Application Status and Development Trend of Industrial Robots in China

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Keywords: Industrial robot, Automobile manufacturing, Aerospace assembly, Intelligent manufacturing

Abstract: With the continuous development of computer technology in the direction of intelligence, the application fields of industrial robots continue to expand and deepen, e.g., automobile manufacturing, express logistics, aerospace, shipbuilding and other industries. The related research of the industrial robot has become an important component for the high-tech research filed, which is not just a significant supplement of manufacturing industry, but also a key to improve human life. The research and development of industrial robots and their industrial application is one of the essential standards to weigh the development level of a country's technological innovation and high-end manufacturing. Therefore, based on the current research status of industrial robots, this article introduces the typical applications of industrial robots based on comparing the technical levels and gaps of various countries and proposes several development trends of industrial robots.

1. Introduction

A primary goal of science and technology is to liberate labor. For this purpose, robots were invented in different historical periods [1]. During the Renaissance time, entertaining robots powered by spring and water were created. In the industrial revolution of the 18th century, programmable textile machines powered by steam were invented to reduce the labor and cost [2]. Then, the invention of the electronic motor brought the power mode of industrial production to a new level. In the second half of the 20th century, the demand for automated production gave birth to industrial robots. Since the 1960s, industrial robot technology has become increasingly mature [3][4]. Now industrial robots have matured to the fourth generation, and with the help of computers and bionic technology, they have entered the fifth-generation experimental stage [5]. Because industrial robots play a significant role in modern industry manufacturing, many manufacture-dominate countries or regions (such as the United States, Japan, the European Union, China, etc.) set the development of industrial robot as a goal of own science technology progression. For example, China's "Made in China 2025" plan includes the development of industrial robots [6]. Although many countries pay great attention to the development of industrial robots, the level of development and specialization of industrial robots in each country are quite different [7]. Therefore, the analysis and research on the application status and development trend of industrial robots has become a key issue and has important research significance.

2. Classification and Typical Application of Industrial Robots

Industrial robot is a sophisticate system and is needed to be programed when it is employed, which commonly contains mechanical system, programing and service support systems to implement the manufacturing operations/tasks. According to the working environment or tasks, the industrial robot can be classified into welding robots, assembling robots, stacking robots, and spraying robots.

2.1 Welding Robots

Welding robots refer to industrial robots with welding, cutting or thermal spraying functions installed with welding tongs or welding guns on the end of the robot. They are widely used in aviation, shipbuilding, automobiles, petroleum, and other industries, as shown in Fig.1. Such as, in

  DOI: 10.25236/ieesasm.2020.048

field of space craft, they can be utilized to weld complex curve trajectory of the shape of space shell, and in field of petroleum, they can be used to weld oil pipeline [8].

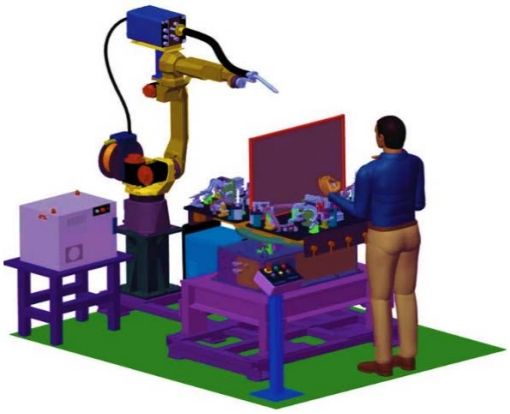

Fig.1 Application of Welding Robot in a Workstation

Note that the welding robot can handle the tasks that human workers cannot done because its high degrees of freedom [9][10]. Also, the welding robot has advantages of stabilizing and improving welding quality, high working efficiency, improving human workers' environment, ability to work in severe environment like future in outer-space, automatic manufacturing [11]. Now the developing trends of the welding robot technology are mainly focused on two directions: (1) the quality of arc welding power source and (2) welding weld tracking technology. Among them, the basis of the seam tracking technology is the design of the sensor, allowing the machine to analyze and process effectively through vision, so that the machine can adapt to the welding environment faster and more accurately.

