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Chinese Manufacturing Industry in the Context of Industry 4.0

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Abstract: The fourth industrial revolution, more popular known as Industry 4.0, has been developed for nearly 10 years since it was proposed, and has gradually evolved into a new revolution in manufacturing on a global scale. It is an era of opportunities for comprehensive digitalization. Through continuous exploration and development, the core technology of Industry 4.0 is constantly being explored and improved. China has written a manufacturing legend in the past 30 years, but its productivity still behind developed countries. If China wants to grow from the world's largest manufacturing country to a manufacturing powerhouse, it must grasp the general trend of Industry 4.0. Therefore, this paper explores the characteristics, core technologies and current global development trends of industry 4.0. And by analyzing the development data of Chinese manufacturing in the past ten years combined with Chinese government policies, the development status of Chinese Industry 4.0 and the problems encountered, some solutions and suggestions are put forward. Help enterprises understand the general environment and the technical characteristics of Industry 4.0, to formulate digital transformation and upgrading strategies based on their own characteristics and development needs.

Keywords: industry 4.0, manufacturing, core technologies, development status, challenges

1. Introduction

In the past 200 years, there have been three industrial revolutions in the world, and each has benefited humans, promoted social development, and accelerated industrial processes. The 1st industrial revolution began in Great Britain in the mid-to-late 1700s and continued until the middle of the 19th. Before that, family workshops were the main mode of production. New manufacturing processes emerged during the 1st industrial revolution, including the advent of steam power, the use of the steam engine, the mechanization of textile production, and the development of steel and iron production [1]. These changes made millions of people migrate from rural fields to urban areas with lots of emerging jobs.

The 2nd industrial revolution from 1870 to 1945, was driven by assembly lines and Henry Ford's introduction of mass production. During this period, there was a major expansion of industry and innovation, with the development of new technologies such as the telephone, electric power, and the internal combustion engine [1]. This revolution created many new manufacturing jobs and greatly improved people's living standards.

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The 3rd industrial revolution is also known as the Digital Revolution. Began in the '70s in the 20th century and is continuing strong today. This period is characterized by the widespread adoption of digital technology, including the development of electronics and computers, the internet, mobile devices, and other digital technologies. Manufacturing has evolved from mass production to customizable production with a degree of flexibility. The third industrial revolution ushered in globalization, allowing industries to grow in more regions. Emerging economies and developing countries have also created more wealth [1].

Nowadays, a new industrial revolution has arrived, called "Industry 4.0". This concept originated in Germany as part of a government-led initiative to promote the computerization of manufacturing. It was first presented at the Hannover Fair in 2011 to promote the high-tech strategic development of German manufacturing. Since then, countries around the world have gradually joined the process of Industry 4.0. The "Industrial Internet" strategy formulated by the United States, the "Manufacturing White Book of the Year 2014" published by Japan, and the "Made in China 2025" issued by the Chinese government. More and more countries regard smart manufacturing as a priority support direction [2].

Today, Industry 4.0 has been developed for nearly 10 years and has become a global phenomenon. This article will focus on the core and development status of Industry 4.0, as well as the status quo of China's manufacturing upgrading.

2. Industry 4.0

2.1. Characteristic

Industry 4.0 refers to a new paradigm in manufacturing. This revolution is very different from the previous three industrial revolutions: (1) Speed -- The world's interconnectedness is growing exponentially, and continuous innovation in all walks of life drives new technology updates faster and faster. (2) Extensive and deep -- compared with the third industrial revolution, Industry 4.0 enables cooperation between machines, combining various technologies for in-depth research and development. (3) Influence -- the influence of the entire system in enterprises, industries, industrial chains, society, and countries has changed [3].

Industry 4.0 involves structural changes in the technological base of manufacturing, making products more flexible from design, and production to delivery [4]. This industrial revolution aims to digitize and automate industrial processes through the integration of Information and Communication Technologies (ICT) [5,6], thereby creating "smart factories" that are highly connected and data-driven.

2.2. The Core Technology of Industry 4.0

But achieving this goal will require integrating digital technologies into every aspect of the manufacturing process, from design to production to logistics and maintenance. This involves the key technologies of Industry 4.0.

Cyber-physical systems: the 4th industrial revolution involves the integration of cyber-physical systems (CPS), which include sensors, actuators, and control systems that are connected to the internet and communicate with each other to enable real-time monitoring and control of manufacturing processes.

Internet of Things (IoT): refers to the connection of everyday items and devices to the internet or other networks, making them unable to collect and share data and perform various tasks autonomously or with minimal human input, optimizing performance, improving decision-making and providing valuable insights into the physical world.

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Big data analytics: enterprises use data analytics tools to collect, process, and analyze vast amounts of data generated by manufacturing processes to derive insights and optimize operations.

Cloud computing: Cloud computing enables manufacturers to access computing resources and data storage over the internet, providing greater flexibility and scalability.

