

The Current Development Status and Problems Analysis of Intelligent Manufacturing in China

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Abstract: Intelligent manufacturing is the deep integration of new generation information technology and advanced manufacturing technology, which is of great significance for improving industrial technological level and production efficiency. Intelligent manufacturing includes fields such as industrial internet, industrial robots, semiconductors, and so on. This article analyzes the development status of these three fields in China, pointing out that the market prospects for these fields in China are broad, the development speed is fast, and the level is constantly improving. On this basis, it analyzes the challenges facing intelligent manufacturing in China, including the shortage of high-end talents, some fields still at junior or intermediate stages, core technology still needs to break through and innovate, and the need for further attention to industrial internet security issues. Finally, some targeted solutions are proposed, hoping to improve the development and construction level of intelligent manufacturing in China to a certain extent.

1. Introduction

Currently, the quantity and quality of intelligent manufacturing products, which are represented by industrial internet, artificial intelligence, cloud computing, big data, and the Internet of Things, have become crucial indicators to assess a country's technological prowess [1]. As a result, countries worldwide are prioritizing the development of intelligent manufacturing industries and focusing on researching key technologies for intelligent manufacturing as a core national strategy for progress. Artificial Intelligence (AI) was included in the Chinese government's work report for the first time in 2017, and national policies have guided the healthy development of the industry from various aspects such as AI industry planning, innovation platform construction, and technology application. These efforts have contributed to improving the application environment and industrial development of AI in China. At a macro level, China has developed into an AI powerhouse with a world-leading patent reserve, talent pool, number of papers, and enterprises. However, there are still areas for improvement in terms of the degree of patent internationalization, the number of basic-level enterprises, and the proportion of outstanding talents.

2. Basic Concepts of Smart Manufacturing

Intelligent manufacturing was first introduced by Japan in 1989, while the United States began its new technology policy in 1992 with a focus on promoting the upgrading of traditional industries and nurturing new ones that involve information technology, new manufacturing processes, and intelligent manufacturing technologies. Therefore, the United States and Japan can be considered as pioneers in the field of intelligent manufacturing.

At the 2013 Hannover Messe, Germany officially introduced the "Industry 4.0" strategy aimed at enhancing the competitiveness of German industry. Intelligent manufacturing, as the core of the strategy, has attracted significant attention from countries around the world. According to the descriptions of Germany's Industry 4.0-related literature, the strategy mainly focuses on smart manufacturing technology and smart production modes. It aims to establish two types of networks: the Internet of Things (IoT) and the Internet of Services (IoS), to closely link products, machines, resources, and people together. This is done to build information-physical fusion systems (CPS) and achieve digitization of the entire life cycle of products and manufacturing processes. The goal is to achieve end-to-end integration based on information and communication technology, resulting in a highly flexible, personalized, digital, and networked production model for products and services. Combined with the definition of smart manufacturing by China's Ministry of Industry and Information Technology, it can be concluded that smart manufacturing is the core of Industry 4.0 strategy.

The Chinese Ministry of Industry and Information Technology defines intelligent manufacturing as follows: "Intelligent manufacturing is a new type of production mode based on the deep integration of new-generation information and communication technologies and advanced manufacturing technologies that runs through all aspects of manufacturing activities such as design, production, management, and service. It has functions such as self-perception, self-learning, self-decision-making, self-execution, and self-adaptation."

Zhou Ji defines intelligent manufacturing as "the deep integration of a new generation of information and communication technologies with advanced manufacturing techniques, throughout the entire lifecycle of products, manufacturing, services, and the optimization and integration of corresponding systems to achieve digitalization, networking, and intelligence in manufacturing. It aims to continuously improve product quality, efficiency, service level, and promote innovation, green development, open sharing, and coordinated development of the manufacturing industry [2]."

3. Analysis of Intelligent Manufacturing Industry Development Status in China

3.1. Advanced Manufacturing Clusters are Developing into a Key Driver of Economic Growth in China

The Ministry of Industry and Information Technology has officially announced the establishment of 45 national advanced manufacturing clusters, including 13 in the field of new-generation information technology, 13 in the field of high-end equipment, 7 in the field of new materials, 5 in the field of biomedical and high-end medical devices, 4 in the field of consumer goods, and 3 in the field of new energy and intelligent Internet-connected automobiles. These clusters cover key areas of building a strong manufacturing country and have become important forces to lead and drive innovation and development in key industries and fields. Jiangsu has the largest number of advanced manufacturing clusters with 10 in the "national team", ranking first in the country; followed by Guangdong with 7, Zhejiang and Hunan both with 4. In terms of city distribution, Shenzhen has the most with four selected, followed by Guangzhou, Shanghai, Changsha, Dongguan, Foshan, Chengdu, Suzhou, Wuxi and other cities with three.

