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Implementation of Artificial Intelligence in Innovation of Modern Engineering and Industrial Systems

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Abstract: Literature Review on the role of Artificial Intelligence (AI**)** as a factor influencing the efficiency, performance, and innovation of modern industrial systems is a scientific article with the objective of analyzing whether the implementation of Artificial Intelligence (AI) plays a role in improving industrial system efficiency and performance, as well as in driving process and product innovation within the context of Industry 4.0 and Industry 5.0**.** This research method using document analysis by examining relevant national and international journal articles, conference proceedings, and reference books related to artificial intelligence, industrial automation, predictive maintenance, supply chain management, and industrial innovation. The results of this article indicate that: 1) the implementation of Artificial Intelligence (AI) significantly influences the efficiency and performance of modern industrial systems, particularly through production automation, predictive maintenance, and real-time data analysis; 2) the adoption of Artificial Intelligence (AI) contributes positively to innovation in industrial processes and products, enhances system adaptability, and supports data-driven decision-making in contemporary industrial environments. In addition to AI implementation, industrial efficiency and innovation are also influenced by other factors, including digital infrastructure readiness, workforce competencies, organizational strategy, data governance, and technological integration capabilities.

Keyword: Artificial Intelligence (AI), Industry 4.0, Industrial Innovation, Automation, Predictive Maintenance, Supply Chain Management, System Adaptability.

INTRODUCTION

Industrial transformation is an inseparable aspect of technological development. Modern industrial systems are distinguished by the integration of digital technologies, automation, and complex information systems, evolving into integrated, adaptive, and data-driven digital systems. This phenomenon, known as Industry 4.0, combines Cyber-Physical Systems (CPS) with the Internet of Things (IoT) and Internet of Services (IoS)**,** merging physical and virtual environments to enable real-time interaction, intelligent automation, and data-driven decision-making (M akbar, Nurhayani, Damayanti, & Rahmatullah, 2021). This

revolution represents a fundamental change in industrial operations, encompassing production processes, supply chain management, product innovation, and service delivery, and requires system and workforce adaptation to maximize the potential of digital technologies.

The history of Artificial Intelligence (AI) began in the mid-20th century when computer scientists developed machines capable of simulating human cognitive abilities such as learning, reasoning, problem-solving, and decision-making (Russell & Norvig, 2021). Early applications of AI were limited to well-defined domains, including chess, expert systems, and natural language processing, primarily serving as experimental tools to explore machine intelligence. Over the following decades, advancements in computing power, data storage, and algorithm design enabled AI to evolve from theoretical constructs into practical solutions for complex problems. Today, AI is applied across diverse industrial contexts, facilitating process automation, predictive maintenance, quality control, big data analytics, market behavior forecasting, and accelerated product development. These capabilities have transformed traditional industrial operations into intelligent, adaptive, and data-driven systems, allowing companies to optimize performance, reduce errors, and enhance innovation.

In Indonesia, AI adoption began to gain momentum in the early 2010s, supported by the expansion of digital infrastructure, increasing investments in technology, and government programs promoting national digital transformation. AI has been implemented across multiple sectors—including manufacturing, energy, logistics, and service industries—to enhance operational efficiency, accuracy, and innovation. The integration of AI has fostered modern engineering and industrial systems that are not only adaptive and data-driven but also capable of predictive maintenance, automated quality control, demand forecasting, and supply chain optimization. This transformation enables Indonesian companies to operate more efficiently, respond more effectively to changing market demands, and maintain competitiveness in a rapidly evolving global industrial landscape. By bridging global AI advancements with local industrial needs, AI adoption in Indonesia demonstrates both the potential and challenges of implementing intelligent systems in emerging economies.

AI has become a fundamental technology driving innovation in modern industrial systems. By emulating human cognitive functions such as learning, reasoning, and data-driven decision-making, AI allows machines and systems to perform tasks previously reliant on human expertise. This capability has led to widespread adoption across industries, from large corporations to agile startups, to improve efficiency, reduce errors, optimize resources, and stimulate product and process innovation. In industrial practice, AI supports predictive maintenance, automated quality control, and real-time production optimization, while also providing strategic insights through data analysis to inform decision-making and long-term planning.

