INDONESIAN INDOVISI INSTITUTE

Jurnal Indovisi
ISSN 2615-4234 (Print) and ISSN 2615-3254 (Electronic)

Vol. 8, No. 1, 2026, pp. 121-138
DOI: https://doi.org/10.32698/19075608

Operational strategy for enhancing automotive parts manufacturing quality and productivity through cycle time optimization

Agustinus Hariadi Djoko Purwanto*)[1], Rosalendro Eddy Nugroho[1], Mohamad Jihan Shofa[2], Wahyu Oktri Widyarto[2], Rahman DS[3]
[1] Universitas Mercu Buana, Indonesia
[2] Universitas Serang Raya, Indonesia
[3] Program Studi Magister Manajemen, Universitas Mercu Buana, Indonesia

Article Info

Article history:

Received Jul 15th, 2026
Revised Aug 07th, 2026
Accepted Aug 19th, 2026

Keyword:

Operational strategy,
Cycle time optimization,
Automotive parts manufacturing,
Manufacturing quality,
Manufacturing productivity,
PLS-SEM

ABSTRACT

Developing effective operational strategies is essential for automotive parts manufacturers to improve quality and productivity while meeting market demand with limited resources. This study empirically validates an integrated operational strategy in which Cycle Time Reduction serves as a primary capability for improving downstream manufacturing performance. A quantitative explanatory approach was employed using Partial Least Squares Structural Equation Modeling (PLS-SEM) based on data from 100 respondents in an automotive parts manufacturing company. The model examined relationships among Cycle Time Reduction, Machining Operational Performance, Burritori Operational Performance, Assembly Operational Performance, Final Inspection Performance, and Overall Manufacturing Productivity. Results show that Cycle Time Reduction significantly improves machining (β = 0.510) and burritori performance (β = 0.388). Machining (β = 0.295) and burritori performance (β = 0.392) positively influence assembly performance, which strongly affects final inspection (β = 0.586) and overall manufacturing productivity (β = 0.598). The model explains 26.0%, 15.0%, 37.2%, 34.4%, and 35.8% of variance in these outcomes, respectively. The findings confirm that Cycle Time Reduction functions as an integrated operational strategy, enabling cascading improvements across the manufacturing value chain and supporting lean manufacturing practices.

Corresponding Author:

Agustinus Hariadi Djoko Purwanto,
Universitas Mercu Buana,
Email: agustinus.hariadi@mercubuana.ac.id

Introduction

The global automotive industry is facing increasingly intense competition driven by technological advancement, shorter product life cycles, rising customer expectations, and the transition toward smart manufacturing. Consequently, automotive component manufacturers are required to continuously improve manufacturing quality, productivity, and operational efficiency while maintaining competitive production costs. Under these circumstances, manufacturing competitiveness depends not only on production output but also on the ability to optimize integrated production processes and systematically eliminate operational waste (Ike et al., 2022).

Among various continuous improvement approaches, cycle time reduction has become one of the most effective operational strategies because it directly influences equipment utilization, production capacity, work-in-process inventory, manufacturing responsiveness, and overall productivity (Wahyuanto, 2025). Lean manufacturing emphasizes that eliminating non-value-added activities improves production flow and operational efficiency without requiring substantial capital investment (Reddy, 2024). Consequently, manufacturers increasingly adopt cycle time reduction as a strategic initiative to strengthen operational excellence and sustain competitive advantage.

This study was conducted at PT Auto Components Indonesia (PTA), an automotive parts manufacturer producing aluminum components for two-wheel and four-wheel vehicles. The manufacturing system consists of sequential processes, including die casting, burritori (deburring), machining, assembly, painting, and final inspection before products are delivered to customers. Manufacturing performance is monitored using Overall Equipment Effectiveness (OEE), with the company establishing a minimum target of 85% for all casting machines as the benchmark for operational excellence.

Table 1. Overall Equipment Effectiveness (OEE) Performance of Casing Machines During the Last Three Months

Machine		**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
	May	81.22		83.56	81.56	85.05	81.54	81.23	83.67	86.23	85.23
OEE Result			80.30								
	Juni	80.34	81.89	84.70	82.37	84.80	82.90	82.34	80.56	87.21	86.12
	July	83.46	80.90	82.56	83.72	85.55	80.20	85.12	83.24	86.23	87.23
Target					The lowest 2	**85%**		The lowest 1			
Machine		**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
	May	81.23	85.33	92.02	82.34	85.23	86.23	83.88	82.34	86.23	93.23
OEE Result	Juni	83.26	87.34	89.22	85.05	84.32	88.23	89.34	84.56	87.21	89.45
	July	88.89	90.24	87.45	84.59	85.05	85.68	85.12	88.23	86.23	90.78
Target						**85%**					

Table 1 presents the OEE performance of twenty casting machines during May–July 2023. The results show that several machines consistently failed to achieve the company's minimum target, particularly Casting Machines No. 2 and No. 6, whose OEE values remained below 85% throughout the observation period. These findings indicate that production losses are associated not only with equipment availability but also with operational inefficiencies occurring during the manufacturing process

Table 2. Operational Performance Comparison of Representative Casing Machines

Machine Number	Performance Indikator	Value
2	Cycle Time Per Part	40 s/part
	Production Output (OEE 80.9%)	72 parts/hour
6	Cycle Time per Part	18.5 s/part
	Production Output (OEE 80.2%	156 part/h

Source: Internal company data 2023

As shown in Table 2, the operational characteristics of the two representative machines differ considerably. Machine No. 2 operates with a cycle time of 40 s/part, producing approximately 72 parts/hour at an OEE of 80.9%, whereas Machine No. 6 operates at 18.5 s/part, producing 156 parts/hour with an OEE of 80.2%. Despite the substantial difference in production capacity, both machines failed to achieve the targeted OEE, suggesting that manufacturing performance is influenced not only by machine speed but also by production flow stability and the existence of non-value-added activities.

Operational observations further revealed that more than six seconds of each production cycle consisted of non-value-added activities identified using the Theoretical Value Production (TVP) approach. The implementation of PDCA and ECRS successfully eliminated unnecessary activities, reduced cycle time, and improved production performance. Moreover, the proposed improvement strategy was technically applicable to other casting machines operating under similar production conditions (Patwari et al., 2024).

Previous studies have confirmed that cycle time reduction improves equipment utilization and manufacturing productivity. However, most investigations have focused on localized improvements within individual production processes, particularly die casting, while studies on production effectiveness and maintenance management generally evaluate planning, scheduling, and maintenance as independent determinants of manufacturing performance (Kumbara, 2021; Fitra & Agustinus, 2024). Consequently, empirical evidence explaining how upstream operational improvements propagate across downstream manufacturing processes remains limited.

In automotive parts manufacturing, production processes are highly interconnected. Improvements achieved during die casting are expected to enhance machining performance, reduce deburring effort, improve assembly performance, strengthen final inspection outcomes, and ultimately increase overall manufacturing productivity. Nevertheless, this sequential operational mechanism has received limited empirical attention.

Accordingly, this study proposes an integrated operational strategy in which cycle time reduction functions as the primary operational capability driving improvements in machining operational performance, burritori operational performance, assembly operational performance, final inspection performance, and overall manufacturing productivity. The proposed framework is empirically validated using Partial Least Squares Structural Equation Modeling (PLS-SEM) to demonstrate how upstream operational improvements generate cascading performance enhancements throughout the automotive manufacturing value chain.

