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Research Article

Industrial Robot Technology and Its Typical Application Analysis

Chen Jiangong
Shandong University

Abstract: With the rising of the manufacturing industry in our neighboring countries, China no longer has advantages in manufacturing sector. New development situation and tasks make it extremely urgent to establish a new manufacturing system featuring standardization, modularization, network and intelligence. Therefore, research on industrial robot technology is of great practical significance. It is believed that in the near future, industrial robots will become an important driving force for the transformation and upgrade of China's manufacturing industry.

Key words: industrial robots, technology, typical application, analysis

0 Introduction

Based on the development situation of industrial robots, this article puts forward some suggestions for the key technology and the development characteristics of industrial robots for reference.

1 The overall structure of control system

The control system of industrial robots mainly includes two parts, namely, hardware and software. Among them, the hardware part is mainly in charge of driving the industrial robot motor through SERCOS bus and transmitting control signals for the bus to realize its communication with peripheral I/O. And the software part is mainly responsible for using PLC to realize the reading of robot control program, language transformation, logic and motion control. The operating principle and working process of the control system are as follows. When the control system is powered on, the robot control program is loaded to send the logic instructions in the CNC file to the I/O device through language interpreter and field bus interface such as PLC and CanOpen. Meanwhile, the robot language interpreter translates the motion control commands into standard G codes and calculates the control target data of each motor through interpolation program[1]. Then, SERCOS high-speed motion control bus is used to realize the communication among each axis controller and control the movement of each axis of industrial robot, so as to realize the precise control over industrial robots.

2 The main characteristics of industrial robot control system

Industrial robot control system is developed on the basis of traditional manipulation technology. Although there are many similarities between the two, industrial robot control system has its unique characteristics, including the following aspects. Generally, industrial robots have a number of joints, including 5-6 turning joints. Each joint is corresponding to a servo control system. Different servo systems can work together to control the simultaneous movements of different joints. Industrial robots perform their operational tasks primarily through hand movements or displacement. The process of motion control mainly involves complex calculation of coordinate switch, as well as matrix function conversion[2]. Industrial robot control system relies on multivariate nonlinear complex mathematical models. There is a coupling relationship between different model variables. Therefore, industrial robot control technologies mainly include technologies like feedback, compensation, decoupling, and self-regulation.

3 The internal composition of industrial robots

An industrial robot mainly consists of three components, namely, main body, driving system and control

system. The main body includes the torsos of the robot, such as its hands, legs and body. As for the robots with walking function, at present, they have 3-6 freedoms of motion, and their legs have 1-3 freedoms of motion. Consisting of dynamical system and transmission system, the driving system guarantees the motion ability of the robot to support its motion performance. The control system primarily gives commands and instructions to dynamical system and execution system, so as to guide the behaviour of the robot. According to the mode of arm activity, industrial robots can be divided into four types. As shown in Figure 1, the first type is Cartesian robots, whose arms move along the direction of rectangular coordinate[3]. The second type is cylindrical robots, whose arms can reverse, contract, rise and fall. The third type is polar coordinate robots, whose arms can rotate, lift and stretch. The fourth type is articulated robots, whose arms can perform many kinds of rotation operation. According to the motion control function, industrial robots can be divided into two types: point-to-point robots and continuous path controlled robots. Point-to-point robots can perform precise point-to-point locating tasks, such as carrying materials, welding car bodies, packing and dismantling in the production workshop. Continuous path controlled robots can perform operational tasks like paint spraying and continuous loading and unloading based on the preplanned path. According to the control program, industrial robots can be divided into two types: programme input robots and instruction input robots. The programme input robots can transmit the procedure set in advance to robot control system through communication network, so as to realize the control over the behaviour of the robot.

