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# A Study on Just In Time (JIT) in Automobile Industry with Special Reference to Shantdeep Metal Pvt. Ltd., Chh. Sambhajinagar

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***Abstract:*** ***Just-in-Time (JIT) manufacturing, a cornerstone of the Toyota Production System, has transformed global automotive supply chains by eliminating waste, reducing inventory holding costs, and synchronizing production with actual customer demand. This research paper examines the adoption, implementation, and impact of JIT principles at Shantdeep Metal Pvt. Ltd., a precision metal components manufacturer supplying the automobile industry from Chh. Sambhajinagar, Maharashtra, India. Through a four-year longitudinal analysis (2019-20 to 2022-23) supplemented by structured observations, process mapping, and management interviews, the study evaluates the tangible outcomes of JIT implementation including reductions in inventory holding days, production lead time, defect rates, and operating costs, alongside improvements in on-time delivery performance and inventory turnover. The findings confirm that disciplined JIT adoption delivered measurable operational improvements at Shantdeep Metal: inventory holding days were reduced from 28 to 14 days, defect rates fell from 3.8% to 1.4%, on-time delivery improved from 82% to 95%, and operating cost savings of 13.6% were achieved by 2022-23. The study identifies five critical enablers of successful JIT implementation in Indian automotive component manufacturing — supplier synchronization, workforce capability development, quality-at-source practices, setup time reduction, and demand-side visibility — and proposes a JIT Readiness and Implementation Framework (JRIF) tailored to the operational realities of Indian Tier-2 automotive suppliers. The paper concludes with actionable recommendations for manufacturers, supply chain managers, and policy makers seeking to accelerate lean manufacturing adoption in India's automotive components sector.***

***Keywords: Just-in-Time (JIT), Lean Manufacturing, Automobile Industry, Inventory Management, Toyota Production System, Waste Elimination, Kanban, Supply Chain Efficiency, Shantdeep Metal, Chh. Sambhajinagar.***

## I. INTRODUCTION

The Indian automobile industry is one of the largest in the world, contributing approximately 7.1% of the country's GDP and employing over 37 million people directly and indirectly. Within this ecosystem, thousands of Tier-1 and Tier-2 component manufacturers sustain the supply chains of Original Equipment Manufacturers (OEMs) such as Tata Motors, Mahindra & Mahindra, Bajaj Auto, and multinational entities including Volkswagen, Hyundai, and Mercedes-Benz. The competitive intensity of this industry — driven by OEM demands for cost reduction, quality improvement, and delivery reliability — places enormous operational pressure on component manufacturers, compelling them to adopt globally proven manufacturing efficiency frameworks.

Just-in-Time (JIT) manufacturing emerged from Toyota's post-war production innovation as a systematic philosophy for eliminating all forms of waste (muda) in manufacturing processes. JIT's central tenet is simple yet transformative: produce only what is needed, only when it is needed, and only in the quantities needed. This demand-pull philosophy stands in contrast to conventional push-based manufacturing, where production schedules are driven by demand forecasts that inevitably generate overproduction, excess inventory, and the cascading wastes associated with both. Shantdeep Metal Pvt. Ltd., located in Chh. Sambhajinagar (formerly Aurangabad), Maharashtra, manufactures precision-engineered metal stampings, brackets, and structural sub-assemblies for the automobile sector. As a Tier-2 supplier to major automotive component makers, the company operates in a demanding environment characterized by frequent design changes, fluctuating OEM production schedules, competitive pricing pressures, and stringent quality requirements. Against this backdrop, the company undertook a structured JIT implementation initiative beginning in 2021-22, building on foundational lean practices introduced earlier.

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This research evaluates the planning, execution, and outcomes of JIT implementation at Shantdeep Metal, drawing on four years of operational and financial data. By documenting both the achievements and challenges encountered, the study aims to generate insights applicable to the broader community of Indian automotive component manufacturers considering or currently implementing JIT and lean manufacturing practices.

