Quality Festival 2025
ISBN 978-86-6335-121-9

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Research paper
DOI – 10.24874/QF.25.145

THE REALITY OF ARTIFICIAL INTELLIGENCE IN MANUFACTURING

Abstract: *The widespread presence of artificial intelligence applications in modern society has a profound impact on all aspects of manufacturing. The application of artificial intelligence in the manufacturing industry has evolved from a possibility to a necessity for survival in competition. The application of artificial intelligence (AI) is required by organizations intending to improve manufacturing processes. The artificial intelligence (AI) application has been shown to increase the effectiveness of quality processes, render them more stable, and reduce the rate of human error. The machinery manufacturing industry in 2024 is witnessing considerable growth and evolution, fueled by technological innovation, shifting consumer attitudes, and global market trends. It is necessary for companies to find out about the shifting trends in this industry to remain competitive and use new possibilities appropriately. This in-depth paper presents a detailed examination of the most significant trends that shape the machinery manufacturing industry in 2024. It gives stakeholders data and expert insights to assist in navigating this evolving environment effectively.*

Keywords: *Artificial Intelligence, Quality 4.0, Industrial IoT*

1. Introduction

The manufacturing industry is undergoing a profound transformation with the fast evolution of artificial intelligence (AI) technologies. Artificial intelligence is transforming the industry by providing an extensive variety of automation solutions, ranging from streamlining manufacturing processes to minimising costs and enhancing quality.

The worldwide manufacturing industry is an extremely large complex ecosystem that is comprised of numerous sub-industries such as automotive, electronics, pharmaceuticals, chemicals, and consumer goods. With economic size ranging in billions of dollars, the industry employs millions of workers globally and is a key driver of economic growth for most nations. Top companies like General Electric, Siemens, Toyota, and BASF are reasserting their industry position by embracing strategies that emphasize digitalization, automation, and sustainability.

New concepts like digital twins, Industry 4.0 applications and agile manufacturing that have been introduced in the past few years offer great competitive benefits to companies through enhanced efficiency and flexibility of manufacturing processes.

From 2023 to 2028, the market for artificial intelligence (AI) in the manufacturing industry is anticipated to expand at a compound annual growth rate (CAGR) of 45.6% and reach USD 20.8 billion. The driving factors responsible for the growth are productivity increases, cost reductions, and quality gains made possible especially

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through the integration of machine learning, computer vision, and automated technologies into manufacturing. Geographical distribution statistics indicate that the adoption of these technologies has been higher in the North American and Asia-Pacific regions, which are at the forefront of global growth.

The use of artificial intelligence technologies presents tremendous opportunities for application in the manufacturing industry in many different areas, including process enhancement, quality management, and cost management. These technologies cover numerous facets from production lines to supply chain management, enhancing efficiency and flexibility of manufacturing systems as well as sustainability and competitiveness of business processes. In this respect, the principal fields of use of artificial intelligence in the manufacturing sector are discussed below.

1.1. Process Automation

Artificial intelligence and automation technologies are used extensively in robotic systems to improve productivity in manufacturing processes. Machine learning algorithms and robotic process automation (RPA) are specifically used to automate repetitive tasks, thus speeding up manufacturing processes. These technologies not only reduce the cost of production but also improve productivity by minimizing errors.

1.2. Quality Control

Machine vision and machine learning are critical technologies for quick and precise defect detection in quality control measures. Statistics indicate that machine vision technology is applied to inspect for surface defects or dimensional faults on products along production lines. Technology surpasses traditional human inspection, thereby enhancing quality control operations and the quality of manufacture in general. For example, in the automotive industry, machine vision-based systems are utilized to ensure that the components are free from defects and overall quality is improved.

1.3. Maintenance and Repair

Predictive maintenance solutions decrease maintenance expenses and increase operation continuity by foreseeing manufacturing equipment failures. By integrating artificial intelligence with industrial IoT (Internet of Things) data, these systems provide solutions that foresee equipment failure and optimize maintenance requirements by scrutinizing data gathered from sensors, recognizing probable failures, and consequently reducing unplanned downtime.

1.4. Supply Chain and Logistics Optimisation

The application of artificial intelligence is for enhancing efficiency and lowering the cost of supply chain management. Techniques such as machine learning and sophisticated analytical methods assist in enhancing predictability and agility in supply chain processes. Especially in demand forecasting, inventory management, and logistics route planning, the application of artificial intelligence enables firms to be more responsive and agile in their supply chains. A manufacturing company can enhance its operational process by making the effort to identify bottlenecks and risks within the supply chain network through AI-based algorithms.

Artificial intelligence, as a significant contributor to various applications in the manufacturing industry, has several opportunities and challenges in this regard. Based on information derived from the Technology Trends Outlook 2024 and Global Risks Report 2024, the strategic benefits provided by artificial intelligence and the significant challenges encountered are identified as follows.