Research Gap

Previous studies have investigated manufacturing performance improvement from various operational perspectives. Research on production effectiveness has emphasized production planning, raw material control, scheduling, and production control as key determinants of manufacturing performance (Kumbara, 2021). Other studies have demonstrated that cycle time reduction using Theoretical Value Production (TVP), PDCA, and ECRS effectively eliminates non-value-added activities, improves Overall Equipment Effectiveness (OEE), and enhances casting productivity (Andersson, 2026). In addition, maintenance-oriented research has confirmed that maintenance processes, workforce capability, and quality control contribute significantly to maintenance and production performance (Fitra & Agustinus, 2024). Although these studies provide valuable insights, they primarily examine individual operational functions rather than integrated manufacturing processes (Gustafsson et al., 2025).

However, three important research gaps remain. First, previous studies have generally evaluated production planning, maintenance, or casting improvement independently, with limited attention to the integration of sequential manufacturing processes. Second, empirical evidence explaining how cycle time reduction implemented in upstream die casting operations influences downstream processes, including machining, burritori, assembly, and final inspection, remains limited. Third, few studies have validated these sequential operational relationships and their contribution to overall manufacturing productivity using a PLS-SEM approach (Hair et al., 2022).

To address these gaps, this study proposes an integrated operational strategy model in which cycle time reduction serves as the initiating operational capability that drives improvements in machining operational performance, burritori operational performance, assembly operational performance, final inspection performance, and ultimately overall manufacturing productivity. By integrating upstream and downstream manufacturing processes into a single empirical framework, this study extends the literature on operations strategy, lean manufacturing, and manufacturing process integration within the automotive parts manufacturing industry.

Research Novelty

This study introduces an integrated operational strategy model that explains how cycle time reduction implemented in upstream die casting operations generates cascading operational improvements throughout the automotive manufacturing process. Unlike previous studies that examined production planning, maintenance management, or casting process improvement as independent operational functions (Kumbara, 2021; Fitra & Agustinus, 2024), this research conceptualizes cycle time reduction as a strategic operational capability that systematically improves machining operational performance, burritori operational performance, assembly operational performance, final inspection performance, and ultimately overall manufacturing productivity..

The novelty of this study lies in the development and empirical validation of a sequential operational strategy framework using Partial Least Squares Structural Equation Modeling (PLS-SEM). The proposed framework integrates operational effectiveness, operational efficiency, product quality, final inspection performance, and manufacturing productivity into a single process integration model. This study therefore extends the operations strategy and lean manufacturing literature by demonstrating that sustainable improvements in manufacturing quality and productivity are achieved through integrated process optimization rather than isolated improvements within individual production stages.

Research Contributions

This study contributes to the manufacturing management literature by demonstrating that cycle time reduction functions not only as a process improvement initiative but also as a strategic operational capability that enhances manufacturing performance across interconnected production processes. By empirically validating the sequential relationships among die casting, machining, burritori, assembly, final inspection, and manufacturing productivity, this study extends the literature on operations strategy, lean manufacturing, and manufacturing process integration (Rossini et al., 2021).

Methodologically, this study develops and validates a sequential operational model using Partial Least Squares Structural Equation Modeling (PLS-SEM), providing empirical evidence of the causal relationships among successive manufacturing processes. From a managerial perspective, the proposed framework offers a practical reference for automotive manufacturers to improve quality, productivity, and operational integration through cycle time reduction, enabling sustainable performance improvement without substantial capital investment.

Literature Review

Operational Strategy in Automotive Manufacturing

Manufacturing competitiveness in the automotive industry increasingly depends on an organization's ability to develop operational strategies that integrate quality, productivity, flexibility, cost efficiency, and delivery reliability. Rather than relying solely on production capacity or advanced technologies, manufacturers achieve sustainable competitive advantage by continuously improving operational processes, strengthening manufacturing capabilities, and systematically eliminating production inefficiencies (Mudau et al., 2024). Consequently, operations strategy has evolved from a supporting production function into a strategic capability that enables firms to respond effectively to dynamic customer requirements and rapidly changing market conditions (Najjar & Qandeel, 2025).

Recent studies emphasize that manufacturing excellence is achieved through process integration, continuous improvement, and waste elimination across the entire production system rather than through the optimization of isolated workstations (Ullah et al., 2023). These principles are consistent with the Toyota Production System (TPS), which advocates standardized work, continuous improvement (kaizen), and the systematic elimination of waste (muda) to improve production flow, resource utilization, and customer value (Soliman, 2023). In highly integrated automotive manufacturing systems, improvements implemented at one production stage influence the performance of subsequent processes, making operational coordination essential for achieving stable production performance and manufacturing competitiveness (Zehra et al., 2024).

Accordingly, operational strategy should be viewed as an integrated managerial approach that aligns manufacturing processes to improve operational effectiveness, efficiency, and product quality across the entire production system. Within this perspective, cycle time reduction represents a strategic operational capability that supports process integration, enhances production flow, and strengthens overall manufacturing performance.

Cycle Time Optimization as an Operational Capability

Cycle time reduction is widely recognized as a strategic operational capability because it directly influences production throughput, equipment utilization, manufacturing responsiveness, and operational costs (Najjar & Qandeel, 2025). Rather than merely shortening processing time, cycle time reduction aims to improve production flow by eliminating non-value-added activities, reducing waiting time, minimizing unnecessary motion, and stabilizing manufacturing operations in accordance with lean manufacturing principles (Gebeyehu et al., 2022). As a result, manufacturers can increase production capacity and operational efficiency without substantial investment in additional production resources.

Recent studies have reported that organizations implementing systematic cycle time reduction achieve higher production efficiency, lower process variability, improved resource utilization, and greater manufacturing flexibility, all of which contribute to enhanced operational performance (Goyal et al., 2022). In automotive manufacturing, shorter and more stable production cycles also improve Overall Equipment Effectiveness (OEE), strengthen production flow, and increase capacity utilization, enabling manufacturers to satisfy growing customer demand while maintaining consistent product quality.

Within aluminum die casting operations, Andersson (2026) demonstrated that integrating Theoretical Value Production (TVP), PDCA, and ECRS successfully eliminated non-value-added activities, reduced production cycle time, and improved casting productivity. However, the investigation was limited to improvements within the casting process and did not evaluate whether the operational benefits propagated to downstream manufacturing stages such as machining, burritori, assembly, and final inspection. Therefore, the present study extends previous research by examining cycle time reduction as an operational capability that drives sequential performance improvements across interconnected manufacturing processes rather than as a localized process improvement initiative.

Process Integration in Automotive Manufacturing

Automotive component manufacturing consists of a series of interconnected production processes in which the operational performance of each stage directly influences subsequent manufacturing activities. Consequently, manufacturing performance should be viewed as the cumulative outcome of integrated production processes rather than the optimization of individual workstations. This systems perspective emphasizes that sustainable manufacturing competitiveness depends on process coordination, operational stability, and continuous production flow across the entire manufacturing value chain (Slack et al., 2019).

Manufacturing process integration theory suggests that stable upstream processes reduce operational variability, improve process continuity, and enhance the effectiveness of downstream operations (Schmidt et al., 2023). In aluminum automotive parts manufacturing, improvements achieved during the die casting process reduce dimensional variation and process inconsistencies before components enter machining. More stable machining operations subsequently minimize burr formation, facilitating burritori activities, improving assembly performance, and increasing product conformity during final inspection. Therefore, the operational performance of each manufacturing stage becomes an important prerequisite for the performance of subsequent processes, creating a continuous chain of operational improvement throughout the production system (Groover & Jayaprakash, 2015).