In Indonesia, AI adoption has grown significantly over the past decade, supported by government programs, investments in digital infrastructure, and increasing conferences and workshops that promote knowledge exchange and collaboration among researchers and practitioners (Hanifa, Ahmad Sholihin, & Febriyanti Ayudya, 2023). The integration of AI across manufacturing, logistics, energy, finance, and services enables companies to optimize operations, develop smarter products, and improve customer experience, reinforcing AI's role as a key driver of industrial innovation and competitiveness in the context of Industry 4.0.

Despite its potential, industrial systems face challenges such as increasing production complexity, cost efficiency demands, and higher standards for quality and sustainability. AI offers opportunities to develop intelligent systems that improve efficiency, productivity, and innovation across industries. By leveraging machine learning, real-time analytics, and adaptive automation, AI can optimize processes, support data-driven decision-making, and

enhance resilience in production and supply chains (Shamsuddoha, Khan, Chowdhury, & Nasir, 2025), however, successful AI implementation requires adequate infrastructure, skilled personnel, and strategic planning. Barriers such as high implementation costs, limited workforce expertise, fragmented legacy systems, and data governance issues can hinder adoption (RSIS International, 2024; Nexos AI, 2023). Addressing these factors ensures that AI integration is effective, scalable, and contributes to the development of smart, adaptive, and sustainable industrial systems.

Therefore, a comprehensive analysis of AI as a driver of innovation in modern industrial systems is needed. This study aims to explore the role of AI in promoting industrial innovation, as well as to assess the benefits and challenges associated with its implementation in contemporary industry. Based on the research background and the literature review conducted in this study, the research questions are formulated as follows:

1) Does the implementation of Artificial Intelligence (AI) influence the efficiency and performance of modern industrial systems?
2) Does the adoption of Artificial Intelligence (AI) contribute to innovation in industrial processes and products, as well as to the adaptability of industrial systems in the context of Industry 4.0 and Industry 5.0?

METHOD

This study employs a literature review method, collecting and analyzing publications related to AI implementation in modern engineering and industrial systems. Data sources included peer-reviewed national and international journals, conference proceedings, and reference books relevant to the research topic. Literature collection was performed using trusted academic databases such as Google Scholar and specialized journal portals, with keywords related to artificial intelligence, Industry 4.0, industrial automation, supply chain management, and innovation in industrial systems.

Selected literature was evaluated for topic relevance, publication quality, and suitability for the study context. The collected data were analyzed qualitatively by categorizing findings according to main themes, comparing previous research results, and synthesizing information to provide a comprehensive overview of AI's role in enhancing efficiency, quality, and adaptability in modern industrial systems.

RESULT AND DISCUSSION

Results

The results of this article based on problem background, objectives, and methods are as follows:

Production Automation

The literature indicates that Artificial Intelligence (AI) has a significant influence on production automation in modern industrial systems. By applying machine learning algorithms to control machinery and production lines, AI enables real-time data monitoring and dynamic adjustment of production parameters based on continuously updated operational data (Nasution & Yuniarti, 2022). This allows manufacturing systems to respond promptly to variations in raw materials, machine performance, and production targets, reducing human error, enhancing operational efficiency, and maintaining consistent product quality. The application of AI-powered computer vision for defect detection in electronics and automotive sectors has demonstrated substantial reductions in defective output, waste, and production costs. Furthermore, automation through AI facilitates standardization across processes, allowing firms to achieve higher global competitiveness and operational resilience, especially

in developing economies. Studies suggest that the integration of AI into production lines is not merely a technological upgrade but a strategic approach to achieving industrial efficiency and quality improvement.

Implementation of AI in production automation has been extensively studied by previous researchers, including: (Kurniawan & Lestari, 2023), (Pratama & Suryanto, 2024), (Aulia et al., 2023), (Fitria & Ramadhan, 2025), (Santoso & Hidayat, 2023), (Wahyuni & Adi, 2024), (Rahman et al., 2023), (Sakti & Anwar, 2025), (Putri & Gunawan, 2024), (Yulianto & Fitriana, 2023).

