

Intelligent Manufacturing: A New Engine Driving the Transformation and Upgrading of Manufacturing Industry

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Abstract: This article deeply discusses the development trend of intelligent manufacturing, which has far-reaching influence. The beginning expounds the background of its rise, which is related to the needs of scientific and technological progress and industrial upgrading. Then, the connotation of key technologies is analyzed, and the role of intelligent transformation of the manufacturing process is interpreted from the aspects of industrial Internet, artificial intelligence, and big data. Then, it focuses on the application practice of intelligent manufacturing in the dimensions of enterprise production, supply chain and product innovation, highlighting the advantages of efficiency improvement, collaborative optimization and customized expansion. Comprehensively considering the challenges of technology integration, talent shortage, and safety regulations, this paper proposes targeted response strategies, aiming to reveal the core value and development trajectory of intelligent manufacturing driving industrial transformation and reshaping the global manufacturing landscape.

Keywords: Design Manufacturing; Industrial Intelligence; Network Control.

1. Introduction

With the in-depth adjustment of the global economic structure and the rapid development of science and technology, the manufacturing industry, as the cornerstone of the real economy, is undergoing profound changes. With the deep integration of information technology and manufacturing technology, intelligent manufacturing has become the key path for the manufacturing industry to move towards high-end, intelligent and green, break through the bottleneck of traditional development and recast competitive advantage [1]. Its rise is in line with the trend of the fourth industrial revolution, responding to complex challenges such as rising labor costs, rising consumer personalized demands, and tightening resource and environmental constraints, and injecting majestic impetus into industrial innovation.

2. Core Technology Support System of Intelligent Manufacturing

The Industrial Internet: Making "Neural Networks".

The industrial Internet covers the interconnection network of equipment, systems and personnel inside and outside the factory, and integrates sensor and controller data based on communication protocols such as fieldbus and industrial Ethernet to realize real-time perception of the whole production area. In automobile manufacturing, after the workshop equipment is networked, the working condition data of stamping, welding, painting and other links are uploaded in real time to accurately control the production rhythm and equipment status. Predictive maintenance of faults reduces the downtime rate of equipment by about 30% and ensures the efficient circulation of the production line, just like giving the factory a "nerve thread" of keen perception and efficient coordination.

Artificial intelligence empowers intelligent decision-making and production control.

Machine learning algorithms mine the value of mass production data and optimize scheduling. Deep learning visual recognition is used for product appearance defect detection, with accuracy exceeding 95%, far exceeding manual visual inspection, and strictly observing quality barriers in electronic chip packaging and detection. Intelligent robots integrate AI motion control, adjust operation trajectories independently according to the environment, improve the efficiency of complex assembly tasks several times, and leap from empirical management to data-driven accurate decision-making "smart brain" to command production. Machine learning uses algorithms to mine the hidden mode of big data in production, optimize the production scheduling plan and reduce the production cycle [2]. Computer vision is used for surface defect detection of products, with accuracy up to micron level, far better than manual naked eyes, and greatly improving the quality control level. Intelligent robots can flexibly complete complex assembly and welding tasks with AI empowerment, increasing operation efficiency multiples and innovating labor-intensive links.

Big Data: Insight into the "digital gold mine" of production operations "

Collects data such as equipment operation, material flow, market orders, etc., and mines rules through data cleaning, storage (distributed databases such as Hadoop) and analysis (data mining tools). Analysis of historical orders can accurately predict product demand trends, guide raw material procurement, capacity allocation, so that the inventory turnover rate increased by about 40%, with data insight for the manufacturing of all aspects of "blood circulation and pulse", cost reduction, agile response to the market. Big data storage (such as Hive and HBase) and analysis tools (Spark and Flink) dig deep into the value of production and operation data, gain insight into market demand and predict equipment failures. Cloud computing provides flexible computing and storage resources to reduce the cost of enterprise information

construction. Small and medium-sized manufacturing enterprises use cloud platforms to deploy ERP and MES systems at low cost to realize the start of digital management.