Accordingly, manufacturing process integration provides the theoretical foundation for this study by explaining that improvements initiated in upstream operations can generate cascading operational improvements across downstream manufacturing processes. This perspective extends conventional manufacturing improvement approaches by emphasizing process synchronization and operational interdependence rather than isolated workstation optimization, thereby supporting the development of the integrated operational strategy proposed in this research.

Manufacturing Performance

Manufacturing performance has evolved from traditional productivity measurement toward a multidimensional evaluation encompassing product quality, equipment effectiveness, operational efficiency, production capacity, delivery reliability, and customer satisfaction (Ahmad et al., 2022). Accordingly, contemporary manufacturing organizations assess performance not only by production output but also by their ability to consistently deliver high-quality products while utilizing manufacturing resources effectively and maintaining stable production processes (Nganga & Nyaga, 2022).

Among various manufacturing performance indicators, Overall Equipment Effectiveness (OEE) is widely recognized as one of the most comprehensive measures because it integrates equipment availability, operational performance, and product quality into a single performance indicator (Calandreli et al., 2025). However, manufacturing excellence extends beyond equipment utilization. Sustainable factory performance also requires improvements in process effectiveness, operational efficiency, quality consistency, production capacity, and on-time delivery, reflecting the integrated performance of the entire manufacturing system (Slack et al., 2019).

Therefore, this study conceptualizes manufacturing performance as the cumulative outcome of synchronized improvements across interconnected production processes. Within the proposed framework, Final Inspection Performance represents the achievement of operational quality objectives, while Overall Manufacturing Productivity reflects the capability of the manufacturing system to achieve planned production quantity, product quality, and delivery performance. This perspective supports the evaluation of manufacturing performance as an integrated result of process improvement throughout the automotive manufacturing value chain.

Previous Studies

Previous studies have investigated manufacturing performance from diverse operational perspectives. Kumbara (2021) demonstrated that production planning, raw material control, scheduling, and production control significantly improve production effectiveness using a PLS-SEM approach. Andersson (2026) reported that cycle time reduction through Theoretical Value Production (TVP), PDCA, and ECRS effectively eliminated non-value-added activities, improved Overall Equipment Effectiveness (OEE), and increased casting productivity. Meanwhile, Fitra and Agustinus (2024) confirmed that maintenance processes, workforce capability, and maintenance quality control positively influence maintenance and production performance.

Beyond these studies, international research has consistently highlighted the importance of operations strategy, lean manufacturing, and manufacturing process integration in improving manufacturing competitiveness (Skalli et al., 2023). These studies emphasize that operational excellence is achieved through continuous improvement, waste elimination, and process synchronization across manufacturing systems. However, they generally focus on lean implementation, production planning, maintenance management, or individual process optimization, without empirically examining how operational improvements initiated at upstream production stages propagate through successive manufacturing processes.

Therefore, limited empirical evidence explains the sequential operational mechanism linking cycle time reduction in die casting to improvements in machining, burritori, assembly, final inspection, and overall manufacturing productivity. To address this gap, the present study proposes and validates an integrated operational strategy model using Partial Least Squares Structural Equation Modeling (PLS-SEM), providing empirical evidence of how upstream process improvements generate cascading operational benefits throughout the automotive manufacturing value chain.

Theoretical Framework

This study is grounded in three complementary theoretical perspectives: operations strategy, lean manufacturing, and manufacturing process integration. Operations strategy argues that sustainable manufacturing competitiveness is achieved through the effective alignment of manufacturing resources, continuous process improvement, and coordinated operational activities rather than through isolated production optimization (Jean, 2024). From this perspective, operational capabilities developed within production processes constitute an important source of long-term competitive advantage.

Lean manufacturing further explains that operational excellence is achieved by systematically eliminating non-value-added activities, reducing process variability, and improving production flow across the entire manufacturing system (Gomaa, 2026). Consequently, cycle time reduction is not merely a technical effort to shorten processing time but a strategic operational capability that enhances manufacturing effectiveness, operational efficiency, and product quality.

From the perspective of manufacturing process integration, operational improvements implemented in upstream production stages are expected to propagate through downstream manufacturing activities, generating cumulative performance improvements across the production system (Almelhem et al., 2025). Accordingly, this study proposes that cycle time reduction implemented during die casting operations enhances machining operational performance, burritori operational performance, and assembly operational performance, which subsequently improve final inspection performance and overall manufacturing productivity. These theoretical perspectives collectively provide the conceptual foundation for the proposed research model and the development of hypotheses tested using Partial Least Squares Structural Equation Modeling (PLS-SEM).

Conceptual Framework

Figure 2 illustrates the conceptual framework developed in this study based on the theories of operations strategy, lean manufacturing, manufacturing process integration, and manufacturing performance. The framework conceptualizes Cycle Time Reduction (X1) as a strategic operational capability that enhances manufacturing performance through sequential improvements across interconnected production processes. This perspective is consistent with operations strategy theory, which emphasizes that sustainable manufacturing competitiveness is achieved through integrated process improvement rather than isolated workstation optimization (Slack et al., 2019).

The proposed model positions Cycle Time Reduction as the initiating operational capability because the elimination of non-value-added activities improves production flow, process stability, and equipment utilization, thereby creating favorable operating conditions for downstream manufacturing processes (Sofrankova et al., 2022). Consistent with manufacturing process integration theory, improvements achieved during die casting operations are expected to propagate sequentially through Machining Operational Performance (X2), Burritori Operational Performance (X3), and Assembly Operational Performance (X4) before influencing Final Inspection Performance (Y1) and Overall Manufacturing Productivity (Y2). Accordingly, the proposed framework views manufacturing performance as the cumulative outcome of coordinated operational improvements across the entire automotive manufacturing system rather than the result of isolated process optimization.

The conceptual framework also reflects previous findings demonstrating that cycle time reduction using Theoretical Value Production (TVP), PDCA, and ECRS improves casting productivity and Overall Equipment Effectiveness (OEE) (DS, 2024). However, unlike previous studies, the present research extends the analysis beyond die casting by empirically examining how upstream operational improvements generate cascading operational improvements throughout the manufacturing value chain. The proposed framework therefore provides the conceptual basis for developing the research hypotheses and evaluating the structural relationships using Partial Least Squares Structural Equation Modeling (PLS-SEM).

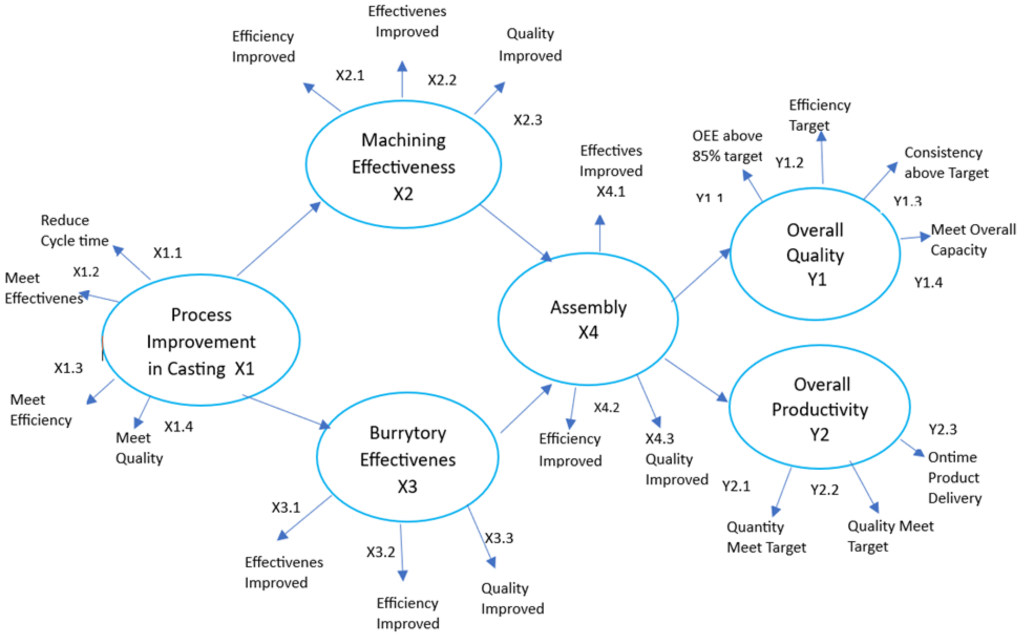

Figure 1. Proposed Conceptual Framework Linking Sustainability Strategy, Organizational Transformation Capabilities, and Sustainable Ship Performance