3.2. Industrial Internet Development Is in Primary Stage, Applications are Enriching, and Prospects are Broad

Currently, the deep integration between intelligent manufacturing and industrial internet has been achieved, and the construction of this system provides assistance in improving the level of intelligent manufacturing [3]. The Industrial Internet is a new infrastructure, application mode, and industrial ecology for the deep integration of new-generation information and communication technologies (ICT) and the industrial economy. It builds a new manufacturing and service system that covers the entire industrial chain and value chain through the comprehensive connection of people, machines, things, and systems. The Industrial Internet provides a realization of digitalization, networking, and intelligence for the industry, and even society as a whole. It is an important cornerstone of the fourth industrial revolution. The Industrial Internet includes four major systems: network, platform, data, and security. These systems are not only the infrastructure for transforming industrial digitization, networking, and intelligence but also the application mode for the deep fusion of the Internet, big data, artificial intelligence (AI), and the real economy. The Industrial Internet is also a new form of business and industry, which will reshape the forms of enterprises, supply chains, and industrial chains.

The Chinese government has placed great importance on the development of the Industrial Internet and has introduced a series of policy measures, such as the Action Plan for the Development of Industrial Internet and Made in China 2025, to provide policy support and guarantee. Currently, China's industrial Internet is still in its primary stage of development, with its industrial chain mainly divided into network layer, edge layer, IaaS layer, platform layer, application layer, and downstream application enterprises. These enterprises are categorized into upstream, middle, and downstream segments of the industrial chain and form the three major systems of network, platform, and security of the industrial Internet. The upstream link mainly refers to intelligent terminal production equipment, network technology, and other basic security, including sensors, industrial robots, networks, etc. The representative enterprises include Neusoft, Newstar, Cisco, ZTE, Huawei, etc. The midstream link mainly provides the development environment, operation environment, software application, and security guarantee for the industrial Internet. Specifically involving edge data processing, cloud computing, internet platforms, industrial apps, etc. The related enterprises include Haier, Alibaba, Aliyun, Dongfang Guoxin, etc. The downstream link refers to the industrial Internet scenarios mainly applied by industrial enterprises, including high-energy-consuming equipment, general-purpose power equipment, new energy equipment, high-value equipment etc. The application scenarios of the industrial Internet are becoming increasingly diverse and cover a wide range of fields such as manufacturing, energy, transport etc. Examples include intelligent manufacturing, smart city, intelligent logistics etc.

3.3. The Chinese Semiconductor Industry is Experiencing Rapid Growth with a Vast Market Space

The Chinese semiconductor industry has been experiencing rapid growth due to various advantageous conditions such as a large market demand, abundant demographic dividend, stable economic growth, and favorable industrial policies. In 2020, China's semiconductor manufacturing capacity accounted for 15% of the global total, but it lags behind in cutting-edge semiconductor technology [4]. In 2021, the sales of China's semiconductor industry reached 1,242.3 billion yuan, with a compound annual growth rate of 12%. As shown in Figure 1, China's chip design industry is projected to surpass USD 100 billion by 2027. In 2022, the total sales of China's chip design industry (including Fabless and IDM) amounted to 54.3 billion U.S. dollars, with a year-on-year growth of 5.3%. Despite the global economic slowdown and the global semiconductor industry

entering a downward cycle, the growth rate of China's semiconductor industry is expected to remain positive in 2022. The top 30 design companies in China had combined revenue of US\$29.1 billion in 2022, up 1% year-on-year, which is approximately 214% of the combined revenue of the top 10 Fabless companies. The communications market is the largest application market for China's semiconductor industry, while the consumer electronics market continues to be the second largest market for semiconductor chips in China.