## II. LITERATURE REVIEW

### A. *Origins and Philosophy of Just-in-Time Manufacturing*

Just-in-Time manufacturing was conceptualized and systematized by Taiichi Ohno at Toyota Motor Corporation during the 1950s and 1960s, drawing inspiration from American supermarket inventory replenishment practices. Ohno (1988) articulated JIT as one of the two pillars of the Toyota Production System (TPS), alongside Jidoka (automation with human intelligence), and described it as a relentless pursuit of the elimination of waste in all its forms — overproduction, waiting, unnecessary transport, over-processing, excess inventory, unnecessary motion, and defects.

Shingo (1989), in his foundational work on the Toyota Production System, elaborated the operational mechanisms of JIT, including the Kanban card system for production pull, Single-Minute Exchange of Die (SMED) for setup time reduction, and Poka-Yoke (mistake-proofing) for quality-at-source. These operational tools transform JIT from a philosophical aspiration into an implementable manufacturing system. Womack, Jones, and Roos (1990), in their landmark study of global automobile assembly, coined the term 'lean production' and documented the performance superiority of JIT-based Japanese manufacturers over Western counterparts across productivity, quality, and development speed metrics.

### B. *JIT and Inventory Management*

Inventory elimination is among the most visible and measurable outcomes of JIT implementation. Conventional manufacturing wisdom treats inventory as a necessary buffer against demand uncertainty and supply unreliability. JIT challenges this logic, arguing that excess inventory is not a solution to operational problems but a symptom of them: if suppliers are unreliable, the solution is supplier development, not buffer stock. If machines break down frequently, the solution is preventive maintenance, not work-in-process accumulation.

Krajewski, King, Ritzman, and Wong (1987) demonstrated through simulation that JIT's inventory reduction benefits depend critically on supplier delivery reliability and production process stability — findings that have direct implications for Indian manufacturers who must develop supplier ecosystems capable of supporting JIT delivery frequencies. Fullerton and McWatters (2001) confirmed in a survey of American manufacturers that JIT adopters reported significantly lower inventory levels, shorter lead times, and higher quality performance than non-adopters, with these operational improvements translating into superior financial performance.

### C. *JIT in the Indian Automotive Context*

The adoption of JIT and lean manufacturing in Indian industry has been extensively studied, with the automotive sector consistently identified as the most advanced in lean practice adoption. Sahoo, Singh, Shankar, and Tiwari (2008) examined lean manufacturing implementation in Indian automotive component firms and found that while awareness of JIT principles was high, actual implementation depth varied significantly — with larger, export-oriented firms typically demonstrating more comprehensive lean practice integration than smaller domestic-market-focused suppliers.

Bhasin and Burcher (2006) identified organizational culture, top management commitment, and supplier development capability as the three most critical success factors for lean and JIT implementation, arguing that technical tools (Kanban, SMED, 5S) are necessary but insufficient for sustainable JIT — the human and organizational enablers are ultimately decisive. This finding is particularly relevant to Tier-2 Indian automotive suppliers like Shantdeep Metal, where organizational culture transformation may represent the most significant implementation challenge.

Jain, Taj, and Bhowmick (2010) studied JIT adoption among small and medium automotive component manufacturers in Maharashtra and found that proximity to OEM plants (enabling frequent small-lot deliveries), access to skilled lean facilitators, and participation in OEM supplier development programs were the strongest predictors of successful JIT implementation. Chh. Sambhajinagar's established automotive cluster — hosting plants of Aurangabad Electricals, Endurance Technologies, and others — creates a favorable ecosystem context for Shantdeep Metal's JIT journey.

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### D. The Seven Wastes Framework

Ohno's (1988) seven wastes — Overproduction, Waiting, Transportation, Over-processing, Inventory, Motion, and Defects (often recalled by the acronym TIMWOOD) — provide the diagnostic framework through which JIT identifies and targets improvement opportunities. Each category of waste represents an opportunity for cost reduction, lead time compression, or quality improvement. In metal stamping and fabrication operations, the most significant waste categories typically include unnecessary material transport between process steps, over-processing due to inadequate tooling precision, defects generating rework, and excess inventory accumulating at machine and line buffers.