Based on manufacturing process integration theory, improvements achieved during die casting are expected to enhance Machining Operational Performance (X2) by improving workpiece consistency and reducing process variability, which subsequently facilitates Burritori Operational Performance (X3) through lower burr formation and improved component conformity. Stable machining and burritori operations further improve Assembly Operational Performance (X4) by reducing assembly interruptions, enhancing component fit, and maintaining production continuity.

The framework further proposes that assembly serves as the operational integration point where the cumulative benefits of upstream manufacturing improvements are transformed into organizational performance. Consequently, improved Assembly Operational Performance is expected to enhance Final Inspection Performance (Y1) by improving equipment effectiveness, operational efficiency, production capacity, and product conformity, while simultaneously increasing Overall Manufacturing Productivity (Y2) through higher production quantity, better product quality, and reliable on-time delivery (Khosroniya et al., 2024).

Overall, the proposed framework represents a sequential operational strategy model in which each manufacturing stage functions both as the outcome of upstream operational improvements and as the driver of subsequent manufacturing performance. Unlike previous studies that examined production planning, maintenance management, or casting process improvement independently (Kumbara, 2021; Fitra & Agustinus, 2024), this study integrates the entire manufacturing process into a single empirical model to explain how Cycle Time Reduction generates cascading operational improvements throughout the automotive manufacturing value chain. The proposed relationships are empirically evaluated through six hypotheses using Partial Least Squares Structural Equation Modeling (PLS-SEM). Based on this conceptual framework, the following hypotheses are proposed.

Hypotheses Development

Cycle time reduction is a fundamental lean manufacturing practice that eliminates non-value-added activities, improves production flow, and enhances equipment utilization, thereby increasing manufacturing efficiency and process stability (Geremew et al., 2022). From an operations strategy perspective, shorter and more stable cycle times improve workpiece consistency and reduce process variability before components enter machining operations (Slack et al., 2019). Previous research also demonstrated that implementing Theoretical Value Production (TVP), PDCA, and ECRS successfully reduced cycle time and improved Overall Equipment Effectiveness (OEE) in automotive die casting (Andersson, 2026). Consequently, more stable casting operations are expected to improve machining effectiveness, operational efficiency, and product quality. Therefore, the following hypothesis is proposed:

H_1 Cycle Time Reduction has a positive effect on Machining Operational Performance.

Cycle time reduction contributes to production stability by minimizing process variability, reducing flash formation, and eliminating unnecessary activities during die casting. Stable casting conditions improve component consistency and reduce burr formation, thereby simplifying burritori operations and improving deburring effectiveness, operational efficiency, and product quality. Manufacturing process integration theory further suggests that stable upstream processes create favorable conditions for downstream operations by reducing rework and operational variability (Imam & Islam, 2023). These arguments indicate that cycle time reduction is expected to improve burritori operational performance

H_2 Cycle Time Reduction has a positive effect on Burritori Operational Performance.

Machining operational performance determines dimensional accuracy, geometric tolerance, and surface quality, all of which directly influence assembly effectiveness. High machining performance minimizes dimensional deviations, reduces rework, and improves production continuity, thereby facilitating smooth assembly operations (Shivani et al., 2025). Consistent with manufacturing process integration theory, improvements achieved in one production stage enhance the effectiveness of subsequent processes by reducing operational variability and improving process stability (Slack et al., 2019). Accordingly, better machining operational performance is expected to improve assembly operational performance

H_3 Burritori Operational Performance has a positive effect on Assembly Performance.

Burritori ensures that machined components are free from burrs, sharp edges, and residual particles before assembly. Effective deburring improves component conformity, minimizes assembly defects, and enhances production continuity (Shivani et al., 2025). Lean manufacturing also emphasizes that defects should be eliminated at their source to prevent quality problems from propagating to downstream processes (Vaghani, 2024). Therefore, superior burritori operational performance is expected to improve assembly operational performance.

H_4 Assembly Operational Performance has a positive effect on Final Inspection Performance.

Assembly is the final value-adding process before quality verification. High assembly operational performance reduces assembly errors, improves product conformity, and enhances production consistency, thereby facilitating more effective final inspection activities. Manufacturing performance literature also suggests that stable production processes improve inspection outcomes by increasing equipment effectiveness, operational efficiency, and quality consistency (Shivani et al., 2025). Consequently, superior assembly operational performance is expected to enhance final inspection performance.

H_5 Assembly Operational Performance has a positive effect on Overall Manufacturing Productivity.

Assembly operational performance directly determines manufacturing productivity because it represents the final stage where products are completed before inspection and delivery. Effective assembly improves production flow, minimizes rework, supports planned production schedules, and increases resource utilization (Yao et al., 2022). From an operations strategy perspective, manufacturing productivity is achieved through integrated improvements in quality, efficiency, production capacity, and delivery reliability rather than through higher output alone (Slack et al., 2019). Accordingly, superior assembly operational performance is expected to improve overall manufacturing productivity.

H_6 Assembly Operational Performance has a positive effect on Overall Manufacturing Productivity.

Method

Research Design

This study employed a quantitative explanatory research design to examine the causal relationships among Cycle Time Reduction, Machining Operational Performance, Burritori Operational Performance, Assembly Operational Performance, Final Inspection Performance, and Overall Manufacturing Productivity. The proposed research model was empirically tested using Partial Least Squares Structural Equation Modeling (PLS-SEM), which is appropriate for analyzing complex structural relationships among multiple latent constructs while providing strong predictive capability (Hair et al., 2022).

Research Site, Population, and Data Collection

The study was conducted at PT Auto Components Indonesia (PTA), an automotive parts manufacturer producing aluminum components through die casting, burritori, machining, assembly, painting, and final inspection processes. Manufacturing performance is evaluated using Overall Equipment Effectiveness (OEE), with a minimum target of 85% for all casting machines. The study involved 100 respondents selected through purposive sampling, comprising production supervisors, production leaders, process engineers, quality engineers, maintenance personnel, production planners, and production operators directly involved in manufacturing activities. Primary data were collected using a structured questionnaire with a five-point Likert scale (1 = strongly disagree to 5 = strongly agree). Secondary data, including OEE reports, cycle time measurements, production capacity records, production forecasts, and continuous improvement reports (TVP and PDCA), were obtained from the company's operational documents.

