

Exploring the Application of Industrial Robots in CNC Machining



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Abstract: The article discusses the application of industrial robots in CNC machining, to understand the significance of strengthening the application of industrial robots in CNC machining, to explore and describe its specific applications, to improve the level of application of industrial robots, and to provide strong support for the modernization and development of the field of CNC machining.

Keywords: industrial robot; CNC machining; application

With the development of modern society, in all walks of life the demand for industrial production activities continues to improve but also put forward higher requirements for the field of industrial production, the requirements of the industrial production industry to ensure that the conditions of the production base, the quality of production is constantly improved. The effective application of industrial robots, on the one hand, can improve the automation level of CNC machining activities, while simplifying the production process, and reducing labor costs. On the other hand, it can effectively reduce the impact of human factors on processing quality, and greatly improve the accuracy of CNC machining, so that the processing quality has been guaranteed accordingly. This is of great significance to meet the needs of social development. Therefore, it is necessary to conduct an in-depth study of the relevant content.

1. The Significance of Strengthening the Application of Industrial Robots in CNC Machining

First, strengthening the application of industrial robots can effectively improve the accuracy of CNC machining. It can be through the reasonable setting of the relevant parameters, the processing of error

problems during the corresponding compensation, to avoid the accumulation of error problems, so that the processing quality is effectively guaranteed. Secondly, the application of industrial robots in CNC machining can make the relevant production activities further enhance the level of flexibility. Industrial robots can be processed according to the shape of the workpiece, specifications, dimensions and models, and other characteristics of the flexible replacement of fixtures to meet the needs of a variety of products processed, and the entire process of changing the production process will not consume too much time, which can effectively ensure the production of energy efficiency. Third, the application of industrial robots can effectively strengthen the functionality of CNC machine tools, so that a single machine tool can be a variety of work can also be completed simultaneously. Fourth, the integration of industrial robots can improve the automation level of CNC machining activities, strengthen the convenience of machining operations, while reducing labor intensity, and effectively improve the efficiency of production and processing activities. Especially at the current stage, with the rapid development of science and technology, the structural system of industrial robots, and control systems have been greatly improved, especially the enhancement of the level of robot intelligence, The

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modernization of the field of CNC machining has produced a great impetus to the development of the field.

2. The Specific Application of Industrial Robots in CNC Machining

In industrial production activities, the application of CNC machining is very wide, with the help of the powerful functionality of CNC machine tools, not only to complete the disk, and shaft parts inside and outside the ring of the cutting process but also for drilling, reaming and grooving and other processing activities. CNC machine tools are usually composed of the main body of the machine tool, CNC device, tool holder feed, spindle box, lubrication system, cooling system hydraulic system, and other components. At present, the more commonly used CNC machine tools are mainly horizontal and vertical two types. Among them, the former can have a longer axial size of the disk parts for processing, while the latter can be relatively large rotary diameter disk parts for processing. With the development of modern society, the application of CNC machine tools has become more and more widely used, and gradually become the core equipment in the production and processing activities of many enterprises. But many companies in the production of CNC machine tools in the production process, but also in the way of artificial operation, which also leads to its production efficiency and production quality being difficult to effectively improve, seriously affecting the market competitiveness of enterprises. In this regard, there is a need to strengthen the application of industrial robots.

2.1 Design ideas

An enterprise's CNC machine tool height of 1500mm, its spindle center is 900mm from the ground, and production processing activities to cylindrical workpiece-based, but in practice, the need to use the staff for loading and unloading operations, which also leads to its production efficiency in the production and processing process is not high. To comprehensively improve the effectiveness of CNC

machine tools, the need for manual loading and unloading of workpieces to strengthen the technical improvement of the situation, the use of industrial robots to replace the staff for loading and unloading operations. As industrial robots have more types, and different types of characteristics there are certain differences, so the first thing to do is robot selection. Common industrial robots have three types, The first, is a cylindrical coordinate robot. The control itself is relatively simple, and for the space occupation is relatively small, but in terms of positioning accuracy is relatively weak, for workpiece handling has a strong applicability. Second, the right-angle machine coordinate robot, itself has a high positioning accuracy, but because the body is relatively large, the overall flexibility needs to be improved. Third, the articulated robots, its structure is similar to the human body joints, the application of rotary joints, suitable for its six degrees of freedom, can be most of the production activities to effectively meet the needs, such as Figure 1, for example, automatic loading and unloading and spray painting and so on. And because the structure of this robot is more compact, less space occupation. Therefore, the enterprise combined with their production reality, decided to use the articulated robot. Specifically, the robot is set between two CNC machine tools, and the material box is set on the upper side of the robot, while the material tray is set on the lower side of the robot, The distance between the robot and the CNC machine tool should be 1200mm, and the working radius is set to 1000mm (Zhao & Lin, 2020).