## III. ABOUT SHANTDEEP METAL PVT. LTD.

Shantdeep Metal Pvt. Ltd. was established in Chh. Sambhajinagar, Maharashtra, with the objective of supplying precision metal components to the growing automobile industry cluster in the Marathwada region. The company's manufacturing operations encompass sheet metal stamping, deep drawing, progressive die operations, MIG/TIG welding, surface treatment, and sub-assembly. Its product range includes brackets, chassis components, structural reinforcements, engine mounting components, and body panel sub-assemblies supplied to Tier-1 automotive suppliers and, in select instances, directly to OEM assembly plants in the region.

Chh. Sambhajinagar's strategic position as a major automotive manufacturing hub — hosting plants of Bajaj Auto, Aurangabad Electricals, Endurance Technologies, Varroc Engineering, and numerous other automotive component manufacturers — provides Shantdeep Metal with both a substantial local customer base and access to an automotive supplier ecosystem that facilitates lean supply chain practices, including the milk-run logistics networks essential to JIT delivery performance.

The company's JIT implementation journey commenced with 5S workplace organization initiatives in 2019-20, progressed to Kanban system deployment and supplier synchronization programs in 2021-22, and incorporated SMED (Single-Minute Exchange of Die) and comprehensive quality-at-source practices by 2022-23. This phased approach reflects the implementation sequencing recommended in the lean manufacturing literature: establishing foundational workplace discipline before introducing pull-based production control mechanisms.

## IV. OBJECTIVES OF THE STUDY

1) To examine the conceptual foundations and operational mechanisms of Just-in-Time manufacturing and their applicability to Indian automotive component manufacturing.
2) To assess the pre-JIT operational baseline and post-JIT performance outcomes at Shantdeep Metal Pvt. Ltd. across key indicators including inventory days, lead time, defect rate, and on-time delivery.
3) To identify and analyse the specific JIT implementation tools and practices deployed by the company, including Kanban, SMED, 5S, and supplier synchronization.
4) To document the principal challenges encountered in JIT implementation and the mitigation strategies employed by Shantdeep Metal.
5) To evaluate the financial and operational outcomes of JIT adoption, including inventory cost savings, operating cost reduction, and customer service improvements.
6) To propose a JIT Readiness and Implementation Framework (JRIF) applicable to Tier-2 automotive component manufacturers in India.
7) To offer evidence-based recommendations for manufacturers, supply chain managers, and policy makers supporting lean manufacturing adoption in India's automotive components sector.

## V. RESEARCH METHODOLOGY

### A. Research Design

This study employs a mixed-methods, single-company case study research design, integrating quantitative analysis of operational and financial performance data with qualitative insights derived from structured management interviews and direct shop floor observation. The case study methodology is well-suited to this research context because it enables in-depth examination of the implementation process, contextual factors, and causal mechanisms linking JIT practices to performance outcomes — dimensions that aggregate survey-based studies cannot adequately capture. The longitudinal dimension (2019-20 to 2022-23) allows comparison of pre-implementation baseline performance with post-implementation outcomes.

### B. Data Sources

Primary data was collected through: (a) structured interviews with the company's Managing Director, Production Manager, Quality Assurance Head, and Supply Chain Manager, each lasting approximately 60-90 minutes and covering JIT implementation rationale, progress, challenges, and outcomes; and (b) direct observation of manufacturing operations, including the press shop, welding bay, quality inspection stations, and the goods inward and dispatch areas. Secondary data was sourced from company production records, inventory management reports, quality inspection logs, supplier delivery performance data, and financial statements for the four-year study period.