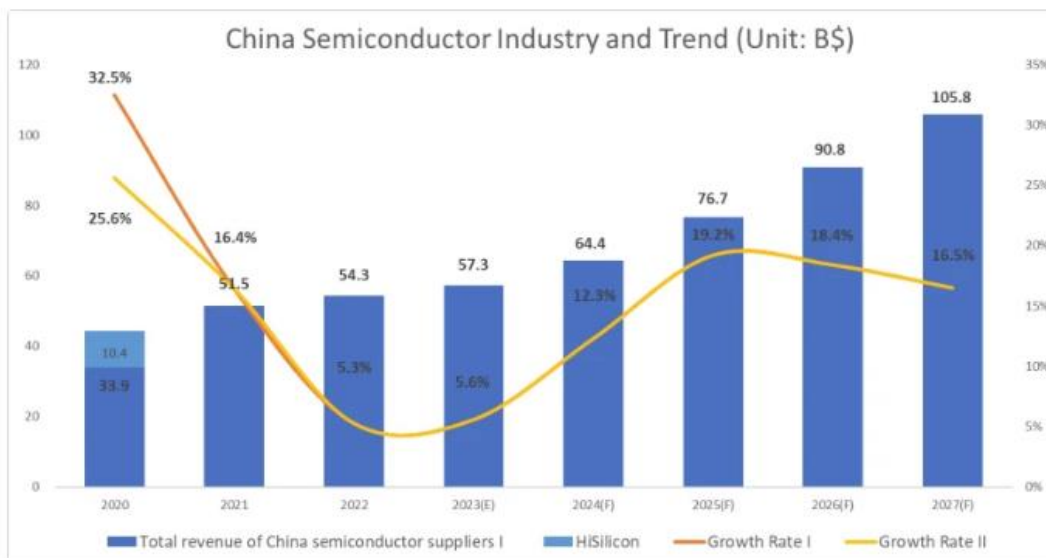


Figure 1: China Semiconductor Industry and Trend from 2020 to 2027

3.4. The global market share for industrial robots is ranked first due to strong demand

Industrial robots are an important embodiment of artificial intelligence technology in the manufacturing industry, and they are the core part of achieving intelligent manufacturing in manufacturing [5]. The demand for industrial robots is strong and the global market share for them is ranked first. The PUMA series of robots was launched by Unimation company. In the 1970s, marking the full maturity of industrial robotics. In the 1980s, robots entered a period of popularity due to the development of the manufacturing industry. With the progress and development of computer technology and intelligent technology, the second generation of robots with sensory functions became practical and began to be promoted. By the 1990s, the third generation of intelligent robots with advanced capabilities such as vision, touch, and high dexterity fingers appeared. In China, the development of the first domestic industrial robot was initiated by the Shenyang Automation Institute of the Chinese Academy of Sciences in 1982. However, during the next decade, the domestic Industrial Robotics industry did not appear in a comprehensive development stage and remained limited to industrialisation mapping and scientific research stages. In the 21st century, with the rapid development of China's manufacturing industry, industrial robots ushered in a golden stage of rapid development. According to the "China Robotics Industry Development Report 2019" released by the Chinese Institute of Electronics in August 2019, there is an increasing demand for intelligent transformation and upgrading of China's manufacturing industry, leading to a continued strong demand for industrial robots. China's industrial robotics market maintains good development, accounting for about one-third of the global market share and being the world's largest industrial robot application market. According to Figure 2, China's industrial robot production skyrocketed from 72,400 units in 2016 to a whopping 443,100 units in 2022, while sales also experienced a significant surge, growing from 85,000 units in 2016 to an

impressive 303,000 units in 2022. Regional distribution shows that Chinese industrial robotics enterprises are mainly distributed in the Yangtze River Delta Economic Circle, with H1 in 2022 accounting for 36.62%, far more than other regions. The Bohai Economic Circle ranks second with 19.69% and Pearl River Delta Economic Circle and Chengdu-Chongqing Economic Circle enterprises account for 10.07% and 3.82% respectively.