Figure 1

2.2 Workflow design

The loading and unloading unit in this design mainly involves the following items, namely: one industrial robot, two CNC machine tools, one material box, and one material tray. The CNC machine tool on the industrial robot's instructions, will control the hydraulic chuck for loosening or tightening and other operations, and the disk of the various stations is equipped with sensors, to detect whether there are workpieces. There is a motor under the material tray to meet the rotational needs of the material tray so that each time the material tray can rotate to the position of the workpiece. The industrial robot will move the finished workpiece from the CNC machine to the material box. The process flow of the machining orderer is as follows:

First of all, the industrial robot's manipulator will move to the place near the picking position, At this time the manipulator is in a loose state, after the industrial robot obtains the relevant instructions, it will control the manipulator to reach the picking position and change from the loose state to the clamping state after the workpiece is clamped, it will move back to the standby position.

Secondly, the industrial robot moves the robot from the standby position to the front of the safety door of the machine and then moves to the front of the chuck, slowly moves to the chuck, adjusts to the loosened state, so that the clamped workpieces will fall into the chuck, and returns to the front of the safety door. In turn, the CNC machine will clamp the

chuck and complete the workpiece machining and processing activities.

Finally, the industrial robot to determine the safety door open, will move the robot to reach the chuck directly in front of the chuck, and slowly move into the chuck, The CNC machine tool will be loosened after the chuck, and the robot will be clamped in the chuck of the workpiece, and move to the safety door, the completion of the processing of the workpiece is placed in the material box.

Of course, with the realization of this workflow, you need to do a good job of industrial robot program writing. To improve the convenience of program debugging and management, the program can be divided into multiple routines. These are the main program, material clamping program, material clamping to the machine program, workpiece placement program, machine tool processing program, and interrupt program. Through the effective preparation of the above programs, the industrial robot can be operated in strict accordance with the program settings. The interrupt program can be used for emergency treatment in the event of an emergency, that is, in the event of a program error, etc., the interrupt program will play a role in stopping the robot to avoid safety accidents or worsening of the problem, to ensure the safety of production at the same time, but also to ensure the quality of the production activities (Lu & Zan, 2019).

2.3 Robot slewing structure

First, arm slewing. The industrial robot applied in the case study has an arm that mainly contains two parts, i.e., the small arm and the large arm. Its slewing program has two kinds, One is, with the help of a harmonic reducer, the arm and the motor are directly connected, so that the motor can drive the slewing motion of the robot arm. Secondly, the motor is used to drive the harmonic reducer, so that it can carry out the rotary movement, and the reducer will drive the linkage mechanism of the robot's small arm, so that the small arm to complete the rotation. For these two rotary programs, the first has a relatively simple overall structure, while the second has a relatively complex structure, but with better stability,

due to its application of the four-bar structure in the robotic arm, so it can effectively reduce the self-weight, to ensure the smoothness of the movement process. In the case of a relatively large operating space, its applicability is a little stronger, therefore. The case enterprise decided to use the second slewing program (Yi, 2018).

Second, waist slewing. In the process of the application of industrial robots, waist rotation is also a very important design content. The specific rotary program also has two kinds, One is, that the motor is set in the upper end of the robot's base, and through the gear drive and coupling, the robot is driven, so that it completes the rotary motion. Secondly, after the motor is set on the upper end of the base, a harmonic reducer is used and connected to the rotary axis, and the robot is connected to the waist with the help of the output axis so that the robot carries out rotary motion on the base. Comparing the two solutions, it can be determined that the second solution has a simpler structural system, which is not only more convenient for installation and operation as well as maintenance but also can improve the control accuracy of the robot. Therefore, it was decided to use the second program (Zhang et al., 2023).

