 25.1%

C. MOST Analysis at UMAS India Pvt. Ltd.

At UMAS India, MOST was applied to analyze the loading and unloading operation on a CNC turning center. The analysis revealed that 38% of the operator's time was spent in non-value-adding motions, primarily extended reach distances to the parts tray and awkward tool placement. Corrective actions included workstation reorganization and introduction of a parts presenter at the optimal reach zone. The revised standard time showed an 18.3% reduction, directly contributing to increased machine utilization.

VII. RESULTS AND DISCUSSION

A. Production Efficiency Improvements — Escorts Kubota Limited

Performance Parameter	Before Implementation	After Implementation	Improvement (%)
Assembly Line Cycle Time (min/unit)	48.6	38.9	20.0%
Work-in-Progress Inventory (units)	142	98	31.0%

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Volume 14 Issue IV Apr 2026- Available at www.ijraset.com

Performance Parameter	Before Implementation	After Implementation	Improvement (%)
Overall Equipment Effectiveness (OEE)	67.4%	78.2%	+10.8%
Defect Rate (PPM)	3,840	2,210	42.4%
Value-Added Ratio	32.2%	47.6%	+15.4%
Lead Time (days)	4.6	3.1	32.6%

B. Production Efficiency Improvements — UMAS India Pvt. Ltd.

Performance Parameter	Before Implementation	After Implementation	Improvement (%)
Operator Efficiency (%)	72.4%	88.1%	+15.7%
Standard Time (CNC Turning, min)	6.84	5.59	18.3%
Machine Utilization (%)	61.3%	74.8%	+13.5%
5S Audit Score (/100)	48	79	+31 Points
Tool Search Time (min/day)	22 min	13 min	40.9%
Rejection Rate (%)	2.8%	1.6%	42.9%

C. Discussion

The results demonstrate that the integrated application of Lean Manufacturing tools and MOST work measurement delivers compounding benefits that exceed what either methodology could achieve in isolation. MOST provides the analytical rigor necessary to establish accurate baselines and validate improvements quantitatively, while Lean tools address the systemic and cultural dimensions of waste elimination.

The improvements observed at Escorts Kubota Limited are particularly notable given the complexity of the product (tractor assembly involves over 300 distinct components) and the scale of operations. The reduction in WIP inventory of 31% directly translates to reduced working capital requirements and improved cash flow. The improvement in OEE from 67.4% to 78.2% represents a significant gain in productive capacity without additional capital investment.

At UMAS India, the MOST-driven workstation improvements demonstrate the power of systematic method analysis. A 15.7% improvement in operator efficiency in a precision machining environment is a substantial achievement, particularly given the technical constraints of CNC operations. The accompanying improvement in machine utilization indicates that the two methodologies complement each other effectively — MOST addresses the human work interface while Lean tools address systemic process flows.

VIII. CHALLENGES AND BARRIERS TO IMPLEMENTATION

Despite the positive outcomes, the implementation of Lean Manufacturing and MOST faced several significant challenges at both organizations:

A. Resistance to Change

Shop floor workers and some supervisors exhibited initial resistance to new methods, standardized work procedures, and the introduction of MOST-based time standards. This is consistent with findings from the broader Lean literature (Panwar et al., 2015). Sustained communication, involvement of workers in improvement activities, and visible management support were essential in overcoming this resistance.

B. Skill and Knowledge Gaps

MOST analysis requires trained industrial engineers with proficiency in the MOST sequences and index tables. Both organizations had limited internal capability in work measurement. Investment in training and the use of software tools (MOST software) were required to build analytical capacity.

C. Sustaining Improvements

A common challenge in Lean implementation is sustaining gains over time, particularly as workforce turnover occurs and production pressures increase. The absence of a formal standardized work documentation system at UMAS India meant that some improvements were partially reversed when key personnel changed. This underscores the critical importance of visual standards and documented work instructions.

D. Integration with Existing Systems

At Escorts Kubota Limited, integrating Lean-driven production scheduling changes with the existing ERP system required significant coordination with the IT and production planning functions. Pull-based systems such as Kanban operate on fundamentally different logic from ERP-driven push scheduling, and reconciling these approaches requires careful system design.

IX. RECOMMENDATIONS

Based on the findings of this study, the following recommendations are offered for manufacturing organizations seeking to implement Lean Manufacturing and MOST:

1) Establish a Lean Enterprise team with dedicated industrial engineers trained in both Lean tools and MOST work measurement to provide analytical support and coordinate improvement initiatives.
2) Begin with foundational 5S implementation before deploying advanced tools such as Kanban or JIT, as a disciplined and organized workplace is a prerequisite for sustainable Lean improvements.
3) Use MOST analysis systematically at bottleneck operations and high-labor-content workstations to establish accurate baselines, identify method improvement opportunities, and validate improvement outcomes quantitatively.
4) Invest in employee training and involvement — workers who understand the rationale for change and participate in improvement activities are significantly more likely to sustain new methods and standards.
5) Develop standardized work documentation (operation sheets, work instructions, visual aids) for all improved methods to ensure that gains are codified and maintained over time.
6) Implement OEE measurement as a comprehensive performance indicator for equipment-intensive operations, and use TPM practices to sustain machine availability.
7) Adopt a phased implementation approach — pilot improvements in a defined area, measure results, and then scale successful practices to other areas of the plant.