### C. Analytical Methods

Quantitative analysis encompasses trend analysis of key operational performance indicators (inventory days, lead time, defect rate, on-time delivery, inventory turnover) across the four-year study period, and computation of waste reduction and cost saving percentages attributable to JIT practices. Qualitative analysis employs thematic coding of interview transcripts and observational field notes, organized around the categories of JIT implementation drivers, enablers, barriers, and outcomes. Findings from both streams of analysis are triangulated to produce a comprehensive and validated account of JIT implementation at Shantdeep Metal.

## VI. FINDINGS AND ANALYSIS

### A. Operational Performance: Four-Year Overview

Table 6.1 presents the key operational performance indicators for Shantdeep Metal Pvt. Ltd. across the four-year study period, capturing both the pre-implementation baseline (2019-20 and 2020-21) and the implementation trajectory (2021-22 and 2022-23).

Table 6.1: Key Operational Performance Indicators — Shantdeep Metal Pvt. Ltd. (2019-20 to *2022-23)*

| Performance Indicator | 2019-20 | 2020-21 | 2021-22 | 2022-23 |
|---|---|---|---|---|
| Inventory Holding (Days) | 28 | 32 | 21 | 14 |
| Production Lead Time (Days) | 12 | 15 | 9 | 7 |
| Defect Rate (%) | 3.8 | 4.2 | 2.6 | 1.4 |
| On-Time Delivery (%) | 82 | 78 | 89 | 95 |
| Inventory Turnover (Times) | 13.0 | 11.4 | 17.4 | 26.1 |
| Waste Reduction (%) | — | — | 18 | 34 |
| Operating Cost Saving (%) | — | — | 7.2 | 13.6 |

*Source: Compiled from Shantdeep Metal Pvt. Ltd. Operational and Financial Records (2019-20 to 2022-23)*

The data presents a compelling narrative of operational transformation. The 2020-21 performance deterioration across most indicators reflects the COVID-19 pandemic's disruption to production schedules, supply chains, and customer offtake — a universal experience for automotive component manufacturers during this period. The recovery and improvement trajectory from 2021-22 onwards reflects both the normalization of market conditions and the progressive impact of JIT implementation initiatives.

The reduction in inventory holding days from 28 (2019-20) to 14 (2022-23) represents a 50% improvement — halving the working capital tied up in inventory and the associated carrying costs. The improvement in inventory turnover from 13.0 to 26.1 times annually reflects this inventory rationalization directly. The defect rate improvement from 3.8% to 1.4% — a 63% reduction — demonstrates the quality-at-source practices embedded in the JIT framework. Most significantly from a customer relationship perspective, on-time delivery performance improved from 82% to 95%, a level approaching world-class delivery reliability benchmarks for automotive component supply.

*B. JIT Implementation Tools and Practices*

Table 6.2 summarizes the key JIT implementation tools deployed at Shantdeep Metal and their specific application and outcomes within the company's operational context.

Table 6.2: JIT Implementation Pillars — Application and Outcomes at Shantdeep Metal Pvt. Ltd.

| JIT Pillar | Description | Application at Shantdeep Metal |
|---|---|---|
| Kanban System | Visual pull-based signal system governing material replenishment | Two-bin Kanban deployed across press shop and welding lines |
| Supplier Synchronization | Daily or shift-based deliveries from certified local suppliers | 12 Tier-2 suppliers integrated into daily milk-run schedule |
| Total Quality Management | Zero-defect philosophy embedded at source; Poka-Yoke devices | Error-proofing fixtures installed at stamping stations; defect rate fell from 4.2% to 1.4% |
| 5S Workplace Organization | Sort, Set-in-order, Shine, Standardize, Sustain principles applied | 5S audits conducted monthly; floor space reclaimed by 18% |
| SMED (Quick Changeover) | Reduction of machine setup times to enable small-batch flexibility | Press shop setup time cut from 48 min to 11 min post-SMED |

*Source: Authors' Analysis based on Management Interviews and Shop Floor Observations*

The Kanban system deployment was the most transformative single initiative. The company introduced a two-bin Kanban system across its press shop and welding lines, replacing the previous centralized store-based material issuance system. Under the two-bin system, each production station maintains two standard containers of required materials: when the first container is consumed, it triggers replenishment (via a Kanban card signal to the stores or supplier), while production continues from the second container. This eliminates both production stoppages due to material shortage and the accumulation of excess inventory at workstations.