Data Analysis

Data were analyzed using SmartPLS 4 following the two-stage PLS-SEM procedure recommended by Hair et al. (2022). The measurement model was evaluated through indicator reliability, internal consistency reliability, convergent validity, and discriminant validity, while the structural model was assessed using variance inflation factor (VIF), path coefficients, coefficient of determination (R^2), effect size (f^2), predictive relevance (Q^2), and bootstrapping. Hypotheses were accepted when the t-value exceeded 1.96 and the p-value was below 0.05.

Research Model

The proposed research model conceptualizes Cycle Time Reduction as the primary operational capability that enhances Machining Operational Performance and Burritori Operational Performance, which subsequently improve Assembly Operational Performance. Improved assembly performance is further expected to strengthen Final Inspection Performance and Overall Manufacturing Productivity. The proposed structural relationships are illustrated in Figure 2 and empirically tested using PLS-SEM The structural relationships among the constructs were evaluated empirically using the conceptual framework presented in Figure 2.

Results and Discussions

Respondent Profile

A total of 100 valid respondents participated in this study, comprising production supervisors, production leaders, process engineers, quality engineers, maintenance personnel, production planners, and experienced production operators directly involved in automotive manufacturing activities. Their operational responsibilities and manufacturing experience ensured that the responses adequately represented practical conditions across the die casting, machining, burritori, assembly, and final inspection processes, thereby providing a reliable basis for evaluating the proposed research model.

Measurement Model Evaluation

The measurement model was evaluated through indicator reliability, internal consistency reliability, convergent validity, and discriminant validity following the recommendations of Hair et al. (2022): 1) Indicator Reliability, the indicator reliability assessment indicates that all measurement indicators achieved outer loading values above the recommended threshold of 0.70, ranging from 0.734 to 0.916, confirming that all indicators adequately represent their respective latent constructs (Hair et al., 2022). Therefore, all indicators satisfy the recommended criterion for indicator reliability; 2) Internal Consistency Reliability, Internal consistency reliability was evaluated using Cronbach's Alpha (CA) and Composite Reliability (CR). As presented in Table 3, all constructs exceeded the recommended threshold of 0.70, indicating satisfactory internal consistency and reliable measurement of the proposed latent constructs (Hair et al., 2022) and The results indicate that all measurement constructs possess satisfactory internal consistency, confirming that the questionnaire items consistently measure the intended operational concepts; 3) Convergent Validity, Convergent validity was assessed using the Average Variance Extracted (AVE). All constructs achieved AVE values ranging from 0.640 to 0.795, exceeding the recommended threshold of 0.50, thereby confirming satisfactory convergent validity (Hair et al., 2022); and 4) Discriminant Validity, Discriminant validity was evaluated using the Fornell–Larcker criterion and the Heterotrait–Monotrait Ratio (HTMT). As shown in Tables 3 and 4, the square root of AVE for each construct exceeded its inter-construct correlations, while all HTMT values remained below 0.90, confirming satisfactory discriminant validity (Hair et al., 2022).

Table 3. Reliability Analysis

Construct	CA	CR	Evaluation
Cycle Time Improvement	0.811	0.876	Reliable
Machining Process	0.798	0.882	Reliable
Burritori Process	0.871	0.921	Reliable
Assembly Process	0.828	0.897	Reliable
Final Inspection	0.881	0.918	Reliable
Overall Productivity	0.866	0.918	Reliable

Structural Model Evaluation

The coefficient of determination (R^2) indicates the proportion of variance in each endogenous construct explained by the proposed operational strategy model. As presented in Table 6, the model explains 26.0% of the variance in Machining Operational Performance, 15.0% in Burritori Operational Performance, 37.2% in Assembly Operational Performance, 34.4% in Final Inspection Performance, and 35.8% in Overall Manufacturing Productivity.

Table 4. Coefficient of Determination (R^2) Values for Research Constructs

Construct	R^2
Machining	0.260
Burritori	0.150
Assembly	0.372
Final Inspection	0.344
Productivity	0.358

These results indicate that the proposed model possesses moderate explanatory power for the endogenous constructs (Hair et al., 2022; Ramadhani et al., 2026). The findings also demonstrate that Cycle Time Reduction, through successive improvements in machining, burritori, and assembly operations, contributes substantially to improvements in Final Inspection Performance and Overall Manufacturing Productivity.

Hypothesis Testing

The proposed hypotheses were evaluated using the bootstrapping procedure in SmartPLS 4. As presented in Table 5, all structural relationships are statistically significant ($p < 0.05$), indicating support for all six proposed hypotheses.

Table 5. Hypothesis Testing

Hypothesis	β	t	p	Result
H1 X1→X2	0.495	4.497	<0.001	Supported
H2 X1→X3	0.360	3.647	<0.001	Supported
H3 X2→X4	0.292	2.406	0.016	Supported
H4 X3→X4	0.387	3.242	0.001	Supported

Hypothesis	β	t	p	Result
H5 X4→Y1	0.587	7.501	<0.001	Supported
H6 X4→Y2	0.596	8.597	<0.001	Supported

Among the hypothesized relationships, Assembly Operational Performance exerts the strongest positive effect on Overall Manufacturing Productivity (β = 0.598), followed by its effect on Final Inspection Performance (β = 0.586). These findings indicate that assembly functions as the primary operational integration point through which upstream manufacturing improvements are translated into organizational performance. In addition, Cycle Time Reduction significantly improves both Machining Operational Performance (β = 0.510) and Burritori Operational Performance (β = 0.388), confirming that operational improvements initiated during die casting propagate sequentially through downstream manufacturing processes.

Summary of Empirical Findings

The empirical findings provide strong support for the proposed integrated operational strategy model. Rather than producing localized improvements within the die casting process, Cycle Time Reduction generates cascading operational improvements throughout the automotive manufacturing system. The results demonstrate that improvements initiated in die casting significantly enhance Machining Operational Performance and Burritori Operational Performance, which subsequently strengthen Assembly Operational Performance. Improved assembly performance further enhances Final Inspection Performance and Overall Manufacturing Productivity, confirming the sequential relationships proposed in the conceptual framework.

Among all structural relationships, Assembly Operational Performance exhibits the strongest influence on both Final Inspection Performance (β = 0.586) and Overall Manufacturing Productivity (β = 0.598). These findings indicate that assembly serves as the operational integration point where upstream manufacturing improvements are translated into measurable organizational performance. Consequently, the proposed model demonstrates that sustainable improvements in manufacturing quality and productivity are achieved through integrated process optimization rather than isolated improvements within individual production stages

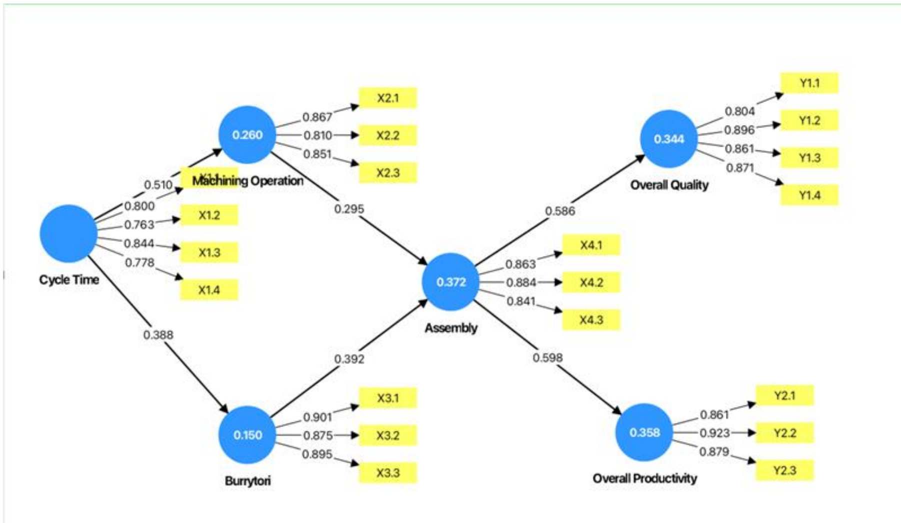

Figure 2. PLS-SEM Structural Model Showing Path Coefficients, Factor Loadings, and R^2 Values

Cycle Time Reduction Enhances Machining Operational Performance

The empirical results demonstrate that Cycle Time Reduction has a positive and significant effect on Machining Operational Performance (β = 0.510, $p < 0.001$), supporting H1. This finding indicates that improvements implemented during the die casting process significantly enhance the effectiveness, efficiency, and quality of downstream machining operations. By eliminating non-value-added activities and stabilizing production flow, cycle time reduction improves workpiece consistency, reduces dimensional variation, and minimizes process interruptions before components enter machining. Consequently, machining operations require fewer setup adjustments, utilize manufacturing resources more efficiently, and maintain more consistent product quality.