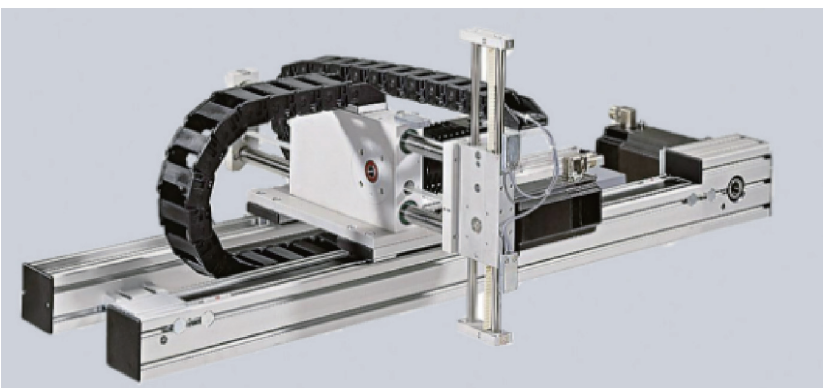

Figure 1 Cartesian Robot

4 Technical analysis of industrial robots

4.1 High-precision reducers

At present, 75% of the market share for high-precision robot joint reducers is monopolized by Nabtesco and Harmonic Drive. Some domestic manufacturers and R&D units conduct research on the productization of high-precision cycloidal pin gear speed reducers. In terms of harmonic devices, China has produced corresponding alternatives. However, compared with Japan, our products still have a long way to go in the input of rotation rate, torsional strength, and the accuracy and efficiency of rotation [4]. Key technologies for the development of high-precision reducers are as follows.

4.1.1 Material forming control technology

In order to ensure the high rigidity of the reduction gears, the development of industrial robots should enhance the abrasion resistance of the reduction gears of RV reducers. Only in this way can the high accuracy of the robot be guaranteed. Therefore, during the production of RV reducers, it's necessary to strengthen the control over the chemical elements of basic components, material content and metallographic structure. It's also important to improve the quality of ultra-conventional technology for heating processing, so as to ensure the quality of materials.

4.1.2 The processing technology for special parts

Special bearings are important components of RV reducer, the processing technology for which is accurate and sophisticated. In order to make the overall structure of the robot more compact, the gap between special bearings should be dynamically adjusted based on the sizes of components and parts, so as to realize the zero clearance of thin-walled angular contact ball bearings.

4.1.3 Precision assembly technology

When applied in industrial robots, due to its fast decrease speed, RV reducer tends to be micro-feeding and non-backlash. It also has high rigidity and relatively large torque. Therefore, based on the on-site measurement technologies, it is necessary to use precise assembly technologies and tools to ensure the zero side gap of the output shaft and the rated static rigidity[5].

4.2 Robot technology

1) Manipulator technology. As shown in Figure 2, manipulator technology includes high-speed manipulator (servo drive, dynamic control method), flexible manipulator, redundant manipulator, high-precision and multi-degree of freedom force control (precision assembly), and micromanipulator. 2) Mobile technology. It includes new-type moving mechanism (moving mechanism suitable for non-structural environment) and motion control (moulding, guidance, navigation, path planning). 3) Perceptive technology. It includes vision and image identifying and processing, hand-eye coordination, visual touch miniaturization, and multiple information fusion[6]. 4) Autonomous control technology. It mainly includes distributed computer control technology and artificial intelligence technology. Well-targeted robot technology can closely associate the control work of each link with its target. The entire control flow of robot is as follows. The local joint controller outputs control signal, followed by the output of transmission. The executive components is controlled by reducing mechanism. The overall coordinate system is used to determine the position coordinates of the robot, and the local joint coordinates are used to determine the specific position coordinates of each joint, so as to complete the local targets of each manipulator. Internal sensor detection can realize the closed-loop control of manipulators. External sensor detection can help robots sense the external environment. Processors are used to collect and analyze the perception, control, and operating data of robots and manipulators. Based on this, decisions will be made. The optimal control plan will be applied to achieve an optimal implementation effect.

Figure 2 The Application of Manipulator Technology

4.3 Robot control system

The kinematic control system of robots has high requirements for real-time performance. At present, the motion control cards of robots are all specifically custom-made and can cooperate with real-time operating system, thus effectively realizing data transmission and ensuring the accuracy and stability of the system[7]. Currently, since the message processing mechanism of the operating system commonly used by industrial robots fails to meet the requirements of high stability and rapid response in the operation process, the real-time performance will be inevitably affected, which, to some extent, will also affect the industrialization development of industrial robots.

5 Measures to strengthen the use of industrial robots

5.1 Strengthening the industrialization of patented technologies

Foreign patent applications for industrial robots are mainly enterprise-centered. Patented technologies are closely linked with industries and markets. The

submission of international patent applications through Patent Cooperation Treaty (PCT) is also paid much attention to protect the international market. However, the patent applications for industrial robots in China mainly focuses on colleges, universities, and research institutes. Most of the patented technologies of researchers still remain at the stage of publishing papers, applying for patents, and the conferring of evaluating academic titles. The industrialization of patented technologies doesn't receive enough attention[8]. Of course, this also means that the industrialization of the patented technologies for industrial robots in China has huge potential to tap.