Artificial intelligence and machine learning: AI and machine learning are used to automate processes, optimize operations, and make predictions based on data analysis.

Additive manufacturing: another name is 3D printing, which is the process of creating a three-dimensional product by printing material on each layer. It allows for the rapid and relatively inexpensive construction of complex custom-designed objects that may have extremely complex or special geometries that would be difficult or impossible to manufacture with traditional crafting methods. In addition, it results in shorter production times and fewer production consumables.

Augmented reality (AR) and virtual reality (VR): AR and VR technologies are used to enhance the visualization of manufacturing processes, training, and maintenance.

Human-robot collaboration: The integration of robots and humans in manufacturing processes, enabling greater efficiency and flexibility [7,8].

2.3. Industry 4.0 Development Status

All these technologies can not only be applied in the manufacturing industry but are also closely related to our daily life, such as adding intelligent control operations to traditional electrical appliances to realize complex smart home systems, thereby affecting people's daily life [5]. But in fact, the migration from traditional industrial manufacturing to intelligent manufacturing includes a comprehensive upgrade of process control technology and overall safety measures. It is not simple to transition from a traditional industry to one that uses more advanced technologies. Many reports focusing mainly on the positive aspects of Industry 4.0 implementation, and the hype surrounding Industry 4.0, have largely ignored the difficulties of Industry 4.0 implementation. Thus, many enterprises only see that the upgrading of industrial technology will have a major impact on their production model, profit distribution, and business development. But the difficulty of Industry 4.0 technologies adoption has yet to be fully comprehended by many enterprises.

Here is a brief overview of the development status of the 4th industrial revolution around the world:

Europe: Europe has been at the forefront of Industry 4.0 adoption, with countries such as Germany and the Netherlands leading the way. The European Union has also launched several initiatives to promote more enterprises to upgrade Industry 4.0 technology.

North America: The United States has been investing heavily in technologies, particularly in the areas of artificial intelligence and robotics. Canada has also been making significant strides in adopting new technologies, particularly in the manufacturing sector.

Asia: Countries such as China, Japan, and South Korea have been investing heavily in Industry 4.0 technologies as they seek to maintain their competitive edge in the global economy. Manufacturing White Book of the Year 2022 published by Japan, still points out that it is necessary to promote the research and development of innovative AI, big data, Internet of Things (IoT), materials, optical/quantum technology, environment/energy, and other sophisticated technologies research and development.

Latin America: While Industry 4.0 adoption in Latin America has been slower compared to other regions, countries such as Brazil and Mexico are starting to invest in these technologies to increase productivity and competitiveness.

Overall, the adoption of Industry 4.0 technologies continues to gain momentum globally, with some countries in every region spearheading the first steps into Industry 4.0 over the past 10 years due to the increasing demand for efficiency, productivity, and competitiveness across industries.

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3. Status of Industry 4.0 in China

3.1. Made in China 2025

China is one of the leading countries in adopting and developing Industry 4.0 and has been actively embracing Industry 4.0. The Chinese government has identified Industry 4.0 as a key priority in its "Made in China 2025" strategy, which aims to transform the country from a low-cost manufacturing base to a high-tech manufacturing powerhouse.

"Made in China 2025" is the first stage, the total plan has three stages, which will lead China from the current largest manufacturing plant to become a world manufacturing power. Based on its own actual situation and reform experience, the Chinese government promulgated the "Made in China 2025" plan in 2015, which will be implemented in three stages. The first phase runs from 2015 to 2025. The second phase covers the next 10 years, during this time, China will strive to enter the middle class of the world's manufacturing powerhouses. The last stage ends in 2049, when the 100th anniversary of the founding of the People's Republic of China, China dreams of becoming the world's leading manufacturing power [1].

The plan emphasizes that China should create its own independent brand and improve the quality of Chinese manufacturing. Achieve independent manufacturing capabilities by developing high-end technology, researching new materials, and producing core components of key products [9].

3.2. Manufacturing Development Status

In recent years, Chinese companies have made significant investments in Industry 4.0 technologies such as Additive manufacturing, cloud computing, and the Internet of Things. Chinese manufacturers are also embracing advanced automation technologies such as robots, 3D printing, and autonomous vehicles to improve production efficiency and reduce labor costs. China has some of the world's largest companies in the technology and manufacturing sectors, including Alibaba, Tencent, Huawei, and Foxconn. These companies are investing heavily in Industry 4.0 and are driving innovation in areas such as smart factories and digital supply chains.