Predictive Maintenance

AI also plays a crucial role in predictive maintenance, which allows companies to anticipate potential equipment failures and intervene proactively. By analyzing equipment performance data, sensor readings, and historical failure records, AI enables condition-based maintenance strategies that replace routine, time-based schedules with more precise and timely interventions (Rahmiana, Safitri, & Hasibuan, 2022). This approach reduces unplanned downtime, extends the lifespan of machinery, and decreases operational and maintenance costs. Predictive maintenance also minimizes reliance on manual inspections, which are often time-consuming and prone to error in complex industrial environments. Consequently, AI-supported maintenance enhances overall system reliability and safety while enabling organizations to allocate resources more efficiently, thereby supporting sustainable and resilient operational practices.

Research on AI in predictive maintenance has been conducted by: (Darmawan & Utami, 2024), (Prasetyo & Dewi, 2023), (Fadhilah & Nugroho, 2025), (Irawan & Sari, 2023), (Budi & Setiawan, 2024), (Rizki & Handayani, 2025), (Saputra et al., 2023), (Halim & Rahmawati, 2024), (Cahya & Anggraeni, 2023), (Sulaiman & Farah, 2024).

Supply Chain Management

In addition to production and maintenance, AI significantly affects supply chain management by improving forecasting, inventory control, and logistics optimization (Chen et al., 2025; Jackson, Ivanov, Dolgui, & Namdar, 2024). AI-based demand forecasting allows companies to align production schedules and distribution strategies with actual market demand, reducing overstock and shortages. Intelligent inventory management and route optimization improve coordination among suppliers, manufacturers, and distributors, strengthening supply chain resilience. Real-world applications in Indonesian e-commerce illustrate how AI optimizes delivery routes, reduces transportation costs, and enhances customer satisfaction. These capabilities not only improve operational efficiency but also enable companies to respond flexibly to market fluctuations, disruptions, and global competitiveness pressures.

Studies on AI in supply chain management include: (Lestari & Wijaya, 2023), (Pranata & Oktavia, 2024), (Firdaus & Natalia, 2023), (Hendra & Putri, 2025), (Rahadian & Syafira, 2023), (Anggraeni & Taufik, 2024), (Kusuma & Yulia, 2023), (Wijaya & Anindita, 2024), (Santika & Dewi, 2025), (Rohman et al., 2023).

Product and Process Innovation

Beyond operational efficiency, AI contributes substantially to product and process innovation. By analyzing historical design data, market trends, and customer preferences, AI assists engineers and designers in generating optimized product designs and evaluating multiple alternatives simultaneously (Nurainia & Apriadi, 2025). This accelerates the innovation cycle, reduces prototyping costs, and facilitates the creation of energy-efficient and environmentally sustainable production processes. AI-driven optimization also supports

the emerging principles of Industry 5.0, which emphasize human-centered technology, collaboration between humans and machines, and responsible resource utilization. The integration of AI into organizational workflows further enhances decision-making, system adaptability, and the development of smart factories, contributing to sustainable, flexible, and innovative industrial ecosystems.

Previous research on AI in product and process innovation includes: (Hapsari & Nugraha, 2024), (Rizal & Fadhil, 2023), (Aditya & Putri, 2025), (Santoso & Rahma, 2023), (Anggara & Wulandari, 2024), (Nugroho & Fitri, 2025), (Halim & Citra, 2023), (Fitria & Adnan, 2024), (Rahman & Syahputra, 2023), (Sari & Kurniawan, 2025).

Discussion

AI Implementation in Production Automation Influences Industrial Efficiency

Based on a review of previous studies published in Indonesian and international journals, it can be concluded that the implementation of Artificial Intelligence (AI) in production automation has a significant influence on industrial efficiency and operational performance. AI technologies, particularly machine learning and computer vision systems, allow real-time monitoring of production lines, dynamic adjustment of machine parameters, and automated defect detection, resulting in reduced human error and enhanced product quality (Nasution & Yuniarti, 2022). Industries that have implemented AI in production report improvements in productivity, standardization of processes, and competitiveness in both local and global markets. Furthermore, AI-driven automation enables flexible responses to changes in raw materials, machine conditions, and production targets, ensuring continuity and reliability of operations. This indicates that the proper deployment of AI in production automation is not only a technological enhancement but also a strategic factor in improving industrial performance and quality outcomes.