These findings are consistent with the principles of lean manufacturing, which emphasize that waste elimination should improve the performance of the entire production system rather than isolated workstations (Okpala, 2026). They also support operations strategy theory, which argues that sustainable manufacturing competitiveness is achieved through coordinated process improvement and manufacturing capability development (Slack et al., 2019). From the perspective of manufacturing process integration, improved operational stability in upstream processes reduces process variability and creates favorable conditions for downstream manufacturing activities (Schmidt et al., 2023).

From a managerial perspective, these findings suggest that Cycle Time Reduction should be implemented as a strategic operational capability rather than merely as a machine-level productivity improvement initiative. Investments in reducing non-value-added activities at upstream production stages are expected to improve downstream machining performance, strengthen manufacturing process integration, and contribute to factory-wide operational excellence. This evidence supports the view that sustainable improvements in manufacturing performance are achieved through integrated process optimization rather than isolated improvements within individual production stages.

Cycle Time Reduction Enhances Burritori Operational Performance

The empirical results demonstrate that Cycle Time Reduction has a positive and significant effect on Burritori Operational Performance ($\beta = 0.388$, $p < 0.001$), supporting H2. This finding indicates that operational improvements implemented during the die casting process significantly enhance downstream deburring operations. By reducing flash formation, dimensional variation, and other casting imperfections, cycle time reduction minimizes the amount of deburring required before components proceed to assembly. Consequently, burritori operations become more effective and efficient, enabling operators to focus on standardized finishing activities while improving component conformity and overall product quality.

These findings are consistent with the principles of lean manufacturing, which emphasize that eliminating waste and reducing process variability in upstream operations simplify downstream activities and improve production flow throughout the manufacturing system (Ike et al., 2022). They also support manufacturing process integration theory, which argues that operational stability achieved in upstream production stages reduces variability and enhances the effectiveness of subsequent manufacturing processes. Furthermore, the present study extends the findings of Sheel (2025) by demonstrating that the benefits of Cycle Time Reduction extend beyond improvements in casting productivity and Overall Equipment Effectiveness (OEE) to generate measurable improvements in burritori operations.

From a managerial perspective, the findings suggest that Burritori Operational Performance should not be managed as an isolated finishing activity but as an operational outcome that reflects the quality and stability of upstream manufacturing processes. Accordingly, improving burritori performance requires continuous efforts to reduce process variability at the die casting stage rather than relying solely on improvements within the deburring process itself. This evidence further reinforces the role of Cycle Time Reduction as the initiating operational capability that drives cascading operational improvements throughout the automotive manufacturing value chain.

Machining and Burritori Operational Operational Enhance Assembly Operational Performance

The empirical results demonstrate that both Machining Operational Performance ($\beta = 0.295$, $p = 0.013$) and Burritori Operational Performance ($\beta = 0.392$, $p = 0.001$) have positive and significant effects on Assembly Operational Performance, supporting H3 and H4. Notably, burritori exhibits a stronger influence than machining, indicating that successful assembly depends not only on dimensional accuracy but also on the elimination of burrs, sharp edges, and residual particles before components enter the assembly stage. This finding suggests that component readiness is determined by the combined contribution of precision machining and effective finishing operations.

Jurnal Indovisi
Vol. 8, No. 1, 2026, pp. 121-138

From an operational perspective, machining establishes the dimensional accuracy and functional characteristics required for automotive components, whereas burritori ensures that these components are free from surface defects that may interfere with assembly. Even components manufactured within specified tolerances may still cause assembly interruptions if residual burrs remain on critical contact surfaces. Consequently, effective burritori operations reduce rework, improve component fit, minimize assembly interruptions, and maintain stable production flow. These findings are consistent with the quality-at-the-source principle of lean manufacturing, which emphasizes preventing defects before they propagate to subsequent production stages.

The findings also support manufacturing process integration theory, which argues that downstream manufacturing performance reflects the cumulative quality of preceding production processes rather than the optimization of individual workstations (Sherif & Salonitis, 2025). The stronger influence of burritori further suggests that, in aluminum automotive parts manufacturing, component surface condition and production readiness immediately before assembly are more critical than dimensional precision alone. Therefore, machining and burritori should be managed as complementary operational capabilities within an integrated manufacturing system rather than as independent improvement initiatives.

From a managerial perspective, the findings indicate that sustainable assembly performance requires synchronized improvements in both machining and burritori operations. Manufacturing managers should therefore prioritize process integration by ensuring that dimensional accuracy, component cleanliness, and surface quality are consistently maintained before products enter assembly, thereby improving production continuity and reducing downstream quality losses.

Assembly Operational Performance as the Key Driver of Manufacturing Performance

The empirical results demonstrate that Assembly Operational Performance exerts the strongest positive influence on both Final Inspection Performance ($\beta = 0.586$, $p < 0.001$) and Overall Manufacturing Productivity ($\beta = 0.598$, $p < 0.001$), supporting H5 and H6. These findings indicate that assembly represents the most influential operational stage in translating upstream manufacturing improvements into measurable organizational performance. While Cycle Time Reduction, Machining Operational Performance, and Burritori Operational Performance contribute significantly to manufacturing performance, their operational benefits are fully realized only when integrated into stable and effective assembly operations.

This finding supports operations strategy theory, which argues that sustainable manufacturing competitiveness depends on the effective integration of interconnected operational capabilities rather than isolated improvements within individual production stages (Slack et al., 2019). It also reinforces manufacturing process integration theory, which emphasizes that downstream performance reflects the cumulative outcomes of upstream process improvements (Zhong et al., 2026). As the final value-adding stage before quality verification and product delivery, assembly integrates dimensional accuracy, component conformity, and process stability achieved during die casting, machining, and burritori operations into finished products that satisfy quality and production requirements.

The findings further support the principles of lean manufacturing, particularly continuous flow, standardized work, and built-in quality, which emphasize that manufacturing excellence is achieved through synchronized production processes rather than isolated operational optimization. Unlike previous studies that examined production planning (Kumbara, 2021), maintenance management (Fitra & Agustinus, 2024), or casting process improvement independently, this study demonstrates that Assembly Operational Performance functions as the operational integration point through which cumulative upstream improvements are transformed into higher Final Inspection Performance and Overall Manufacturing Productivity.

From a managerial perspective, the results suggest that Assembly Operational Performance should be adopted as a strategic manufacturing performance indicator because it reflects the cumulative effectiveness of upstream production processes. Accordingly, continuous improvement initiatives should focus not only on optimizing individual workstations but also on strengthening process integration to achieve sustainable improvements in product quality, production efficiency, and factory productivity.