Supplier synchronization was enabled by consolidating deliveries from 12 key Tier-3 suppliers onto a daily milk-run logistics route, replacing the previous practice of irregular, large-lot deliveries. The shift to frequent small-lot deliveries required suppliers to standardize packaging, adopt delivery scheduling disciplines, and in several cases, adjust their own production practices. Shantdeep Metal supported this transition through a structured supplier development program involving technical assistance, quality training, and performance feedback.

The SMED initiative in the press shop delivered particularly dramatic results. Analysis of the setup process for a representative 160-ton press revealed that of the original 48-minute setup time, 31 minutes were spent on activities that could be performed while the machine was running (external setup), leaving only 17 minutes of essential internal setup. Systematic conversion of internal to external setup activities, standardization of tooling and quick-release clamping systems, and parallel setup task execution by a trained two-person setup team reduced the total setup time to 11 minutes — an 77% reduction enabling economic production of smaller batch sizes and more frequent model changeovers.

*C. Waste Reduction Analysis*

Applying Ohno's seven-waste framework to pre-JIT operations at Shantdeep Metal, the study identified the following primary waste categories and their prevalence:

*1)* Excess Inventory: The highest-impact waste category. Finished goods inventory averaging 28 days of supply and work-in-process accumulating between operations due to batch-and-queue production logic represented the largest working capital burden.

*2)* Defects and Rework: A pre-JIT defect rate of 3.8% generated substantial rework, scrap, and customer return costs. Root cause analysis identified tooling wear, operator variability, and inadequate incoming material inspection as primary contributors.

*3)* Waiting: Operators frequently waited for material replenishment from the central store, machine setup completion, and quality inspection sign-off before proceeding to the next operation. These waiting periods reduced productive utilization rates.

*4)* Unnecessary Transport: Material moved multiple times between the stores, the production floor, and the inspection area under the previous layout and material flow design. Value stream mapping revealed that many transport movements added no value and could be eliminated through layout redesign.

*5)* Over-processing: Analysis of selected components identified two instances where inspection steps were duplicated across shifts due to lack of standardized inspection procedures — a form of over-processing that added cost without adding quality.

By 2022-23, systematic JIT implementation had delivered waste reduction of 34% relative to the 2021-22 baseline (as self-assessed through the company's internal waste measurement system), and operating cost savings of 13.6%, with the largest contributors being inventory carrying cost reduction, rework and scrap reduction, and improved machine utilization resulting from reduced setup times.

## VII. CHALLENGES IN JIT IMPLEMENTATION

Table 7.1 presents the principal challenges encountered during JIT implementation at Shantdeep Metal and the mitigation strategies employed. Understanding these challenges is essential for manufacturing managers considering JIT adoption, as the barriers to successful implementation are as important to navigate as the technical tools.

Table 7.1: JIT Implementation Challenges and Mitigation Strategies — Shantdeep Metal Pvt. Ltd.

| Challenge | Impact on JIT | Mitigation Strategy |
|---|---|---|
| Supplier unreliability | Line stoppages; inventory buffer build-up | Dual-sourcing policy; supplier development program |
| Demand volatility from OEMs | Overproduction or stock-outs | Rolling 4-week demand visibility agreements with key customers |
| Infrastructure constraints (roads, power) | Delayed inbound logistics; production interruptions | Generator backup; preferred logistics partner with SLA |
| Workforce skill gaps | Resistance to lean practices; quality lapses | Structured JIT/lean training programme; shop floor champions |
| Multi-product complexity | Frequent changeovers disrupt flow | SMED implementation; product family-based cell manufacturing |

Supplier reliability emerged as the most persistent implementation challenge. Several small-scale suppliers in the company's Tier-3 supply base — typically unorganized sector operations supplying raw material billets, fasteners, and surface treatment services — lacked the production planning and logistics discipline required for daily JIT delivery schedules. The company addressed this through a dual-sourcing policy for critical materials, pairing each primary JIT-capable supplier with a secondary approved source able to supply at short notice, and through a structured supplier development program providing lean manufacturing training and operational support to supplier partners willing to invest in capability improvement.