Third, manipulator transmission. For industrial robots, the manipulator is its end execution device. Commonly used transmission mechanisms include left and right screw rod type, rack and pinion type, and slotted lever type. These three transmission mechanisms have different structural forms and different advantages and disadvantages, and the case study company decided to apply the rack and pinion lever type for the design of the manipulator transmission mechanism after practical analysis and comparison (Zhou & Wang, 2018).

Fourth, wrist pitching. Specific programs are as follows: First, the use of couplings to connect the motor and gears, the use of drive shafts to drive the small arm, to change its direction, and then achieve the purpose of driving the wrist to carry out the tilting operation. Second, the use of harmonic reducer and motor together to drive the robot for

wrist tilt operation; third, the use of motors, rubber synchronous belt, and the pulley for rotary movement, so that the movement force can be transmitted to the front of the arm, driving the wrist into the pitch operation. Among these solutions, the first solution has a more reasonable structure. The second solution is a direct drive, Although the structure is simple and easy to control, due to the need to set the speed reducer and the motor in the robot's wrist at the same time, it will increase the weight of the wrist and affect the stability of its operation. The third solution, due to the setting of a synchronous belt and supporting pulleys, will increase the complexity of the structure, resulting in greater difficulty in its installation and post-maintenance. Therefore, after a comprehensive comparison, the case enterprise decided to apply the second wrist pitching scheme (Cui & Lv, 2017).

Fifth, the driving mode. Combined with the actual situation of the case enterprise, the drive device in this design is mainly used to supply the power source of the robot arm movement. There are three commonly used robot drive methods. Including electrical drive, hydraulic drive, and motor drive. Among them, the motor drive has a high output power, and compact structure, and fast response speed, Not only can mention the flexibility of the operation control but also ensures its positioning accuracy is effectively guaranteed. Therefore, the case enterprise decided to use servo motors to drive the rotation of the robot (Tao, 2020).

2.4 Design and selection of transmission system

For the mechanical structure of CNC machine tools, there are three main requirements involved, First, to ensure that there is no gap in the transmission exists. Secondly, to ensure that there is no obvious friction problem that exists during transmission. Finally, to ensure that there is no deformation during transmission. Only by effectively meeting the above requirements can we ensure that the robot sets position and the scientific and reasonable operation path. As a result of the servo motor used by the case enterprise for robot drive, compared to the actual demand, the motor torque

output is relatively small, and the speed is greater than the actual need, for this situation, needs to be adjusted through the speed reducer, to improve the actual effect of the drive. For industrial robots, there are many kinds of speed reducers, including synchronous belts, harmonic reducers, and reduction gears. However, the application of a reducer must ensure that it has a small return difference and a large reduction ratio. The smaller the size of the reducer, the better, To avoid its size being too large, increase the weight of the whole structure. Therefore, the case enterprise decided to the application of harmonic reducer, the use of double-wave transmission of harmonic reducer, at the same time in the flex wheel and roller wheel between the setting of the anti-bending ring, to ensure that the flex wheel gear can effectively mesh with the outer teeth of the output wheel. And because the harmonic reducer does not have bearings on the output shaft, it can effectively improve the compactness of the structure, to better meet the needs of the enterprise's use, as shown in Figure 2 (Shen, 2019).



Figure 2

2.5 Application effectiveness

Cases of enterprises in CNC processing after the application of industrial robots, loading and unloading have changed greatly, The automatic operation of industrial robots, so that the production and processing activities of enterprises to obtain a higher loading and unloading speed, not only reduces the intensity of the work of the relevant personnel, the overall production efficiency has also been greatly improved, so that the enterprise to obtain a higher economic return.

Conclusion

In summary, the reasonable application of industrial robots in CNC machining, can make the efficiency and quality of CNC machining has been significantly improved, which is very important for the development of CNC machining enterprises. Therefore, the relevant enterprises must maintain a high degree of attention to the application of industrial robots, to strengthen their research, and combine them with their production practice for its reasonable application, to enhance their production level.

Conflict of Interest

The authors declare that they have no conflicts of interest to this work.

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