Chinese large population and extensive data resources make it a prime location for AI research and development. China is one of the world's largest markets for industrial robots. The 2022 World Robotics Report released by the International Federation of Robotics shows that in China's manufacturing industry, the number of industrial robots in operation has reached 322 per 10,000 employees. Ranked fifth in the world. Besides, China is also the fastest-increasing robot market in the world. The data shows that in 2021, the number of industrial robots newly installed in global factories will increase by 31% compared with the previous year, increasing to 517,385 units. The demand for automation in factories has also strengthened as social and economic activities that have stagnated due to the new crown epidemic have recovered to a certain extent. Among them, the number of installations in China in 2021 is 268,195 units, ranking first. Accounting for about 50% of the world's total installations, with demand expected to continue growing in the coming years [10]. Chinese companies such as DJI, Siasun, and Efort are leading the way in the R&D and manufacture of advanced robots for manufacturing and other industries.

In addition, more and more Chinese companies are already using Industry 4.0 technologies to improve their competitiveness in a range of industries, including automotive, electronics, and consumer goods. In the past ten years, the added value of the Chinese manufacturing industry has increased from 16.98 trillion yuan in 2012, accounting for 22.5% of the global share, to 31.4 trillion yuan in 2021, and its global share has risen to nearly 30%. Among them, the export volume of technology-intensive electromechanical products increased from 7.4 trillion yuan in 2012 to 12.8 trillion

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yuan in 2021. And high-tech products also increased from 3.8 trillion yuan to 6.3 trillion yuan, maintaining the world's largest manufacturing power status [11].

3.3. Implementation Challenges

Although some Chinese companies are world-leading in specific fields and have great enthusiasm and expectations for the realization of Industry 4.0, most companies still have a large gap overall and have more doubts about implementing specific strategies. During the digital transformation of Chinese manufacturers, only a small number of companies can really refine the clear division of responsibilities and formulate a clear implementation path. This ratio is much lower than in other manufacturing powerhouses. Correspondingly, without these specific strategies, it will become very difficult for the Chinese manufacturing industry to upgrade.

At present, digital management tools have not been fully and successfully used by Chinese businesses in the areas of product development, supply chain, manufacturing, and customer service. Take the steel manufacturing industry as an example: Product R&D, quality control, and supply chain are all key areas that need to be upgraded and transformed. In order to reduce costs and improve product quality, Chinese companies need to start building R&D capabilities, use the digital system and process management to gradually improve the digital quality management system, and achieve information interpenetration and quality improvement throughout the industrial chain.

In addition, a lot of Chinese enterprises currently lack the essential enterprise organizational architecture and performance management frameworks for Industry 4.0. In terms of organizational structure, enterprises lack a clear division of responsibilities and a clear development direction for Industry 4.0 projects. Similarly, the absence of specific implementation path planning, digital talents, and real cases of industrial upgrading has become the largest obstacles for enterprises in the process of comprehensive industrial upgrading. The separation of performance management systems and Industry 4.0 projects is another common problem among Chinese enterprises. In terms of management concepts, many enterprises pay less attention to industrial technology upgrading and industrial digital transformation, but only symbolic moves, resulting in a lack of practical experience in Industry 4.0. Many Chinese companies are not ready to embark on the journey of Industry 4.0 in all aspects, from management to workers, and from Individual ability to core technologies.

3.4. Suggestion

Chinese manufacturing has unequal capacities, and the status quo is complicated. To successfully complete industrial upgrading, what is needed is not a "one size fits all" solution, but a tailored industrial upgrading plan based on factors such as the company's actual situation and development needs. For enterprises that are absent the foundation of lean operations and still rely on large-scale human production. The adoption of a lean operation mode and concept can quickly improve the efficiency of enterprises. In addition, it is also crucial to promote the automation of key production processes and establish databases to improve data analysis, optimization, and upgrading capabilities. For enterprises that already have semi-automated production and collect data at key quality nodes, upgrading the management organizational structure, cultivating digital talents, and improving the ability to combine big data analysis with practical applications will be the focus of continuous improvement in the future. For industry leaders who already have advanced manufacturing technology and a sound management system, using digital tools to further enhance the agility and flexibility of management and production, and daring to adopt innovative business models, will be a good way to stay ahead.

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4. Conclusion

In general, the Chinese manufacturing industry is affected by multiple factors and has its own development characteristics. Unlike the United States, Germany, and other developed countries, there is no gradual transition of development. Many Chinese companies are still at the level of Industry 2.0 to Industry 3.0. However, with the increasing momentum of Industry 4.0 and the promotion of various factors such as the Made in China 2025 plan, many enterprises have generated new enthusiasm and expectations for digital transformation. However, to truly realize digital transformation and smart manufacturing, companies cannot rely solely on the support of policies such as huge and fast-growing high-tech product markets, government subsidies, and tax incentives. Chinese enterprises must make good use of lean management, proceed from their own reality, and train high-end talents in combination with industry development trends. Moreover, enterprises should look at the overall situation, strengthen cooperation, and create a good industrial ecosystem. Seizing the opportunity, China is likely to be at the forefront of the world's Industry 4.0 in the next few years, driving further growth and transformation of the global manufacturing industry.

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