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АВТОМАТИЗАЦИЯ ПРОЦЕССОВ НА АВТОМОБИЛЬНЫХ ЗАВОДАХ
AUTOMATION OF PROCESSES IN AUTOMOBILE PLANTS

Аннотация. В представленном исследовании рассматривается роль автоматизации на автомобильных заводах и ее влияние на эффективность производства, качество и безопасность. Подробно анализируются ключевые процессы автоматизации, включая автоматизацию сборочных линий, роботизированную сварку, системы покраски и контроль качества. В исследовании также подчеркивается важность таких технологических инструментов, как промышленные роботы, датчики, SCADA, MES и искусственный интеллект. Оцениваются также современные тенденции развития, такие как “умные заводы”, технология цифровых двойников и интеграция IoT.

Abstract. This study examines the role of automation in automobile manufacturing plants and its impact on production efficiency, quality, and safety. Key automation processes, including assembly line automation, robotic welding, painting systems, and quality control, are analyzed in detail. The study also highlights the importance of technological tools such as industrial robots, sensors, SCADA, MES, and artificial intelligence. Modern development trends such as smart factories, digital twin technology, and IoT integration are also evaluated.

Ключевые слова: Автоматизация, автомобилестроение, промышленные роботы, искусственный интеллект, цифровой двойник, Индустрия 4.0.

Keywords: Automation, automobile manufacturing, industrial robots, artificial intelligence, digital twin, Industry 4.0ю

The automotive industry is one of the most important manufacturing sectors, rapidly evolving through the application of advanced technologies. In this field, optimizing and automating production processes is essential for enhancing competitiveness. Automation technologies not only increase production speed but also ensure consistent product quality [1-3]. In particular, robotic systems, sensor technologies, and software solutions are widely implemented in automotive plants. These systems reduce human labor while enabling hazardous and repetitive operations to be performed more safely. At the same time, automation contributes to cost reduction and more efficient use of resources. In the modern era, the integration of artificial intelligence and IoT technologies has made automotive production smarter and more flexible. Therefore, the automation of processes in automobile manufacturing plants is a topic of significant scientific and practical importance.

Historical conceptions of leadership - rooted in trait, behavioral, contingency, and transformational theories - provide a backdrop for understanding how leadership adapts to sociotechnical change and guides effective human-machine cooperation in complex environments [4,5]. This body of work illustrates how foundational computational theories underpin the reliability of automated systems that increasingly permeate critical domains, from software utilities to industrial control and autonomous agents [6]. Automation has continually expanded its scope, capabilities, and governance requirements to meet the automotive industry's demands for efficiency, quality, and adaptability [7]. Automation in automobile plants has progressed through several interconnected stages, from early mechanization and the adoption of standardized production lines to contemporary Industry 4.0/5.0 paradigms that integrate artificial intelligence, digital twins, and advanced quality assurance. This historical arc reflects evolving organizational capabilities, technological breakthroughs, and shifting managerial practices aimed at improving productivity, quality, and agility in global manufacturing networks (Figure 1).