3. Practical Application of Intelligent Manufacturing in Manufacturing Industry

Intelligent design innovation.

Fusion of virtual reality (VR)/augmented reality (AR) technology, designers immersive collaborative creation, remote review modification, shorten the design cycle. Automotive interior design uses AR to present the effect in real time, users participate in interaction, and the number of design modifications is reduced by about 40%. The product conforms to the market preference and is favored when it goes on the market.

Intelligent manufacturing.

The intelligent factory introduces flexible production lines and automated warehousing and logistics systems to achieve efficient production of multiple varieties and small batches. The intelligent workshop of household electrical appliance enterprises can quickly switch the production of refrigerators and washing machines on the same production line [3]. The change time is reduced from several hours to tens of minutes, the capacity utilization rate is increased by about 35%, and the defective rate of products is controlled within 1% with the help of automatic detection.

Intelligent supply chain collaboration.

Relying on blockchain and Internet of Things technology, the entire supply chain information is transparent and visible and cannot be tampered. Food enterprises from raw material procurement, processing to distribution, each link of temperature and humidity, logistics trajectory on the chain record, accurate and efficient traceability, inventory turnover speed up by about 25%, response time to market fluctuations shortened by half, enhance the resilience of the industrial chain.

Intelligent service expansion.

Based on equipment networking and big data analysis, remote fault diagnosis and predictive maintenance become the norm. Construction machinery manufacturers through the intelligent service platform, early warning equipment failure, remote guidance maintenance, after-sales maintenance costs reduced by about 30%, customer satisfaction rose to more than 90%, extending the value of the industry space.

4. Practical effectiveness of intelligent manufacturing at all levels of enterprise operation

Intelligent production: efficiency and quality "double jump".

The intelligent factory introduces flexible production lines, and with the help of automation equipment, AGV (automatic guided vehicle) and industrial robots, it can flexibly switch product models according to orders to realize high-efficiency production of many varieties and small batches. The intelligent production line of a clothing enterprise has reduced the production cycle of customized clothing from 7 days to 3 days, improved the cutting accuracy by millimeter level, and reduced the defective rate to less than 2%, thus reshaping the production competitiveness with high precision and fast delivery.

Smart supply chain: collaborative ecological "cohesion".

Relying on the Internet of Things, blockchain, etc., the information of each node in the supply chain is transparently shared, suppliers are accurately replenished according to the manufacturer's inventory and production progress, and logistics and distribution are tracked and optimized in real time. Cold chain food monitors temperature and humidity with the help of intelligent sensors, and the block chain records the whole process information to ensure food safety and traceability. The inventory cost is reduced by about 25%, the delivery time rate exceeds 90%, and the upstream and downstream work closely together to create a resilient supply ecology.

Product innovation: personalized customization "new engine".

With the help of virtual design, user interaction platform to collect demand preferences, customer creativity into product development. Smart home enterprises customize functional modules according to users' living habits. Users participate in design and real-time feedback through APP. Products are in line with personalized life scenes. The compatibility of new products to market is increased by about 35%. Customized innovation is used to develop market segments and activate growth potential.

5. Analysis of Challenges Faced by Intelligent Manufacturing Promotion

Technology integration dilemma.

Different manufacturers have different interface standards for equipment and software systems. Data interaction is blocked when industrial Internet platforms integrate various industrial APP. For example, old machine tools are retrofitted into intelligent control systems. Due to incompatible communication protocols, high adaptation costs are required, which restricts the breadth and depth of overall intelligent upgrading. It is necessary to unify specifications and strengthen middleware adaptation capabilities to solve the dilemma. The existing automation equipment and legacy systems in manufacturing enterprises are mostly sourced from different suppliers, with different interface standards and communication protocols, making system integration difficult and costly. The core technology of industrial software is controlled by others, the process of domestic substitution is slow, and the road of independent control is long, which restricts the overall intelligent upgrade.