The main characteristic is the enhancement of efficiency and productivity. Application of artificial intelligence technology throughout the manufacturing sector can improve operational productivity and efficiency to a great level through process automation and optimization. Empirical evidence substantiates that the incorporation of artificial intelligence into automation platforms, including robotic process automation (RPA) and machine learning algorithms, can boost factory production line productivity by 20 to 30 percent. This enhancement is brought about by automating repetitive tasks, thereby reducing error rates and enhancing speed and efficiency of business processes.

Cost savings and operational efficiency are another opportunity area. AI-based solutions streamline inventory management, demand planning and production planning by using big data analytics and machine learning in production processes. It minimizes the cost of inventory and avoids unnecessary cost. It has been observed that by enhancing the demand planning accuracy by up to 50%, the cost can be reduced by up to 15% by optimizing the stock level.

Another is energy efficiency and sustainability. The evidence shows that artificial intelligence-based energy management systems can realize 10% to 20% energy savings by optimizing energy usage within factories. They make the flow of energy more efficient through big data analytics and machine learning applications, reducing unnecessary energy use in manufacturing operations. These technological solutions could lower costs by up to 15% while helping businesses achieve their sustainability goals.

Particularly in sectors with high energy consumption, AI-based solutions provide tremendous benefits in minimizing environmental impact and achieving carbon neutrality. Moreover, AI assists in adaptability and accuracy of predictions in supply chain management.

The data demonstrates that AI-driven supply chain solutions enable faster response to demand and supply fluctuations throughout the supply chain and thus offer tremendous logistics process enhancement. This enhances crisis resilience and reduces supply chain costs.

Yes, there are various issues associated with the implementation of artificial intelligence.

The following chart indicates the worldwide risk perception that the adverse impacts of AI technologies are likely to grow with the passage of time. In a survey of worldwide risk perception, 27 per cent of the respondents are of the view that AI can have negative impacts on the highest order in 10 years, whereas only 5 per cent are of this opinion in 2 years. This scenario highlights the fear that artificial intelligence can cause more severe threats in the long run.

In addition, the integration of artificial intelligence technologies in the manufacturing industry requires high initial investments, such as spending on hardware, software, and expert staff. The high cost of embarking on artificial intelligence projects may lead to high funding needs, and the financial payoff of such investments may not be certain. This is a major monetary risk consideration, particularly for small and medium enterprises (SMEs). Alternatively, the widespread adoption of artificial intelligence calls for substantial adjustments in the labor market. Employees need to enhance their current skill set and familiarize themselves with new technologies. Research indicates that about 30% of the working population may need to be retrained to suit artificial intelligence and associated technologies. This initiative needs extra investment in training and commitment to resources.

The incorporation of artificial intelligence into the modern manufacturing arrangement is a great challenge, especially with respect to technological system compliance. Specifically, it has been noted that the technical and operational disparities that

would emanate from integrating older systems with contemporary AI alternatives can bring about operational downtimes as well as increased expenditure.

As artificial intelligence systems involve the application of big datasets, they pose high risks in terms of data security and confidentiality. It emphasizes the necessity to make sure that the data applied in artificial intelligence applications are protected against cyber-attacks. In this kind of scenario, data privacy and cybersecurity emerge as key obstacles to the large-scale deployment of artificial intelligence applications.

2. Artificial Intelligence Case Studies and Examples in Manufacturing Sector

The use of artificial intelligence technologies in manufacturing encompasses a set of successful and unsuccessful implementations. On the basis of concrete examples reported in the World Economic Forum and McKinsey reports, a list of successful and unsuccessful applications of artificial intelligence is given below in order to conclude.

2.1. Successful Applications of Artificial Intelligence

Here you can see successful artificial intelligence implementations in the manufacturing industry.

Saudi Aramco has enhanced its operational efficiency through the creation of an artificial intelligence center to analyze five billion data points daily from its oil and gas wells. The application of AI technologies has enabled the prediction and avoidance of drilling problems, tracking of critical equipment conditions, and avoidance of operational interruptions through real-time warnings. Such breakthroughs have led to increased reservoir productivity as well as more complex field development plans, resulting in material cost savings.

Vistra Corp is the US's largest competitive power producer and has committed to 60% emissions cut by 2030 and net zero emissions by 2050. The firm used artificial intelligence to run its power plants more effectively. A two-year plant-trained multilayer neural network model selected optimal set points in the control room, which led to 30% less burner utilization and annual fuel savings of approximately $175,000. It also saved $23 million on carbon emissions.

Meta's HawkEye tool is utilized to supervise machine learning procedures in real-time, oversee data integrity, and quantify model performance. These features allow for the execution of AI applications in the manufacturing process, enhancing their reliability and efficiency and preventing data-induced errors and optimizing model performance. The debugging and explainable AI features of HawkEye incorporated in its design serve to enhance the quality of decision-making in manufacturing processes.