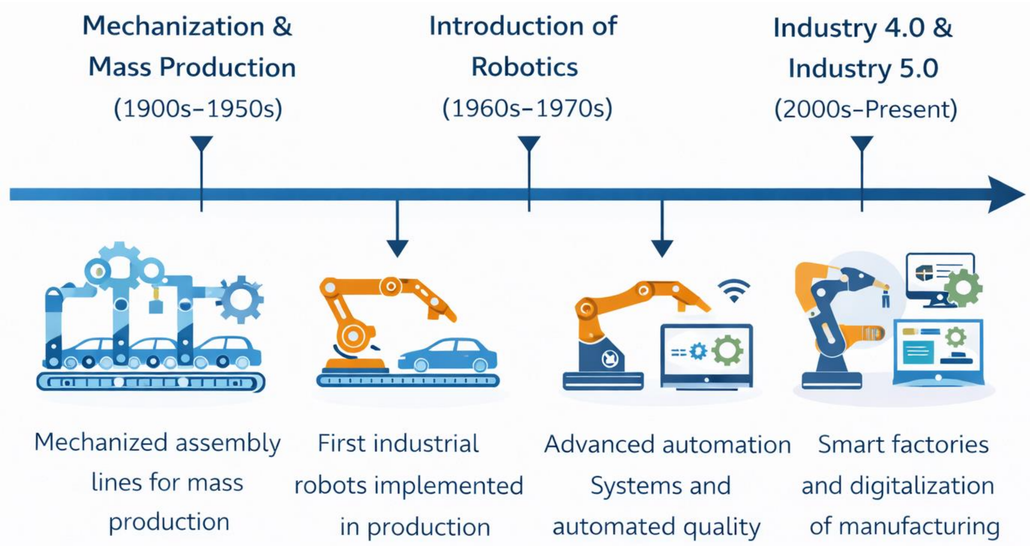

Figure 1. Historical development of automation in automobile plants

A central historical development is the incorporation of AI techniques into factory floor operations to detect defects, predict failures, and optimize processes. Matamoros et al. review AI-driven quality control within the automotive sector, highlighting live part tracking, predictive maintenance, and defect detection using deep learning, neural networks, and related AI methods. The reviewed works discuss the development and implementation of autonomous quality management systems (AQMS) under Quality 4.0 concepts, signaling a historical shift toward holistic, digitally integrated manufacturing environments. These systems fuse IT, the Internet of Things (IoT), AI, and analytics to realize end-to-end quality and process optimization. The Delphi-based study on AI use cases in car manufacturing further documents the breadth of potential AI applications – from predictive maintenance to cost reduction – illustrating how management expectations evolved to embrace AI as a strategic asset in manufacturing planning and operations.

Automation processes in automobile plants form the backbone of modern manufacturing systems. One of the primary processes is the automation of assembly lines, where robots perform repetitive tasks with high precision. Robotic welding is widely used to ensure strong and consistent joints in vehicle structures. Automated painting systems provide uniform coating while reducing material waste and environmental impact. Quality control processes are enhanced through machine vision systems that detect defects in real time. Automated material handling systems, such as AGVs, ensure efficient transportation of components within the plant. Process monitoring systems allow real-time tracking of production performance and equipment status. These processes minimize human error and improve overall production efficiency. As a result, automation significantly increases productivity, quality, and reliability in automobile manufacturing.

Automation in automobile plants relies on a wide range of advanced technological tools. Industrial robots are the most essential components, performing tasks such as welding, assembly, and painting. Sensor technologies, including laser and vision systems, are used for precise measurement and defect detection. Programmable logic controllers (PLCs) play a key role in controlling and coordinating automated processes. SCADA systems enable real-time supervision and data acquisition from production systems. Manufacturing Execution Systems (MES) help manage and optimize production workflows. Enterprise Resource Planning (ERP) systems integrate production data with business operations. Internet of Things (IoT) technologies enable communication between machines and systems. Artificial intelligence is increasingly used for predictive maintenance and process optimization. Together, these tools create a highly efficient and intelligent manufacturing environment. Automation provides significant benefits in modern automobile manufacturing systems. One of the most important advantages is the increase in production efficiency, as automated systems can operate continuously without interruption. It ensures high precision and consistency in manufacturing processes, reducing the likelihood of defects. Automation minimizes human error, leading to improved product quality and reliability. It also enhances workplace safety by reducing human involvement in hazardous and repetitive tasks. Another key advantage is cost reduction, achieved through optimized resource utilization and lower labor requirements. They also support real-time monitoring and data analysis, allowing better decision-making and process control. Furthermore, automation increases flexibility in production, making it easier to adapt to new designs and technologies. The automation industry is undergoing rapid transformation driven by emerging digital technologies. One of the key trends is the development of smart factories, where interconnected systems operate autonomously and efficiently. IoT enables real-time communication between machines, sensors, and control systems. Artificial intelligence is increasingly used to optimize production processes and enable predictive maintenance. Digital twin technology allows virtual modeling and simulation of physical systems to improve performance and reduce risks. Cloud computing supports large-scale data storage, processing, and remote system management. Cyber-physical systems are being widely implemented to integrate physical processes with digital control. Sustainability is also a growing focus, with automation helping reduce energy consumption and waste.

Automation has become a fundamental component of modern automobile manufacturing systems. It significantly enhances production efficiency, quality, and operational reliability across all stages of the manufacturing process. The integration of advanced technologies such as robotics, artificial intelligence, and IoT has transformed traditional production lines into intelligent and interconnected systems. Automation not only reduces human error but also improves workplace safety by minimizing exposure to hazardous tasks. Furthermore, it enables real-time monitoring and data-driven decision-making. Modern trends such as smart factories and digital twins indicate that automation will continue to advance toward greater autonomy and flexibility. Overall, automation plays a crucial role in shaping the future of the automotive industry by enabling sustainable, efficient, and innovative production systems.

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