The professional talent gap.

The scarcity of compound talents who understand both mechanical manufacturing technology and digital technology, the lag in the connection between university training and industrial demand, and the imperfect internal training system of enterprises, resulting in the implementation of intelligent manufacturing projects often encounter the "no one is available" of technology landing, requiring the coordination of production, teaching and research, and the diversified incentives of enterprises to introduce and educate people to fill the gap. The compound talents needed for intelligent manufacturing have knowledge and skills in manufacturing technology, information technology, data analysis and other fields. The existing discipline training system in colleges and universities focuses on a single major, which is not in good agreement with the actual situation of the industry. The internal training system of enterprises is not perfect, and the

talent attraction and retention mechanism needs to be perfected, resulting in the situation that "It is hard to find" high-end talents.

Safety and specification short board.

After the industrial control system is networked, it faces a sharp increase in the risk of cyber attacks and data leakage, the manufacturing industry lacks a targeted security protection system and regulatory rules, and the security of key production data is difficult to guarantee. It is necessary to strengthen technical protection such as encryption and identity authentication, and improve laws and regulations to escort the industry forward steadily. Manufacturing data is related to the core secrets of enterprises, production safety, industrial Internet environment, data cross-system, cross-regional circulation, network attacks, data leakage risks rise, the current data security regulations for the manufacturing industry adaptation is insufficient, the enterprise's own protection means are limited, data security "moat" fragile.

6. Strategies and Prospects for the Challenges of Intelligent Manufacturing

Technology integration breaks.

Industry associations, leading enterprises to take the lead in the development of interfaces, data formats and other standards, the government to encourage enterprises to participate in the mutual recognition of standards; "soft connection" dissolution equipment and system "hard estrangement" weave a tight technical integration network under the framework of standard specifications. Industry associations and leading enterprises take the lead in formulating unified equipment interfaces and data interaction standards, and build open source technology communities to share integration experience; the state increases investment in industrial software research and development, supports innovative enterprises, and promotes the mature application of domestic industrial software through tax incentives and special funds to consolidate the foundation for technological integration.

Talent cultivation ecological construction.

Colleges and universities optimize the setting of disciplines, integrate machinery, automation and other majors into big data and AI curriculum modules, jointly build training bases between enterprises and colleges and universities, carry out digital skills training subsidy programs for on-the-job employees, and enrich the talent echelon in parallel with the dual track of "college education foundation + enterprise fine

skills". Colleges and universities adjust the setting of disciplines, create an interdisciplinary and interdisciplinary curriculum system, and strengthen practical teaching; enterprises cooperate in depth with universities and vocational colleges to carry out order-based talent training, continuing education for in-service employees, set up talent reward funds, broaden talent introduction channels, and enrich intelligence Manufacturing talents "reservoir".

Safety specification strengthening initiatives.

The government has improved regulations on industrial data classification and network security review, built intrusion detection and data encryption systems by enterprises, regularly rehearsed emergency response plans, built a secure "firewall" from multiple dimensions of regulations, technology and management, and escorted intelligent manufacturing to a stable and far-reaching future. The government has accelerated the improvement of data security regulations and policies in the manufacturing industry, refined data classification and access rights rules; enterprises have strengthened the application of security technologies such as data encryption, identity authentication and intrusion detection, regularly carried out data security audits and emergency drills, and built a life-cycle data security protection mechanism.

7. Conclusion

Intelligent manufacturing, as the "new engine" of manufacturing transformation and upgrading, relies on cutting-edge technology to stimulate innovation vitality in design, production, supply chain and service, and reshape industrial competitiveness. Although the journey is full of thorns and faces many challenges in technology, talents, and security, as long as we coordinate the forces of all parties and implement targeted policies to overcome difficulties, the manufacturing industry will surely break the cocoon into a butterfly in the wave of intelligent manufacturing, achieve high-quality and sustainable development, and stabilize the real economy. The status of "ballast stone" is shining a new light on the global industrial stage.

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