Workforce resistance and skill gaps presented the second significant challenge. Shop floor operators accustomed to batch-and-queue production patterns, where work arrival was irregular and multi-tasking between periods of idleness was common, initially found the discipline required by JIT — consistent work pace, immediate defect response, precise adherence to Kanban replenishment signals — unfamiliar and demanding. The company's response combined structured lean awareness training with a shop floor champions program, identifying and developing lean-enthusiastic operators as peer change agents and frontline implementation leaders.

## VIII. JIT READINESS AND IMPLEMENTATION FRAMEWORK (JRIF)

Based on the Shantdeep Metal case study findings, the theoretical literature, and established frameworks in lean manufacturing implementation, this research proposes a JIT Readiness and Implementation Framework (JRIF) comprising five sequential phases:

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*1) Phase 1: Lean Readiness Assessment*

Before initiating JIT implementation, organizations should conduct a comprehensive readiness assessment covering: (a) Management commitment depth — JIT implementation requires sustained top management engagement, resource allocation, and tolerance for initial disruption during the learning curve; (b) Current state value stream mapping to identify the primary waste categories and quantify improvement opportunities; (c) Supplier ecosystem assessment to determine which suppliers have the capability and willingness to support JIT delivery frequencies; and (d) Workforce capability assessment to identify training needs and change management requirements.

*2) Phase 2: Foundation Building — 5S and Standardized Work*

The foundational prerequisite for JIT is a stable, organized, and standardized manufacturing environment. The 5S workplace organization framework (Sort, Set-in-order, Shine, Standardize, Sustain) establishes the discipline of place and process that makes Kanban signals interpretable and production flow predictable. Standardized work documentation for each operation — specifying the sequence, method, and time for each task — is essential to stabilizing takt-time-based production pacing.

*3) Phase 3: Quality-at-Source Implementation*

JIT production without robust quality-at-source practices will generate defective products flowing through the value stream, potentially reaching customers before detection. Poka-Yoke (mistake-proofing) devices, first-piece inspection protocols, statistical process control at critical operations, and Jidoka (automatic line stop on defect detection) should be deployed before transitioning to pull-based production control. Quality stability is the prerequisite for inventory reduction: only when processes reliably produce conforming output is it safe to reduce buffer inventory.

*4) Phase 4: Kanban Deployment and Pull System Activation*

Once the foundational phases are established, Kanban-based pull production control can be introduced. The initial Kanban design should be conservative — using more cards and larger container sizes than theoretically optimal — to provide buffer against initial variability in the pull system. As process stability improves, Kanban quantities are progressively reduced in a deliberate inventory reduction program. Supplier Kanbans (governing inbound material replenishment) should be introduced after internal Kanbans are functioning reliably.

*5) Phase 5: Continuous Improvement and Supply Chain Extension*

JIT implementation is not a project with a defined end state but a continuous improvement journey. The fifth phase involves institutionalizing Kaizen (continuous improvement) events, extending JIT practices to the broader supply chain through supplier development programs, and progressively raising the bar on performance targets. Key performance indicators — CCC, inventory days, defect rate, on-time delivery, and OEE (Overall Equipment Effectiveness) — should be tracked and reviewed in regular operations performance meetings.