X. CONCLUSION

This research paper has demonstrated that the integrated application of Lean Manufacturing techniques and MOST work measurement is an effective and proven approach to improving production efficiency in Indian manufacturing organizations. Through the detailed study of Escorts Kubota Limited and UMAS India Pvt. Ltd., the research has provided empirical evidence of measurable improvements across multiple performance dimensions — including cycle time, WIP inventory, OEE, operator efficiency, and defect rates.

Lean Manufacturing's systematic approach to waste identification and elimination, when combined with MOST's rigorous method analysis and work standardization capabilities, creates a comprehensive framework for operational excellence. MOST provides the analytical foundation — accurate work standards and method improvement insights — upon which Lean's flow-improvement and pull-based systems can be effectively built and sustained.

The study also highlights that technical tools alone are insufficient for sustained improvement. Organizational factors — including management commitment, employee engagement, training, and a culture of continuous improvement — are equally critical determinants of success. For Indian manufacturers competing in an increasingly demanding global environment, the strategic adoption of Lean and MOST represents not merely a productivity initiative but a fundamental transformation in operational capability and competitive positioning.

Future research could explore the integration of digital technologies — such as IoT-based real-time tracking, digital VSM tools, and AI-driven MOST analysis — into the Lean-MOST framework, building upon the Industry 4.0 transformation currently underway in the Indian manufacturing sector.

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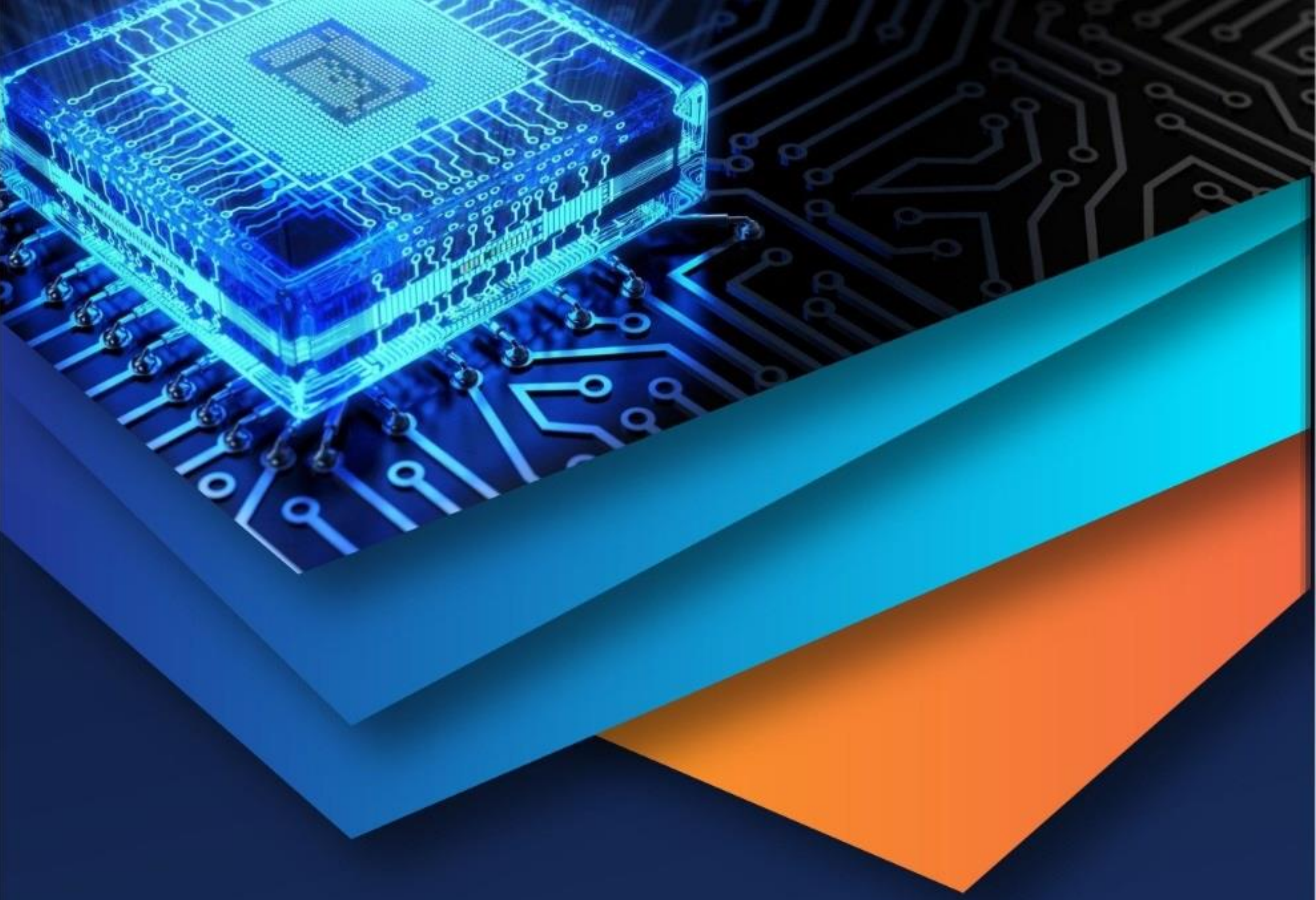

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