2.2 Assembling Robots

In modern industry, assembling tasks account for 50-60% of the total workload of product production. The assembly robot is the core equipment of the flexible automated assembly system, as shown in Fig.2, which is generally composed of a robot manipulator, a controller, an end effector and a sensor system.

Fig.2 Application of the Assembling Robot

Compere with normal robots, the assembling robot has the advantages of high accuracy, stable working status, high flexibility, high agility, small working range, and high compatibility with other devices. Assembling robots are normally used in the working environment with high repeatability and high working-precision assembly requirements, such as automobile assembly production line, mass production chip assembly production line to circuit board, various electrical appliances manufacturing, small motors, computers, toys, mechanical and electrical products and assembly of their components [12]. So far, technology of assembling robot is relatively mature, and it plays a powerful role in many industrial production assembling lines. With the continuous development and functions improvement, as well as the further reduction of the production costs, the assembling robot will play a more important role in more fields in the future.

The technology of the assembling robot is related to many scientific fields, depending on the innovation on many related fields [13]. In details, the first one is the intelligent technology, because intelligent robots are the inevitable trend of future robot development. With the help of the intelligent technology, robots will have the ability to think logically in the face of complex working environments and tasks, as well as the ability to actively learn experiences and find solutions to deal with problems independently [14]. In addition, the miniaturization of assembling robots is also an important research field, which depends on the advancement of electronic component integration technologies, e.g., micro sensors, microprocessors, and micro actuators [15].

2.3 Palletizing Robots

Palletizing robots are the kind of industrial robot that are used to perform tasks such as obtaining, handling, palletizing, and depalletizing large quantities of workpieces and packages in the industrial production process, as shown in Fig.3 [16]. They are a combination of machinery, electronics, information, intelligent technology, computer science and other disciplines. Of high-tech mechanical and electrical products. Palletizing robot technology has great potential in solving labor shortages, improving labor productivity, reducing production yield, reducing labor intensity of workers, and improving the production environment [17].

Fig.3 Application of the Palletizing Robot

Industrial robots have been studied since the 1960s, among which palletizing robots have emerged with the development of industrial robot technology. At present, the research in developed countries such as Japan, Germany, and the United States has achieved fruitful results. However, China's research in this area has just started, and it is necessary to accelerate and improve the research level. For the standard of China’s technology of the palletizing robot, there are mainly two types of robots: Cartesian coordination type and joint type. Compared with these two types of palletizing robots, the joint type has more advantages than the Cartesian coordinate type. In terms of industrial applications, the use of palletizing robots in China is not as unimpeded as abroad, and is restricted by some factors [18]. For example, labor is cheap and there is a shortage of science and technology talents. Therefore, the application of palletizing robots is only currently used in some large, well-known enterprises.

2.4 Spraying Robots

To cater to the need of automatic, large-scale surface finishing of products, spraying robot appears. Spraying robots have high level of integrity and also equipped with automatic technology that combines multiple fields and technologies like industrial robot controlling, robot kinetics and memetics, finite element analysis, laser beam machining, module program designing, intelligent measurement [19], as shown in Fig. 4. Note that the spraying robots are widely utilized in modern industry. And its high degree of freedom improves working efficiency leading to ensure high spraying precision. Note that although modern spraying robots can cope with most of manufacturing tasks, the nozzle of each spraying robot can only adapt to a specific or small range of spraying materials so that multiple coatings are needed on the surface. When the surface treatment is required,

multiple robots are still needed to complete it, which also greatly increases the production cost of the spray robot [20].