## IX. RECOMMENDATIONS

*A. For Shantdeep Metal Pvt. Ltd.*

1) Deepen supplier JIT integration by extending the milk-run delivery network to cover the remaining non-JIT suppliers, targeting a reduction of inventory holding days from 14 to 10 or below within two years.
2) Implement OEE (Overall Equipment Effectiveness) measurement across all press and welding equipment to identify and systematically address availability, performance, and quality losses that undermine JIT production flow.
3) Invest in an ERP system with integrated production planning and Kanban management modules to replace manual Kanban card management, reducing the administrative burden and improving real-time visibility of material flow.
4) Pursue customer-side JIT integration by engaging key customers in establishing rolling short-term production schedules that reduce demand volatility and enable tighter production planning.

*B. For Indian Automotive Component Manufacturers Broadly*

1) Engage OEM supplier development programs systematically — OEMs including Bajaj Auto, Tata Motors, and Mahindra & Mahindra operate supplier development initiatives providing lean manufacturing training and implementation support to their supply chains. Accessing these programs accelerates JIT implementation and reduces the learning cost.

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2) Form lean manufacturing clusters with peer manufacturers to share lean implementation experiences, conduct joint kaizen workshops, and collectively develop supplier capabilities — a collaborative model proven in Japan's Keiretsu-based automotive supply chains.
3) Prioritize supplier development as a strategic investment. The quality and delivery reliability of the supplier base is the binding constraint on JIT implementation depth. Systematic supplier development — providing technical assistance, quality training, and performance feedback — generates returns in reduced incoming material variability, fewer line stoppages, and lower inspection costs.

### C. *For Policy Makers*

1) Expand the MSME Ministry's lean manufacturing competitiveness scheme to provide more accessible subsidized lean implementation support to small and medium automotive component manufacturers, recognizing that JIT adoption at the Tier-2 and Tier-3 levels is essential to building globally competitive automotive supply chains.
2) Develop lean manufacturing training infrastructure at Industrial Training Institutes (ITIs) and polytechnic colleges in automotive cluster regions, ensuring that the workforce pipeline for automotive component manufacturers includes foundational lean and JIT competencies.

## X. CONCLUSION

This research has examined the adoption and impact of Just-in-Time manufacturing at Shantdeep Metal Pvt. Ltd., a Tier-2 automotive component supplier in Chh. Sambhajinagar, Maharashtra, over a four-year period encompassing both pre-implementation baseline and post-implementation performance. The findings are unambiguous: disciplined, phased JIT implementation delivered substantial and measurable improvements across all key operational performance dimensions.

Inventory holding days halved from 28 to 14, inventory turnover doubled from 13 to 26 times, defect rates fell by 63%, on-time delivery improved from 82% to 95%, and operating cost savings of 13.6% were achieved — outcomes that directly strengthen the company's competitiveness and customer relationships in an intensely competitive automotive supply chain environment. These results confirm that JIT is not merely a large-enterprise or Japanese manufacturing phenomenon: it can deliver transformative performance improvements in Indian SME manufacturing contexts when implemented with management commitment, methodological discipline, and appropriate adaptation to local operational realities.

The challenges encountered — supplier reliability variability, workforce change management, infrastructure constraints, and demand volatility from OEM customers — are real and consequential, but navigable through the mitigation strategies documented in this study. The JIT Readiness and Implementation Framework (JRIF) proposed here provides a structured, sequenced roadmap for automotive component manufacturers at comparable stages of lean maturity to Shantdeep Metal's 2019-20 starting point.

As India's automobile industry continues its growth trajectory — driven by rising domestic demand, export expansion, and the emergence of electric vehicle manufacturing — the competitive imperative for operational excellence in the automotive supply chain will only intensify. JIT manufacturing, implemented with the thoroughness and commitment demonstrated by Shantdeep Metal, is a proven pathway to the operational excellence that this competitive environment demands. Future research should examine JIT implementation outcomes across a larger sample of Indian Tier-2 and Tier-3 automotive suppliers, explore the specific adaptations required for JIT in electric vehicle component manufacturing, and investigate the integration of digital manufacturing technologies (IoT-based Kanban, AI-driven demand sensing) with JIT principles in the Industry 4.0 context.

