Application and Research of Industrial Robot Technology in Intelligent Manufacturing Field

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Abstract: At present, The use of robotics and automation is growing at a breathtaking speed, injecting strong momentum into economic and social development. With the acceleration of the new round of technological revolution and industrial transformation, the robot industry is ushered in a window period of upgrading and changing development. The world's major industrial developed countries have taken robots as the forefront and focus of competition in the technology industry. This article mainly introduces the basic structure of industrial robots and their applications in the field of automotive assembly and pump manufacturing. It also analyzes the shortcomings of domestic robots and the current solutions.

Keywords: Industrial Robot; Intelligent Manufacturing; Localization

1. Introduction

Industrial robots were first put into use in the late 1950s. In the 1960s, the development of industrial robots ushered in the dawn period, and the simple functions of robots were further developed. By the 1990s, with the advancement and development of computer technology and intelligent technology, the second generation of robots with certain sensory functions had been practicalized and began to be promoted. The third generation of intelligent robots with vision, touch, highly dexterous fingers, and walking capabilities had emerged and began to be applied [1]. In 2020, the operating revenue of China's robotics industry exceeded 100 billion yuan for the first time. During the 13th Five-Year Plan period, the output of industrial robots increased from 72, 000 to 212, 000, with an average annual growth rate of 31 %. From the perspective of technology and products, key technologies and components such as precision reducers, high-performance servo drive systems, intelligent controllers, and intelligent integrated joints have accelerated breakthroughs, innovative achievements have continued to emerge, the performance of the entire machine has been greatly improved, the functions have become richer, and the quality of products has been increasingly optimized [2].

2. Hardware and software architecture of industrial robot

2.1 The Drive System of Industrial Robots

The driving system is a device that provides power to the mechanical structure system. According to the different power sources, the transmission methods of the driving system can be divided into four types: hydraulic, pneumatic, electric, and mechanical. The early robot was powered by hydraulic drive. Due to the drawbacks of hydraulic system such as leakage and instability, currently only large heavy-duty robots and robots using hydraulic drive in special occasions use pneumatic drive. Pneumatic drive has the advantages of high speed and simple system structure. However, pneumatic drive has a low working pressure and is difficult to be precisely positioned. It is generally used for the driving of end-effectors of industrial robots. Rotating cylinders and pneumatic suction cups serve as end-effectors It can be used for grasping and assembling workpieces with medium and small loads. Electric drive is the most commonly used driving mode, characterized by convenience, fast response, high driving force, convenient signal detection, transmission and processing, and a variety of flexible control modes can be used. Drive motors commonly adopt stepping motors or servo motors, but their cost is higher and their control is complex [3].

2.2 Industrial robot's perception system

The perception system of industrial robots converts various internal state information and environmental information of the robot from signals into data and information that can be understood and applied by the robot itself or between robots. The perception system consists of internal sensor modules and external sensor modules. The use of intelligent sensors improves the mobility, adaptability, and intelligence level of the robot. It makes the sensor more effective than human sensory systems in perceiving special information [4].

2.3 Industrial robot's basic hardware

The basic hardware refers to the base and the executing mechanism, including the arm, the forearm, the wrist, and the hand, which form a multi-degree-of-freedom mechanical system. Some robots also have a walking mechanism. Industrial robots have 6 degrees of freedom or more, and the wrist typically has 1 to 3 degrees of freedom.

2.4 Industrial robot's operating system

The robot control system is the brain of the robot and is the main factor that determines its function and capabilities. The control system receives instructions from the input program and controls the drive system and executing mechanism. The main task of control technology is to control the range of motion and duration of the industrial robot's movements in the workspace. Due to the limitations of existing general-purpose chips in terms of functionality, cost, integration, and interfaces, there is a need for robot systems to utilize System on Chip (SoC) technology. Integrating a specific processor with the required interfaces can simplify the design of peripheral circuits, reduce system size, and reduce costs.

3. Current Situation of China Industrial Robots

3.1 The localization rate of industrial robots has accelerated

Since the 13th Five-Year Plan, through continuous innovation and deepening application, China's robotics industry has shown a good development momentum. According to the data, from 2017 to 2021, the localization rate of China's industrial robots increased from 24.2%to 32.8%. In 2022, the localization rate of China's industrial robots reached 35 %, with market shares of the leading domestic makers such as ESTUN and INOVANCE, respectively, at 6% and 5%. There is still much room for improvement in localization. The localization rate of industrial robots in 2023 is 41 %, up 9 % year on year, and the localization rate is accelerating [5].

3.2 Rapid increase of industrial robot output

According to the "China Robotics Industry Development Report (2022)" [6] released at the 2022 World Robot Conference, in 2021, the revenue of China's robotics industry exceeded 130 billion yuan,and the production of industrial robots reached 366,000 units,which is 10 times higher than in 2015,making China the world's largest market for industrial robots.