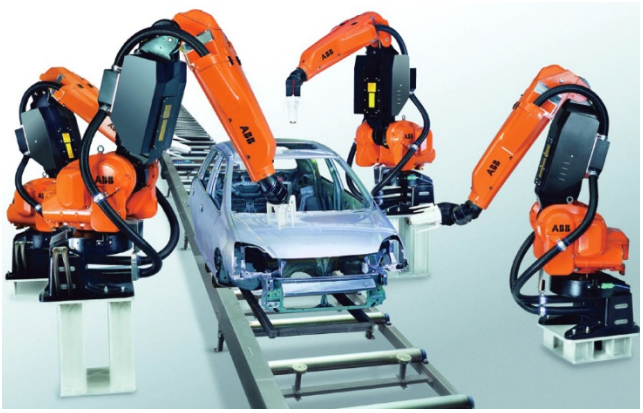

Fig.4 Application of the Spraying Robot

3. Development Status of Industrial Robot Industry

The current industry of industrial robots can be classified into two parts: the developed robot industry dominated by developed countries and the new robot industry dominated by developing countries like China [21][22]. As a technology created in the second half of the 20th century, the industrial robot now becomes a standard to value a country's industry and science technology level. However, there is a gap between the technology level for developing countries like China and that of global first-class technology. The gap is made by mainly two sections. (1) the use of core components such as server motor, controller, and speed reducer depend on import and the technology of speed reducer is hard to make a breakthrough which makes the field of speed reducer is monopolized by a few companies. (2) China lacks its serving systems. In 2018, the serving system made in China just took 10% of the global market [23].

Although there is a gap between the technology of China's industrial robot and that of foreign countries, China has made breakthroughs in some part of robot technology. Some brand in China now can fulfill the requirement of the controlling system. However, for those developing countries, they can absorb experience from those advanced technology countries to stimulate their development. In industry-advanced countries, industrial robots are the essential components in an automatic production line, and widely applied in such fields, such as automobile and parts manufacturing, mechanical processing, electronics and electrical, rubber and plastics, logistics and other industries [24]. So far, in western countries, the technology of the industrial robot is maturing, and the industrial robot has become a necessity of automatic industrial production. The Panasonic, Yaskawa from Japan, Siemens, and Schneider form Europe are the representative companies of the robot industry. With the development of computer science, some technology-advanced countries have gotten a start on combining technology like AI with the industrial robot, strengthening industry interconnection. Companies like Kawasaki Heavy Industries and FANUC now is trying to controlling the robot in the help of artificial intelligence.

These years, for developing its robot industry, China import companies like ABB or FANUC, which makes some problems while boosting China's robot industry. The most direct influence is causing the low rate of the market taken by China's brand [25]. Although importing industrial robots will lower production cost and improve efficiency, in the long run, it will impede China's robot development, which is detrimental to China's robot market environment. Additionally, there are problems in China's companies like small company size, over-development on low-end products and the competition between companies.

After all, there is considerable difference between China's industrial robot technology and employment and that of the foreign countries. There are clear differences of the dependability of the robot, employing fields and production line [26]. China have cost resource to research robot's sensor system, which have made some basics, but it just at the beginning of technology like Multi-sensor

information fusion control technology, remote control plus local autonomous system remote control robot, intelligent assembly robot, robotized machinery. These technologies have relatively large gap, which require pinpoint researching based on current technology in order to form practical, systematic technology and product.

4. Development Trend of Industrial Robots

The technology and application of industrial robots are relatively mature, and they are developing in the direction of modularization, collaboration, and intelligence. In the future industrial robot research and development, the United States, Europe, Japan and other countries and regions have emphasized the importance of new human-machine cooperation and highlighted the collaboration with human-beings.

Improvement of the intelligence level. To conform to the trend of intelligent development, robots will become more intelligent. Although some robots are equipped with perception systems and information processing systems, their ability to deal with emergencies is limited. Therefore, the ability to self-solve problems and deal with emergencies will definitely be a key development direction for the improvement of the intelligent level of industrial robots. In addition, based on Industry 4.0 enabling technology and artificial intelligence technology [27], industrial robots, numerical control equipment and humans can cooperate, so that industrial robots can adapt to various intelligent working conditions, thereby realizing the development of a new generation of industrial robots.

