The Improvement Method of the Auxiliary Tool Holder of the Inner Diameter Tool of the CNC Lathe in the Internet Era

Guo Chen\textsuperscript{1,*}

\textsuperscript{1}Engineering Training Center, Shandong Huayu University of Technology, China, 253000

*Corresponding author e-mail: gcxlzx@huayu.edu.cn

Abstract. Regarding how to make better use of the system functions of the CNC machine tool after the transformation and reduce the cost, this paper studies the vertical data lathe system device to demonstrate that the auxiliary tool holder of the inner diameter tool is controlled by the CNC system and the axis control. Through the fusion of NC and PLC to operate the tool change, develop the tool change and tool change PLC program. Test the function of the tool post, and the experiment proves that the tool change of the machine tool is safe, accurate, and has fewer failures. The control standard of the servo tool post is realized, and the resources of the numerical control system are better adopted, and the cost of the transformation is saved on the basis of reducing the hardware devices.

Keywords: Inner Diameter Tool auxiliary Tool Post, Following Axis, Indexing Control

1. Introduction

With the application of CNC technology in my country's equipment manufacturing industry, the development of CNC equipment has attracted more and more attention from related industries. The use of CNC machine tools, especially CNC lathes, can not only improve the production quality of products, but also improve production efficiency, reduce production costs, and ultimately achieve the goal of improving enterprise production efficiency. In the corresponding production, the cutting tool is an indispensable important tool in the cutting process, whether it is an ordinary machine tool, or an advanced numerical control machine tool (NC), machining center (MC) and flexible manufacturing system (FMC), it must rely on the tool to complete Cutting process. The development of cutting tools has an important impact on improving productivity and processing quality. CNC machine tools are a typical product of mechatronics in the field of mechanical processing. It combines power technology, automation control technology, motor technology, automatic detection technology, computer control technology, sensor technology, machine tool [1-2]. Hydraulic and pneumatic transmission technology and processing technology and other integrated automation equipment, with the characteristics of high precision, high efficiency and high adaptability [3-4]. In many industries, CNC machine tools are in the key process of key jobs [5-6]. If the failure cannot be repaired in time, it will affect the productivity and product quality of the enterprise, and will bring huge losses [7-8]. Therefore, it is
very important to be familiar with and master the fault diagnosis and maintenance technology of CNC machine tools, and to troubleshoot in time [9-10]. Based on the signal flow in the control process of CNC machine tools, the author analyzed the ideas and steps of troubleshooting for the four-station electric tool rest of CNC machine tools, and modified the tool rest device to suit the normal operation of CNC machine tools [11]. Provide certain reference and reference for relevant personnel.

The author unit has a TV-44 CNC lathe imported from the United States in the 1990s. It consists of X and Z feed axes and a spindle. It is equipped with a servo-driven double-layer tower tool post for clamping and loosening the tool post. Realized by hydraulic drive. Due to the long service life and the aging of electrical components, the electrical failure rate is high, and the machine tool cannot work normally. The machine tool has good rigidity and mechanical accuracy. For the consideration of investment cost, the machine tool is electrified. The CNC system uses the Siemens 840D system, equipped with a spindle servo drive and a dual-axis feed drive. With servo control, a single-axis servo amplifier and a servo motor must be added, which will inevitably increase the cost of transformation. If a hydraulic motor is used to drive the tool post to rotate, and the tool post is set as the follow axis of the CNC system, not only can it meet the control requirements of the servo tool post, but also reduce the servo hardware and save the cost of machine tool transformation. The article introduces the application of the CNC system following axis in the transformation of the auxiliary tool post of the TV-44 inner diameter tool of the CNC lathe through an example.

2. Improved design of auxiliary tool holder for inner diameter tool of CNC lathe

In view of the above-mentioned technical problems in the prior art, this design provides an adjustable inner diameter knife auxiliary tool holder, which solves the problems of low speed and low work efficiency in the prior art of using a cushioned knife plate.