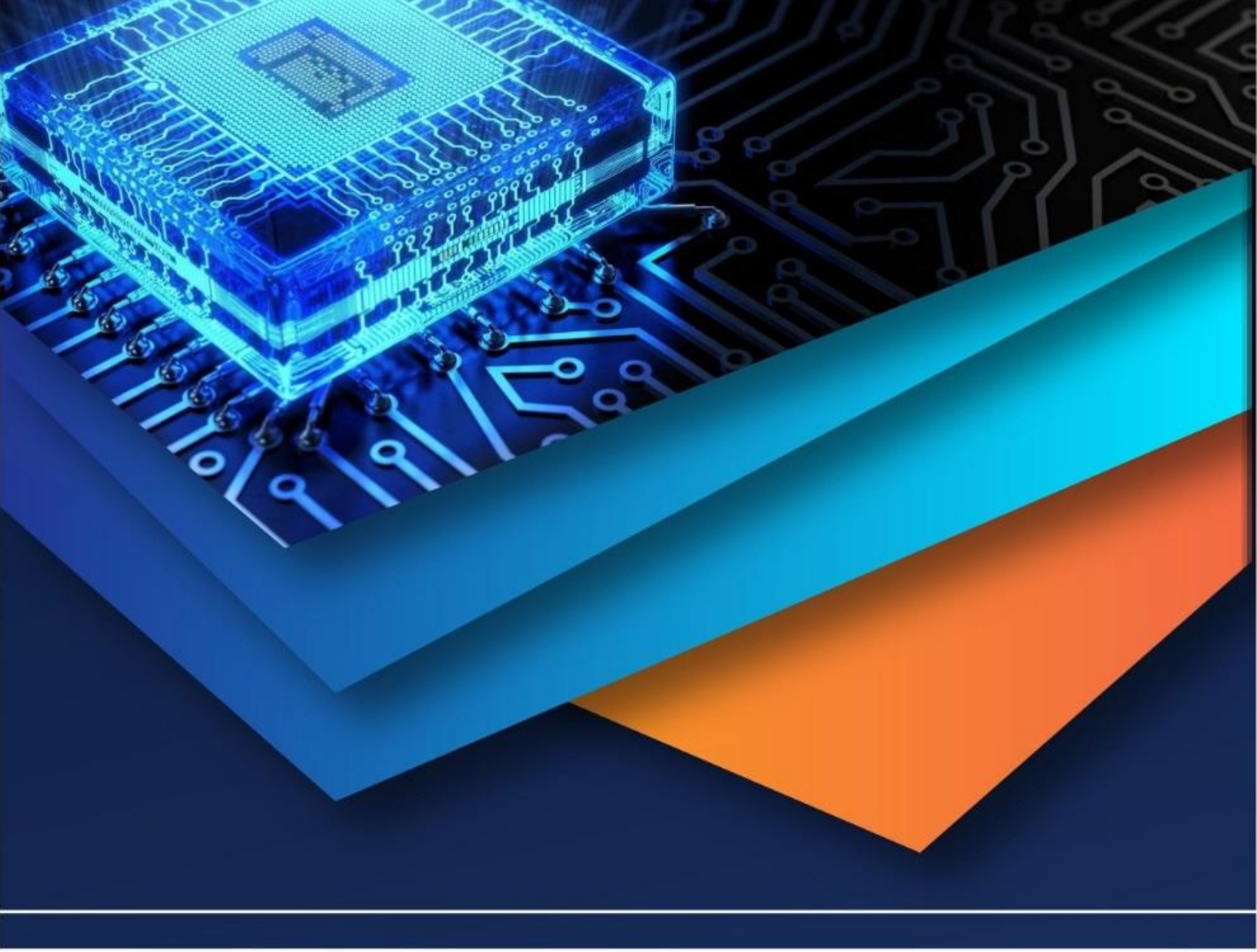
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