Improvement of the working and accuracy. To meet the requirement of improving working performance and the development of new robots, 3D printing technology provides a more suitable solution. 3D printing technology is an essential supplement to the traditional manufacturing process. It has the advantages of low manufacturing cost and the ability to process parts with complex shapes. Besides, 3D printing technology can also meet the needs of small-scale and personalized production of industrial robots. However, the current level of technology cannot support the 3D printing of large-scale robot workpieces and new robot-related parts. Therefore, with the development of technology, 3D printing technology will provide strong technical support for the development and work performance of industrial robots.

Enhancement of the flexible manufacturing capabilities. The current application of industrial robots to the workshop site is mainly to replace the operators to complete some simple and repetitive tasks, but it has not yet been able to make adaptive adjustments according to manufacturing tasks or production site environment. The improvement of the versatility of industrial robots and the strengthening of the modular design of industrial robots are an inevitable requirement for the realization of flexible manufacturing and intelligent manufacturing [28]. Therefore, under a general application platform, with technological innovation and the development of robot supporting software and hardware, modular and easy-to-use industrial robots are a major trend for large-scale applications in the future.

5. Conclusions

With the development of technologies, the application of industrial robots will become more and more widely, and the requirements for technological innovation and production cost reduction of industrial robots will also be higher and higher. Industrial robots are bound to become the key technologies and important products of Industry 4.0 and intelligent Manufacturing, continuously expanding new application areas and being widely used in various fields of social life. This paper analyzes the current development status of industrial robots and the problems existing in the actual production and application of industrial robots, combined with the current development situation, analyzes the development trend of future industrial robots, and can be used for related jobs or technical operators in this field, which provides certain technical support.

References

[1] Xu, W., & Mao, Z. Research status and development trend of nuclear power plant robots. Jiqiren (Robot), vol.33, no.6, pp.758-767, 2011.

[2] Zheng, L., Liu, S., & Wang, S. Current situation and future of Chinese industrial robot development. International Journal of Mechanical Engineering and Robotics Research, vol.5, no.4, pp.295-300, 2016.

[3] Vagaš, M., Hajduk, M., Semjon, J., Koukolová, L., & Jánoš, R. The view to the current state of robotics. In Advanced Materials Research, Trans Tech Publications Ltd, vol. 463, pp. 1711-1714, 2012.

[4] Zhang, G. Q., Li, X., Boca, R., Newkirk, J., Zhang, B., Fuhlbrigge, T. A., & Hunt, N. J. Use of industrial robots in additive manufacturing-a survey and feasibility study. In ISR/Robotik 2014; 41st International Symposium on Robotics. VDE. vol.1, no.1, pp. 1-6, 2014

[5] Ruishu, Z., Chang, Z., & Weigang, Z. The status and development of industrial robots. MS&E, vol.423, no.1, pp.012051, 2018.

[6] Gao, H., Guo, R., & Li, P. Development Situation and Prospect of Chinese Industrial Robots. In 2nd International Conference on Civil, Materials and Environmental Sciences. Atlantis Press, vol.11, pp. 2015.

[7] Wang, T. M., Tao, Y., & Liu, H. (2018). Current researches and future development trend of intelligent robot: A review. International Journal of Automation and Computing, vol.15, no.5, pp.525-546.

[8] Fan, W., Zheng, L., & Wang, Y. (2018). An automated reconfigurable flexible fixture for aerospace pipeline assembly before welding. The International Journal of Advanced Manufacturing Technology, vol. 97, no.9-12, pp.3791-3811.

[9] IOANEŞ, C., & CHIOREANU, A. Current trends regarding the intuitive programming of industrial robots. Acta Technica Napocensis-Series: Applied Mathematics, Mechanics, And Engineering, vol.55, no.1, pp.197, 2012.