5.2 Establishing a patent early-warning system by means of big data analysis

Making full use of big data analysis to timely master the development trend of the world's industrial robots is an important measure to avoid the patent trap of industrial robot powers. Through the big data analysis on patents, markets, and laws, the patent threat trend of industrial robots, the development trend of the key components and technologies of industrial robots, the current situation of major competitors, and possible patent infringement can be warned early.

5.3 Conducting the patent layout aimed at the key components and parts of industrial robots

On the basis of a comprehensive analysis on the patent strategies of multinational companies for industrial robots, China should strengthen the overall layout of patent applications for industrial robots, attach great importance to the forward-looking nature of patent layout, and promptly grasp the development opportunities of the industry. Existing research shows that in the cost structure of local industrial robots, imported reducers account for 40%. Servomotors account for 30%. Controllers account for 15%. It is precisely due to the difficulty in the localization of the key components that the profits of domestic brands have been squeezed. Domestic industrial robot companies should seriously develop their key technologies and core products, conduct the patent layout aimed at the key components and parts of industrial robots, establish a tight network of patent layout network, so as to protect the achievements of independent innovation and avoid the risk of intellectual properties as much as possible.

5.4 Conducting the layout aimed at the future application of industrial robots in advance

At present, the application areas of industrial robots mainly focuses on automobile manufacturing. In China, 50% of industrial robots are used in automobile industry, among which more than 50% are welding robots. In developed countries, the robots used in automobile industry account for more than 53% of the total robot holdings[9]. In multinational companies, the patented technologies of industrial robots used in automotive field are also the strongest, but rapid growth can also be seen in their applications in electronics, plastics, food, and pharmaceutical industries. China's industrial robot companies should aim at the fast-growing areas of industrial robot application, conduct research and development as well as patent layout based on the huge industrial scale, and carry out dislocation competitions with multinational companies.

5.5 Establishing patent strategy alliances for industrial robots

A number of representative industrial robot companies have emerged in China, such as Xinsong in Shenyang, Shukong in Guangzhou, Xinshida in Shanghai, and Boshi in Harbin, but the output value of each company has not exceeded 10 billion yuan. In terms of technology, scale, and R&D investment, no domestic company can compare with the multinational companies of industrial robots represented by "The Big Four" (ABB in Switzerland, KUKA in Germany, Fanuc in Japan, and Yaskawa). Therefore, an important strategy for domestic companies to deal with the patent layout conducted by multinational companies in China is to establish patent strategy alliances and use the strength of alliances to compete with multinational companies.

6 The development trends and characteristics of industrial robots

With the continuous development of information technology, industrial robots are gradually developing towards the direction of high speed, high precision, heavy load, light weight, and intelligence. In 2008, Japan Society of Mechanical Engineering analyzed and predicted the development of industrial robots from the perspective of technology. They also tested the key parameters of robots such as average power, density, accuracy, and intelligence level. Although industrial

robots have high requirements for the absolute accuracy of design, in the process of continuous improvement and practice, the absolute accuracy of robot design will gradually approach the repeated positioning accuracy of robots. The gradual performance improvement of the materials of robots can effectively reduce the weight of actuators, and further increase the stability of them. At the same time, the average power and density of servomotors and actuators of industrial robots will also be promoted. Therefore, in the near future, the development of industrial robots will have the following characteristics. 1) In order to improve the quality, reduce production costs, environmental pollution and energy consumption, in the process of the continuous development of industrial robots, the entire production process will be tested, controlled, optimized, scheduled and managed, so as to realize the production of multifunctional robots featuring high precision, high flexibility and intelligence[10]. 2) Featuring fine processing and flexible production, the automatic equipment of industrial robots is important in the process of production. It's not only a new production tool based on the research on power machinery and the development of computer technology, but also an important way to realize the digitization, automation and network intelligentization of industrial production. In industrial production, it can be used in numerous links, such as product manufacturing, installation, inspection and logistics. It also plays an important role in automobile manufacturing industry, construction machinery industry, rail transit industry, and low-voltage electrical apparatus industry. 3) The technology of the automatic equipment of industrial robots brings together a variety of disciplines. The application areas of this technology are quite wide, including industrial robot control technology, finite element analysis technology, laser processing technology, and fine manufacturing technology of logistics, which has strong comprehensive characteristics.

With the upgrading of industrial structure and the rising of labor cost, the application of industrial robots is becoming more and more common. It is believed that in the near future, the key technologies of industrial robots will make a significant breakthrough and finally cut a figure on the world stage.

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