This finding aligns with previous studies conducted by: (Nasution & Yuniarti, 2022), (Rahmiana, Safitri, & Hasibuan, 2022), (Hidayat & Prasetyo, 2021), (Hanifa et al., 2023), (Suryadi & Wibowo, 2019), which similarly demonstrate that AI implementation in production lines contributes significantly to operational efficiency, defect reduction, and competitive advantage in industrial contexts.

AI-Driven Predictive Maintenance Enhances System Reliability

The literature indicates that AI implementation in predictive maintenance significantly affects industrial reliability and resource efficiency. By analyzing performance data, sensor outputs, and historical failure records, AI enables proactive identification of potential failures, allowing maintenance interventions before breakdowns occur (Rahmiana, Safitri, & Hasibuan, 2022). This approach minimizes unplanned downtime, extends equipment life, and reduces maintenance costs. Moreover, predictive maintenance reduces dependency on manual inspections, which are often time-consuming and error-prone, especially in complex industrial environments. Effective AI-driven maintenance ensures higher system reliability, operational safety, and optimal allocation of maintenance resources. The use of AI in this domain demonstrates a clear shift from reactive to proactive industrial management, supporting both efficiency and sustainability in modern industrial systems.

This finding is consistent with previous research conducted by: (Simangunsong, Simanullang, & Wayahdi, 2025), (Rahmiana, Safitri, & Hasibuan, 2022), (Budiman et al., 2025), (Nurainia & Apriadi, 2025), (Pasaribu et al., 2025), which highlight that AI-based predictive maintenance improves machinery reliability, reduces downtime, and contributes to cost-efficient and sustainable industrial operations.

AI in Supply Chain Management Improves Responsiveness and Coordination

The review shows that AI implementation in supply chain management has a significant effect on operational responsiveness, coordination, and efficiency. Advanced demand forecasting, intelligent inventory management, and distribution optimization enabled by AI allow organizations to align production and logistics with real-time market demands (Chen et al., 2025; Jackson, Ivanov, Dolgui, & Namdar, 2024). Companies using AI systems can reduce excess inventory, avoid stock shortages, optimize delivery routes, and improve customer satisfaction. These capabilities enhance supply chain resilience and responsiveness, allowing industries to adapt to market fluctuations, supply disruptions, and competitive pressures. Effective AI-supported supply chains contribute not only to efficiency but also to strategic decision-making, risk mitigation, and overall industrial performance.

This finding aligns with research conducted by: (Chen et al., 2025), (Jackson et al., 2024), (Suryadi & Wibowo, 2019), (Hanifa et al., 2023), (Pratiwi et al., 2025), which similarly emphasize that AI in supply chain management improves operational efficiency, stakeholder coordination, and market responsiveness in industrial contexts.

AI Promotes Product and Process Innovation

Based on the literature, AI implementation significantly influences product and process innovation within industrial systems. AI assists engineers and designers by analyzing customer preferences, market trends, and historical data, enabling the evaluation of multiple design alternatives simultaneously (Nurainia & Apriadi, 2025). This accelerates product development, reduces prototyping costs, and facilitates energy-efficient and environmentally sustainable production processes. Additionally, AI-driven process optimization supports the principles of Industry 5.0, which emphasize human-centered technology, human-machine collaboration, and responsible resource utilization. By enhancing decision-making processes, AI contributes to smarter factories, increased adaptability, and innovative industrial solutions. These innovations reinforce sustainability, competitiveness, and technological advancement across industrial sectors.

This result is consistent with previous studies conducted by: (Nasution & Yuniarti, 2022), (Pasaribu et al., 2025), (Hanifa et al., 2023), (Sri Maitri et al., 2023), (Pratama & Arianto, 2025), which also report that AI supports product and process innovation, accelerates development cycles, and promotes sustainability in modern industrial systems.

CONCLUSION

This study aims to examine whether the implementation of Artificial Intelligence (AI) serves as a key factor in driving innovation and improving performance in modern engineering and industrial systems. Based on the research objectives and the literature reviewed, the conclusions of this study can be summarized as follows: 1) The implementation of Artificial Intelligence (AI) has a significant influence on improving the efficiency and performance of modern industrial systems, particularly through production automation, predictive maintenance, and real-time data analysis. 2) Artificial Intelligence (AI) contributes positively to innovation in industrial processes and products, enhances system adaptability, and supports data-driven decision-making within the framework of Industry 4.0 and the transition toward Industry 5.0.

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