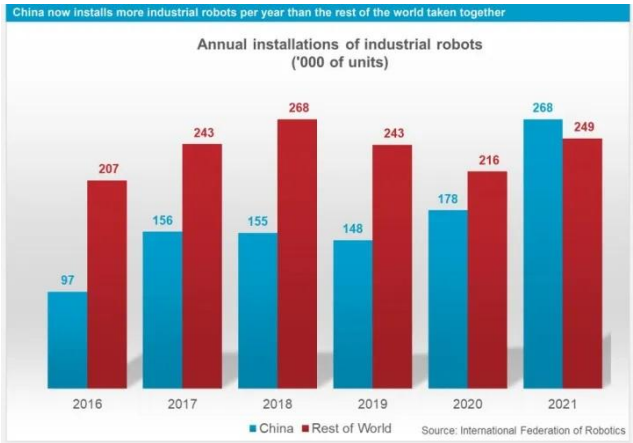

Figure1 Annual installations of industrial robots

The new'Market presentation World Robotics shows that in 2021, China's robot installation increased by 51%, up to

268,195 units.This is almost 52% of the global robot installation[7].“China was leading the global recovery after the Covid-19 pandemic and accounted for half of worldwide robot installations in 2021.”said Marina Bill, President of the International Federation of Robotics.

4. The dilemma and development direction of domestic industrial robots

4.1 Robots for automotive and 3C industries

Automobile and 3C industries are the largest downstream of industrial robots, and their sales in 2022 will account for 47 %. There are high requirements in related industries for the speed, weight, and accuracy of robot movements. Domestic brand products still lag behind customer requirements. The automotive OEM have high safety requirements and strong customer loyalty. These factors make it difficult for traditional automotive OEM to manufacture robots domestically. Based on market research, domestic brands, relying on their accumulated experience in the field of new energy, are expected to advance the domestic manufacturing process through the new energy automotive industry chain, with the help of the trend of lithium-ion battery integration with automobiles.

4.2 Welding

In 2021, the localization rate of welding robots was only 34 %. The pain point of industrial robots lies in the high development and delivery threshold. Professional engineers need to manually code and debug repeatedly to match the specific task requirements of the production line. The high cost greatly hinders the popularization of industrial robots. Through market research, Kaierda focuses on the welding robot business, while ESTUN is to fill the gap in domestic thick plate welding through the acquisition of CLOOS.

4.3 Robotic process software development

The core of industrial robots lies in software, and the development of software related to processes is the key to determining robot performance. The biggest disadvantage of domestic robots is actually in the development of process-related software. This is because the international advanced robot companies have more than half a century of research and technological breakthroughs, and their understanding of process and function optimization are naturally beyond the reach of domestic enterprises. However, there are also some second-tier brands that have achieved good results in certain fields internationally, such as OTC, which also win the market because of their outstanding performance in a certain process area. So making a breakthrough in a certain process field can be a way out for domestic robots.

4.4 The Driving System

There are still significant issues with domestic robots in terms of driving systems. The inability to integrate the design with the control system and the fact that the driver and controller are not made by the same manufacturer means that many control channels and mathematical models cannot be implemented.

4.5 Electrical machinery

The motor level of domestic robots has not been developed, which is actually due to the problem of domestic robot production. Due to the small production volume of domestic industrial robots, the cost of customizing motors is too high, making it impossible for manufacturers to customize motors based on the robot's power requirements, as is the case with mainstream manufacturers. However, using a general-purpose motor will result in the inability to optimize the parameters of the motor such as inertia, current, and torque output response capability, and the robot's load weight will also further increase.

5. Conclusion

Overall, in the rapid development of robotics technology, industrial robots will be increasingly widely used in the field of intelligent manufacturing due to their advantages. Since the birth of industrial robots, their applications in various fields have been continuously studied. Although China's robotics industry started late and lacked a solid foundation, it has achieved a basic level of professionalism in all areas and even advanced levels in some areas with the help of China's advanced political system. Facing the new situation and new requirements, the next few years and even longer will be an opportunity

for China's robotics industry to be self-reliant and undergo technological breakthroughs. Opportunities must be seized, challenges must be faced, and problems such as insufficient technological accumulation, weak industrial foundation, and lack of high-end supply must be accelerated to promote the robotics industry to the mid-to-high-end level.

References

[1] Yang ZZ. Made in China 2025 high-end CNC machine tools and robots [M]. Jinan Shandong Science and Technology Press. May 91-92, 2018.

[2] Li Z. Industrial Robots Embrace New Opportunities - Economy and Technology [N]. People's Daily Overseas Edition, 2022-02-22.

[3] Mou FJ. Analysis of Industrial Robot Technology and Its Typical Applications [J]. Chinese Journal of Fats and Fats, 2017, Volume 42 (4): 157-159.

[4] Tan CL. Research on the Application of Industrial Robot Technology in Intelligent Manufacturing [J]. Equipment and Automation. Issue 1, 2023.

[5] Ministry of Industry and Information Technology of the People's Republic of China The 14th Five Year Plan for the Development of the Robot Industry [R]. 2021-12-28.

[6] China Electronics Society. Report on the Development of China's Robotics Industry [R]. 2022 World Robotics Conference. August 2022.

[7] International Federation of Robotics.Market presentation World Robotics 2022 extended version[R]. Frankfurt, Oct 13, 2022.