MLflow is open-source software that enables the development and management of machine learning models. Its AI generative feature provides the testing of large language models (LLM) and hyperparameters, which enables fast testing and optimization of AI models that are deployed in manufacturing processes. This enables the development and incorporation of new AI solutions into the manufacturing processes to be faster.

3. Future Prospects of Artificial Intelligence According to the McKinsey Report

The trajectory of artificial intelligence (AI) is being influenced by a multitude of application fields, fast-evolving technologies, and the dynamic trends of the corporate arena. Artificial intelligence holds ramifications far beyond the industrial realm, with extensive structural transformation across the board in various industries. As this technology gets added, process

efficiency is enhanced, decision-making processes are further streamlined, and foundations are laid for the establishment of new business models.

The major fields affected by artificial intelligence can be listed as below:

- Aerospace and defence
- Agriculture
- Automotive and assembly
- Travel and logistics
- Trade, legal and professional services
- Construction and building materials, chemicals
- Consumer packaged goods
- Education
- Utility services, natural gas, and electricity generation.
- Financial services
- Health systems and services
- Information technology and electronics,
- Media and entertainment
- Mining and metals
- Oil and gas
- Medicinal products and pharmaceutical substances
- Public and social services,
- Real estate,
- Retail

The extensive use of artificial intelligence technologies in these industries has major importance, not just in terms of operational efficiency but also in the delivery of a strategic competitive advantage.

Industrial Machine Learning (MLOps) and Scaling. This model and accompanying toolkit allow for the creation, deployment, and management of machine learning models. The industrial use of artificial intelligence in future years will be more scalable and under control. According to the McKinsey report, MLOps have the potential to lower manufacturing times by 80% and can lower project expenses by as much as 40% by streamlining machine learning installations within corporations. This enables organizations to extract value from machine learning and big data applications at a quicker and more effective rate.

Gene AI has grown exponentially in the past few years, augmenting the value of numerous artificial intelligence solutions. Facts indicate that the growth of this technology has been boosted by huge investment and heightened search volume, as confirmed by an amazing 700 percent growth. Gene AI has a broad array of applications, which are found in fields such as creative content generation, customer service, automated copywriting, and pharmaceutical research.

These systems are anticipated to open up great opportunities in the manufacturing sector, particularly in product development, process design, and coming up with innovative solutions.

The AI is an approach that highlights the importance of data quality in identifying the success of artificial intelligence implementations. Obtaining, purifying, and processing high-quality datasets are the requirements for the development of more accurate and reliable AI models. The approach highlights the crucial use of data-centric AI strategies across industries such as finance, health, and manufacturing, claiming these tactics lead to better results through bias reduction.

In particular in manufacturing, data-driven strategies will enable the advancement of stronger and higher-performing artificial intelligence solutions in areas like predictive maintenance, supply chain optimization, and quality control.

Applied artificial intelligence refers to AI applications that become part of established business processes and operational systems. It is expected that organizations will use AI more strategically and operationally in the near future, taking advantage of opportunities to reduce costs, drive efficiency, and accelerate innovation. In manufacturing, these applications may

include the development of fast and flawless production processes, real-time quality control, and automatic decision-making support systems.

They enable organizations to attain competitive edge and facilitate the swift launch of new products and services in the market.

The AI ethics and governance guidelines are very important to the prudent use and regulation of AI technologies under the responsible AI principle. It is argued that with the growing pervasive use of AI applications, problems related to data privacy, reducing bias, and ethical decision-making processes will become more significant. Organizations will have to develop robust governance structures and transparency principles in order to fulfill both legal compliance and societal acceptance in this regard.

4. Conclusion

This article widely discusses the imperative function of artificial intelligence in the manufacturing industry, both the potential and challenges it experiences. AI technologies are observed to have the capability to enhance production efficiency, decrease costs, and enhance product quality. Nevertheless, there are several challenges that still exist, including high initial investments, the process of technological adaptation, and data security issues. Though artificial intelligence holds the potential to revolutionise manufacturing processes, its full realisation is possible only with apt strategic actions and a prepared transformation process.

The main findings of this study are presented below, followed by strategic suggestions aimed at companies working in the manufacturing industry and relevant stakeholders.

- Strategic Planning: Incorporation of artificial intelligence must be in coherence with long-term strategic objectives rather than being focused on short-term solutions. In this framework, there is a need to create a symbiotic relation between machine-based processes and human labor.

- Data Management and Security: Artificial intelligence systems are only as good as the data they utilize. As such, organizations should formulate robust data management policies and enhance their cybersecurity measures.

- Training and Digital Transition: Continuous training and skill development programs need to be implemented for employees to adjust to artificial intelligence technologies. This transition must be viewed not just as a technological transition but also as a cultural transition.

- Starting Pilot Projects: The efficacy of investments in artificial intelligence should be evaluated and examined through pilot projects of limited scale. An orderly expansion of successful projects will reduce risks and increase the effectiveness of resources.

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