[10] Wang, H. P., Yang, Y., & Liu, J. T. Research and development trend of high-speed mobile robot. Zidonghuayu Yibiao/ Automation & Instrumentation, vol.26, no.12, pp.1-4, 2011.

[11] Bolmsjö, G., Olsson, M., & Cederberg, P. Robotic arc welding–trends and developments for higher autonomy. Industrial Robot: An International Journal, 2002.

[12] Wu, L., Zhang, G., & Gao, H. Technology of welding robot. China Surface Engineering, vol.19, no.5, pp.29-35, 2006.

[13] Bekey, G., & Yuh, J. The status of robotics. IEEE Robotics & Automation Magazine, vol.15, no.1, pp.80-86, 2008.

[14] TAN, Y. J., ZHOU, F. M., WANG, J. C., & HUANG, Z. J. Development trend and situation of technology of welding robot. Electric Welding Machine, 3, 2006.

[15] Li, P., & Liu, X. Common sensors in industrial robots: A review. In Journal of Physics: Conference Series. IOP Publishing, vol. 1267, no. 1, pp. 012036, 2019.

[16] Yan, D. Research and Application Status of Industrial Robot Control System. In 2018 3rd International Conference on Mechanical, Control and Computer Engineering (ICMCCE) IEEE, pp. 16-20, 2018.

[17] Huang, R. Characteristics of International Robot Industry Development and Its Enlightenment to China. Canadian Social Science, vol. 11, no.1, pp.110-113, 2015.

[18] McGhee, R. B. Future prospects for sensor-based robots. In Computer Vision and Sensor-Based Robots. Springer, Boston, MA pp. 323-334, 1979.

[19] Ray, J., Atha, K., Francis, E., Dependahl, C., Mulvenon, J., Alderman, D., & Ragland-Luce, L. A. China's Industrial and Military Robotics Development. Defense Group, Incorporated, Center for Intelligence Research and Analysis, 2016.

[20] Zhixiang, C., Yong, H., & Shuyan, Y. Analysis and design for off-line welding robot programming system. Chinese Journal of Mechanical Engineering, vol. 37, no.10, pp.104-106, 2001.

[21] JI, P. C., & SHEN, H. P. Current Situation and Development Trend of Service Robot. Journal of Changzhou University (Natural Science Edition), vol.2, 2010.

[22] Afsari, K., Gupta, S., Afkhamiaghda, M., & Lu, Z. Applications of Collaborative Industrial Robots in Building Construction. In 54th ASC Annual International Conference Proceedings, 2018.

[23] Mi, X., & Li, B. Research on Application of Laser Quenching of Industrial Robots on Automobile Moulds. Journal of Engineering Mechanics, vol.4, pp.29-35, 2019.

[24] Hashimoto, M., Domae, Y., & Kaneko, S. I. Current status and future trends on robot vision technology. Journal of Robotics and Mechatronics, vol.29, no.2, pp.275-286, 2017.

[25] Kim, H. S., Koo, D. S., Nam, Y. J., Cho, K. J., & Kim, S. (2019). Research on Technology Status and Development Direction of Wearable Robot. Fashion & Textile Research Journal, vol. 21, no 5, pp.640-655, 2017.

[26] Wu, D.Research on Development and Prospect of Industrial Robots In China. In Applied Mechanics and Materials. Trans Tech Publications Ltd, vol. 536, pp. 1717-1720, 2014.

[27] Zhi-jun, D. U. A Survey of Industrial Robots in Their Application and Development. Mechanical Engineer, vol.5, 2002.

[28] Zhang, W., Dong, Z., & Liu, Z. Present situation and development trend of welding robot. In 2017 2nd International Conference on Materials Science, Machinery and Energy Engineering (MSMEE 2017). Atlantis Press, 2017.