Toward an Integrated Operational Strategy

The principal contribution of this study is the empirical demonstration that Cycle Time Reduction should be viewed not merely as a machine-level productivity improvement initiative but as a strategic operational capability that drives cascading performance improvements throughout the automotive manufacturing system. The results show that Cycle Time Reduction significantly enhances Machining Operational Performance (β = 0.510) and Burritori Operational Performance (β = 0.388), which subsequently improve Assembly Operational Performance. As the strongest predictor of both Final Inspection Performance (β = 0.586) and Overall Manufacturing Productivity (β = 0.598), assembly functions as the operational convergence point where upstream manufacturing improvements are translated into measurable organizational outcomes. These findings demonstrate that manufacturing performance is achieved through the cumulative integration of sequential production processes rather than isolated operational improvements.

The findings reinforce operations strategy theory, which argues that sustainable manufacturing competitiveness depends on the integration of operational capabilities across the manufacturing value chain (Slack et al., 2019). They also extend lean manufacturing theory by demonstrating that the benefits of waste elimination and production flow stabilization propagate beyond individual workstations to improve downstream manufacturing performance. Furthermore, the study provides empirical support for manufacturing process integration theory, confirming that improvements initiated in upstream production processes create cumulative performance gains across successive manufacturing stages.

Unlike previous studies that examined production planning (Kumbara, 2021), maintenance management (Fitra & Agustinus, 2024), or cycle time reduction in die casting independently, this study develops and validates an Integrated Operational Strategy in which Cycle Time Reduction serves as the initiating operational capability, Machining Operational Performance, Burritori Operational Performance, and Assembly Operational Performance function as sequential operational enablers, and Final Inspection Performance together with Overall Manufacturing Productivity represent the ultimate organizational outcomes. This integrated framework provides both a theoretical explanation of how manufacturing improvements propagate across interconnected production processes and a practical roadmap for automotive manufacturers seeking to improve quality and productivity through process integration rather than capital-intensive investments.

Conclusions

This study developed and empirically validated an Integrated Operational Strategy that explains how Cycle Time Reduction enhances manufacturing quality and productivity in automotive parts manufacturing. The findings demonstrate that Cycle Time Reduction functions as the initiating operational capability that generates cascading operational improvements across interconnected manufacturing processes. Specifically, improvements achieved during die casting enhance Machining Operational Performance and Burritori Operational Performance, which subsequently strengthen Assembly Operational Performance. As the operational convergence point within the manufacturing system, assembly translates upstream process improvements into superior Final Inspection Performance and Overall Manufacturing Productivity. From a theoretical perspective, this study extends the literature on operations strategy, lean manufacturing, and manufacturing process integration by demonstrating that sustainable manufacturing competitiveness is achieved through integrated process improvement rather than isolated workstation optimization. The proposed framework provides empirical evidence that manufacturing performance emerges from the sequential integration of operational capabilities across the production system. From a managerial perspective, the proposed framework offers a practical operational strategy for automotive manufacturers seeking to improve quality, productivity, equipment utilization, and production capacity through systematic Cycle Time Reduction and process integration without substantial capital investment. The model can therefore serve as a decision-support framework for implementing continuous improvement initiatives across interconnected manufacturing processes. This study is limited to a single automotive parts manufacturing company and focuses primarily on operational process variables. Future research is encouraged to validate the proposed framework across different manufacturing sectors and incorporate additional variables, such as Industry 4.0 technologies, predictive maintenance, workforce capability, digital manufacturing, and supply chain integration, to further explain integrated manufacturing performance.

Acknowledgments

The authors would like to express their sincere appreciation to PT Auto Components Indonesia (PTA) for providing access to operational data, production facilities, and valuable technical information throughout this research. The authors also gratefully acknowledge the management team, production supervisors, engineers, and operators who participated in the survey and shared their practical insights during the data collection process.

References

Ahmad, K., Mohamed Zabri, S., & Atan, S. (2022). Multidimensional Performance Measures And Factors And Their Linkage With Performance. *International Journal Of Emerging Markets*, *18*, 5338–5358. Https://Doi.Org/10.1108/IJOEM-05-2021-0797

Almelhem, M., Buics, L., & Edit, S. (2025). Comparison Of Sustainability And Circularity Indicators: Downstream Vs. Upstream Supply Chain Strategies. *Discover Sustainability*, *6*. Https://Doi.Org/10.1007/S43621-025-01158-0

Andersson, E. (2026). *Utilizing Lean Manufacturing Principles To Enhance Efficiency And Reduce Waste-A Comprehensive Analysis Of The Process Manufacturing System And Operations At GPI Flexibles, Lund*.

Calandreli, P., Valle, P., & Deschamps, F. (2025). Maximizing Operational Efficiency With Industry 4.0 Technology: Integrating OEE As A Performance Indicator. *The International Journal Of Advanced Manufacturing Technology*, *138*, 855–872. Https://Doi.Org/10.1007/S00170-025-15408-Y

DS, M. H. D. R. (2024). *PENINGKATKAN PRODUKTIVITAS PABRIK MELALUI MESIN CASTING DENGAN ANALISA CYCLE TIME MENGGUNAKAN METODE THEORITICAL VALUE PRODUCTION & PDCA*. Universitas Mercu Buana-Menteng.

Fitra, J., & Agustinus, H. (2024). *Analysis Of Improving Production Performance Based On Maintenance Management Including Process, Maintenance Workforce, And Quality Control (Case Study At Pt. XYZ)*.

Gebeyehu, S. G., Abebe, M., & Gochel, A. (2022). Production Lead Time Improvement Through Lean Manufacturing. *Cogent Engineering*, *9*(1), 2034255.

Geremew, S., Tiruneh, M., & Gochel, A. (2022). Production Lead Time Improvement Through Lean Manufacturing. *Cogent Engineering*, *9*. Https://Doi.Org/10.1080/23311916.2022.2034255

Gomaa, A. (2026). Enhancing Manufacturing Excellence Through Lean Six Sigma: A Case Study Approach. *Transnational Supply Chain Research*, *2*, 1–26. Https://Doi.Org/10.65773/Tscr.2.2.122

Goyal, A. A., Vaish, D., Agrawal, R., Choudhary, S., & Nayak, R. (2022). Sustainable Manufacturing Through Systematic Reduction In Cycle Time. *Sustainability*, *14*, 16473. Https://Doi.Org/10.3390/Su142416473

Groover, M. P., & Jayaprakash, G. (2015). *Automation, Production Systems, And Computer-Integrated Manufacturing*. Pearson Education Limited. Https://Books.Google.Co.Id/Books?Id=T2fxoaeacaaj

Gustafsson, C., Chirumalla, K., Bruch, J., & Sannö, A. (2025). Additive Manufacturing Technology Integration: An Operational Capability Perspective. *Journal Of Manufacturing Technology Management*, *36*, 134–153. Https://Doi.Org/10.1108/JMTM-02-2024-0098

Hair, J., Hult, G. T. M., Ringle, C., & Sarstedt, M. (2022). *A Primer On Partial Least Squares Structural Equation Modeling (PLS-SEM)*.