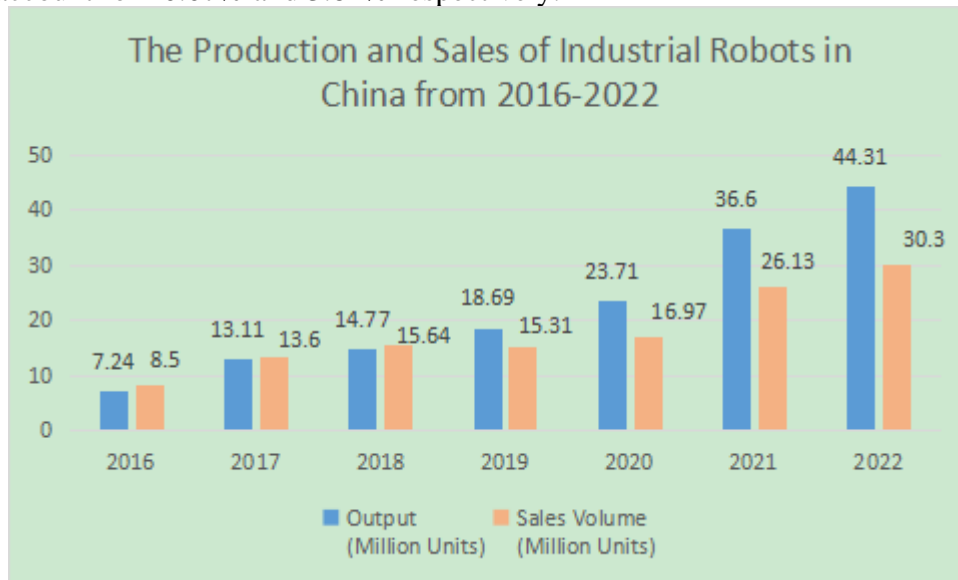


Figure 2: The Production and Sales of Industrial Robots in China from 2016 to 2022

4. China's Intelligent Manufacturing Faces Challenges and Solutions Measures

As information technology continues to advance, the level of manufacturing in enterprises is constantly improving. Intelligent manufacturing holds great significance in enhancing production efficiency, strengthening the digital production capacity of companies, and gaining competitive advantages in the fiercely competitive market. It also plays a crucial role in industrial restructuring and transformation and upgrading.

4.1. China's Intelligent Manufacturing is Rapidly Advancing, but Certain Areas Remain at the Beginning or Middle Stages

China's intelligent manufacturing, particularly in industrial robotics, semiconductors, and the industrial internet, has taken the lead in market size and development speed globally. However, there are still areas where the level of development is uneven, and advanced technology is still controlled by developed countries in Europe and the United States. Currently, there are already dozens of listed companies in the field of domestic chip design, but the actual investment in semiconductor equipment, materials and components enterprises that have been "stuck" is still far from enough [6]. To address this issue, it is necessary to implement top-level design and special planning for the development of artificial intelligence at the national level. The country has also been improving its intelligent manufacturing industrial policy, with a focus on developing advanced manufacturing as a core objective and establishing a strong path for intelligent manufacturing through strategic planning. Additionally, efforts have been made to enhance advanced manufacturing industry clusters, resulting in continuous improvements in the national level of intelligent manufacturing.

4.2. Intelligent Manufacturing Faces Challenges in High-End Talent Shortage and Personnel Mobility

China's rapid development in intelligent manufacturing-related fields has led to an increasing demand for talent. However, the talent training system is lagging behind, and there is a shortage of high-end talent with certain industry experience and professional and technical knowledge. This shortage is hindering China's ability to reach high levels of intelligent manufacturing. According to research, the allocation of talents in terms of informationization, digitization, and intellectualization only accounts for 0.5-1% of the total number of employees in enterprises. During the process of digital transformation, there is a lack of specialized technicians who are proficient in business and technology [7]. Data shows that by 2025, the talent gap in high-grade CNC machine tools and robots will reach 4.5 million, and the demand for talent is set to increase as intelligent manufacturing deepens. Intelligent manufacturing also triggers technological innovation in the industry, which inevitably generates new job demands. For example, among the 29 new occupations released by the state in 2019 and 2020, those related to the industrial internet accounted for 13 out of 29, such as big data engineers and technicians and cloud computing engineers and technicians, which accounted for 44.8% of the new occupations.

The emergence of the above problems is difficult to avoid, and it is necessary for China to increase the enterprise training system and improve the existing vocational education and higher education system to adapt to the needs of intelligent manufacturing for high-end talents in various industries.