Ike, P., Ogbuefi, E., Nnabueze, S. B., Olatunde-Thorpe, J., Aifuwa, S., Oshoba, T., & Akokodaripon, D. (2022). Lean Supply Chain Practices Improving Operational Efficiency, Reducing Waste, And Enhancing Organizational Competitiveness Globally. *Journal Of Frontiers In Multidisciplinary Research*, *3*, 182–192. Https://Doi.Org/10.54660/.IJFMR.2022.3.2.182-192

Imam, M. H., & Islam, A. (2023). THE EFFECT OF PRODUCTION PLANNING EFFICIENCY ON DELIVERY TIMELINES IN U.S. APPAREL IMPORTS. *Journal Of Sustainable Development And Policy*, *02*, 35–

73. Https://Doi.Org/10.63125/Sg472m51
Jean, G. (2024). *Operations Strategy And Competitive Advantage: Aligning Operational Strategies With Overall Business Objectives To Achieve A Sustainable Competitive Position*.
Khosroniya, M., Hosnavi, R., & Zahedi, M. R. (2024). Enhancing Operational Performance In Industry 4.0: The Mediating Role Of Total Quality Management And Total Productive Maintenance At Zarharan Industrial Complex. *International Journal Of Industrial Engineering And Operational Research*, *6*(1), 96–122. Https://Doi.Org/10.22034/Ijieor.V6i1.94
Kumbara, A. (2021). Expanded The Production Effectiveness Through Production Planning, Raw Material Control, Schedule Control And Production Control At Pt. Lpa. *Dinasti International Journal Of Education Management And Social Science*. Https://Doi.Org/10.31933/Dijemss.V2i5.945
Mudau, M., Moshapo, L., Monyela, T., & Thango-Mabizela, B. (2024). *The Role Of Manufacturing Operations In Smes Performance: A Systematic Review*. Https://Doi.Org/10.20944/Preprints202410.0539.V1
Najjar, A., & Qandeel, M. (2025). Operational Strategy, Capabilities, And Successfully Accomplishing Business Strategy. *Journal Of Applied Research In Technology & Engineering*, *6*, 1–11. Https://Doi.Org/10.4995/Jarte.2025.20708
Nganga, G. N., & Nyaga, J. (2022). Continuous Improvement Practices And Organizational Performance Of Large Manufacturing Companies In Kenya: A Case Study Of Nairobi Bottlers Limited. *International Academic Journal Of Innovation, Leadership And Entrepreneurship*, *2*(3), 169–411. Https://Iajournals.Org/Articles/Iajile_V2_I3_411_469.Pdf
Okpala, C. C. (2026). From Lean Manufacturing To Intelligent Production Systems: A Synthesis Of Efficiency, Quality, And Environmental Performance′. *International Journal Of Technology, Health And Sustainability*, *2*(2), 742–753.
Patwari, P., Bhuiyan, S., Noman, K., & Navid, W. (2024). Defects And Remedies In Casting Processes: A Combinatorial Approach Between Manual And Digital Optimization Technique For Enhanced Quality Casting. *Discover Mechanical Engineering*, *3*. Https://Doi.Org/10.1007/S44245-024-00067-2
Ramadhani, K. S., Saputra, M., & Panduwiyasa, H. (2026). Understanding Technostress In AI Adoption: A Study On Chatgpt Use Among Generation Z Students In Indonesia. *2026 IEEE International Conference On Industry 4.0, Artificial Intelligence, And Communications Technology (IAICT)*, 386–391. Https://Doi.Org/10.1109/IAICT71158.2026.11620645
Reddy, C. R. (2024). *Optimizing Production Efficiency Of Aircraft Manufacturing Unit Using Lean Tools: A Comprehensive Analysis On VA And NVA*. Texas A&M University-Kingsville.
Rossini, M., Costa, F., Tortorella, G., Valvo, A., & Portioli-Staudacher, A. (2021). Lean Production And Industry 4.0 Integration: How Lean Automation Is Emerging In Manufacturing Industry. *International Journal Of Production Research*, *60*. Https://Doi.Org/10.1080/00207543.2021.1992031
Schmidt, A., Hengelbrock, A., & Strube, J. (2023). Continuous Biomanufacturing In Upstream And Downstream Processing. *Physical Sciences Reviews*, *9*. Https://Doi.Org/10.1515/Psr-2022-0106
Sheel, C. C. (2025). *Optimizing Overall Equipment Effectiveness (OEE) In The Textile Industry Bangladesh (Esquire Knit Composite Limited): A Mixed-Methods Approach To Manufacturing Efficiency*.
Sherif, Z., & Salonitis, K. (2025). A Systematic Review Of Decision Tools For Process Selection And Performance Improvement In Manufacturing. *The International Journal Of Advanced Manufacturing Technology*, *141*, 1113–1141. Https://Doi.Org/10.1007/S00170-025-16806-Y
Shivani, K., Sharma, M. A., & Jain, S. (2025). Results Of Manufacturing Efficiency Improvement Through Defect Reduction, Quality Enhancement, And Process Optimization. *International Journal Of Research & Technology*, *13*(4), 675–682.
Skalli, D., Charkaoui, A., Anass, C., Garza-Reyes, J. A., Antony, J., & Shokri, A. (2023). *Industry 4.0 And Lean Six Sigma Integration In Manufacturing: A Literature Review, An Integrated Framework And Proposed Research Perspectives*.
Slack, N., Lewis, M., Pearson Education, I., & (Firm), P. (2019). *Operations Strategy*. Pearson. Https://Books.Google.Co.Id/Books?Id=4ekseaaaqbaj
Sofrankova, A., Behun, M., Khouri, S., Cehlár, M., Ferencz, V., & Sofranko, M. (2022). Case Study: The

Simulation Modeling To Improve The Efficiency And Performance Of Production Process. *Wireless Networks*, *28*. Https://Doi.Org/10.1007/S11276-020-02341-Z

Soliman, M. H. A. (2023). *Toyota Production System Concepts: The Guidebook To Toyota' s 13 Pillars System - Series Books 7 To 17*.

Ullah, M. R., Molla, S., Siddique, I., Siddique, A., & Abedin, M. M. (2023). Manufacturing Excellence Using Line Balancing & Optimization Tools: A Simulation-Based Deep Framework. *Journal Of Modern Thermodynamics In Mechanical System*, *5*, 8–22. Https://Doi.Org/10.46610/JMTMS.2023.V05i03.002

Vaghani, B. M. (2024). *Quality At Source As A Strategic Tool For Minimizing Supply Chain Risks And Defects*.

Wahyuanto, E. (2025). EFFECTIVE STRATEGIES IN PRODUCTION MANAGEMENT TO IMPROVE OPERATIONAL EFFICIENCY. *MSJ : Majority Science Journal*, *3*, 211–219. Https://Doi.Org/10.61942/Msj.V3i2.376

Yao, X., Almatooq, N., Askin, R., & Gruber, G. (2022). Capacity Planning And Production Scheduling Integration: Improving Operational Efficiency Via Detailed Modelling. *International Journal Of Production Research*, *60*, 1–23. Https://Doi.Org/10.1080/00207543.2022.2028031

Zehra, K., Mirjat, N., Shakih, S., Harijan, K., Kumar, L., & El Haj Assad, M. (2024). Optimizing Auto Manufacturing: A Holistic Approach Integrating Overall Equipment Effectiveness For Enhanced Efficiency And Sustainability. *Sustainability*, *16*, 2973. Https://Doi.Org/10.3390/Su16072973

Zhong, D., Um, K.-H., & Jia, L. (2026). Aligning Customer And Supplier Integration For AI-Enabled Supply Chain Responsiveness And Efficiency. *Journal Of Manufacturing Technology Management*, 1–25. Https://Doi.Org/10.1108/JMTM-01-2026-0060