4.3. The Safety of Production in the Industrial Internet Requires Further Attention and Effective Measures for Security

Intelligent manufacturing is closely linked to the industrial internet, which can enhance the information construction of enterprises and improve production efficiency. Network security in the field of industrial internet involves a wide range of areas and complex processes [8]. However, security issues also arise during its development. In July 2019, the Ministry of Industry and Information Technology and ten other departments jointly issued the "Guiding Opinions on Strengthening the Security of the Industrial Internet" (hereinafter referred to as the "Guiding Opinions"), which set two major objectives: first, by the end of 2020, an initial industrial internet security system should be established; and secondly, by 2025, the system mechanism should be sound and perfect, with significant improvements in technology and means capability, a formed scale for the security industry, and a more complete and reliable industrial internet security guarantee system is basically established. From January to June 2020, the National Industrial Internet Security Situation Awareness and Risk Early Warning Platform continued to monitor the security of 136 major internet platforms, over 100,000 industrial enterprises, and more than 9 million pieces of networked equipment. It has cumulatively monitored and identified malicious network behaviors 13.563 million times, affecting 2,039 enterprises. As the level of intelligent manufacturing continues to improve, the network completely the problem of all aspects of the enterprise threat is becoming more and more obvious, the Ministry of Industry and Information Technology and other relevant state departments have a deep understanding of these issues, and not on the development of relevant policies to prevent security, various departments need to implement the relevant policies level by level, the enterprise also needs to have a deep understanding of the security issues, and strengthen network security training, preventive measures for a rainy day [9].

4.4. The Key Technology Areas of Intelligent Manufacturing Still Need to Improve Independent Innovation Ability and Address Key Technology Breakthrough Bottlenecks

Semiconductors, industrial robots, and high-end CNC machine tools are some of the key technologies in high-precision industries. However, a considerable portion of these technologies are still held by developed countries such as Europe, the United States, Japan, and South Korea. Therefore, we need to work hard to improve our ability in these areas. We can start by focusing on talent training, policy support, and industry cultivation. In addition, China should further leverage the promotion role of the Belt and Road Initiative on trade in intelligent manufacturing products in our country. We can take advantage of the international cooperation policies within the Belt and Road Initiative to strengthen scientific and technological and cultural exchanges with European Union countries. By jointly establishing innovation parks and high-end laboratories for intelligent manufacturing products, we can enhance our ability to innovate in this field [10]. By doing so, we can continuously improve the technical level of engineering and technical personnel and move towards the direction of high-precision technology. This will help us break through the blockade of foreign technology and improve our ability for independent innovation.

5. Conclusion

Intelligent manufacturing is a concept that involves the integration and fusion of new generation information technology, building virtual automatic factories, and organically combining artificial intelligence and manufacturing technologies to achieve automation and intelligence in equipment and processes. It also aims to realize the concept of all-time, all-global, and all-system comprehensive management. This article analyzes the current situation of intelligent manufacturing development in China, as well as the existing problems. It also puts forward certain constructive opinions on the problems analyzed in the article.

References

- [1] Hu R. Y (2020). *From Intelligent Manufacturing to the Intelligent Economy and Society*. *Journal of Shanghai University of International Business and Economics*, 5, 78-90.
- [2] Zhou J. Li P. G., Zhou Y. H (2018). *Toward new-generation intelligent manufacturing*. *Engineering*, 4(1), 11-20.
- [3] Song X. Y (2021). *Technical Architecture Analysis of Intelligent Manufacturing and Industrial Internet*. *Science and Technology Innovation*, (25), 179-181.
- [4] Zhang X. Y., Wang Y. H., Wu J. J (2021). *Research on the Development of China's Semiconductor Equipment Industry - From the Perspective of US Export Controls*. *North Economic Review*, 404 (07), 40-43.
- [5] Zhou Z. Y (2023) *Analysis of the Application of Industrial Robots in Intelligent Manufacturing*. *Network Security and Information Technology*, 81 (01), 64-66.
- [6] Meng W (2022). *Developing a new global semiconductor supply chain led by China*. *Economic Report*, 283 (12), 74-77.
- [7] Zhao L. J (2022). *Digital Transformation of Changzhou Manufacturing Industry in the 14th Five-Year Plan Period: Development Status and Future Strategies*. *Jiangsu Business Review*, 451 (05), 23-27.
- [8] Chen X. H., Shen B (2023) *The Development Status and Future Prospect of "5G+ Industrial Internet" in China*. *Internet World*, 234 (06), 27-31.
- [9] Zhou X. (2017). *A Brief Discussion on the Development of Intelligent Manufacturing in China*. *Cooperative Economy and Technology*, 566(15), 58-59.
- [10] Duan D. Z., Chen Y., Du D. B (2019). *Technology Trade Pattern and Change in the Belt and Road Region*. *Progress in Geography*, 7, 998-1008.