In order to achieve the above technical requirements, this design embodiment provides an adjustable inner diameter knife auxiliary tool holder, including: a knife sleeve (the knife sleeve has an inner hole, and the inner hole is used to install the inner diameter knife); and a knife holder (with the knife Sleeve connection, a lifting mechanism is provided between the knife holder and the knife holder, and the lifting mechanism is used to drive the knife holder to reciprocate up and down relative to the knife holder). The working principle of this design is: the auxiliary tool post is installed on the lathe, and the operator can use the Allen key to turn the lifting screw. Due to the blocking effect of the stop, the lifting screw rotates around its own axis but does not produce axial displacement. It is matched with the first thread The part constitutes a spiral transmission, which can realize the up and down movement of the knife sleeve.

The lifting mechanism includes a lifting screw and a first threaded part. The lifting screw is combined with the tool sleeve (which can rotate relative to each other but does not produce axial displacement). The first threaded part is provided on the tool seat, and the lifting screw rotates around its own axis. There is no axial displacement, and it is matched with the first threaded part to make the tool sleeve reciprocate in the up and down direction. The cutter sleeve is provided with a second threaded part, and the continuous thread formed after the first threaded part and the second threaded part are combined is matched with the lifting screw. The lifting screw includes a screw part and a polished rod part, the screw part is adapted to the continuous thread, the outer diameter of the polished rod part is smaller than the outer diameter of the screw part; the outer wall of the polished rod part is sleeved with a stopper, and the stopper is tightly connected with the knife sleeve , And the outer diameter of the stopper is greater than the outer diameter of the screw part. A fixing hole is arranged on the joint surface of the knife sleeve and the stopper, and a fixing screw matched with the fixing hole is arranged in the fixing hole. An adjustment hole is arranged on the outer end surface of the polished rod part, and the adjustment hole is an inner hexagon counterbore. The lifting mechanism also includes an auxiliary component. The auxiliary component includes a sliding groove and a sliding block matched with the sliding groove. The sliding groove is provided on the knife sleeve, and the sliding groove extends along the movement direction of the knife holder; the sliding block is connected with the knife holder. The sliding groove includes a first groove portion and a second
groove portion. The first end of the first groove portion communicates with the first end of the second groove portion, and the second end extends in a direction parallel to the extending direction of the sleeve; the second groove. The second end of the portion extends to the outer end surface of the sleeve in a direction perpendicular to the extending direction of the first groove portion. The sliding block includes a first sliding block and a second sliding block. The first end of the first sliding block is fixedly connected with the knife sleeve, and the second end extends in a direction parallel to the width direction of the knife holder and is connected to the first end of the second sliding block. Fixed connection; the second end of the second slider extends in a direction parallel to the length of the tool holder; the size of the first slider matches the size of the second groove, and the size of the second slider matches that of the first groove. Match the size. A plurality of fastening screws are arranged on the knife sleeve, and the ends of the fastening screws pass through the inner hole and abut against the outer wall surface of the inner diameter knife to fasten the inner diameter knife.

Figure 1 is a schematic diagram of the three-dimensional structure of the auxiliary tool holder of the inner diameter knife from the first view angle.

Figure 1. The three-dimensional schematic diagram of the auxiliary tool holder of the inner diameter knife from the first perspective

3. Hydraulically driven double-layer turret control analysis
To control the double-layer turret driven by a hydraulic motor as the follow axis of the system, the following three problems should be solved: (1) The problem of detecting the position number of the auxiliary tool holder of the inner diameter tool; (2) How to realize the rapid rotation of the tool holder to find the tool, Slow positioning; (3) How to remember the current tool position number before power off.

The indexing numbers of the upper and lower layers of the inner diameter tool auxiliary tool holder are not the same, so the detection of the tool position number cannot be realized with an absolute encoder like other tool holders. Each tool position on the turret has a fixed angle, and the angle of the No. 1 tool position on each layer is 0. Use TX to represent the upper tool position number of the tool post, then the corresponding angle is (X-1)×60°, and the value range of X is 1~6. Use T1Y to
represent the lower tool position number, the corresponding angle is \((Y-1) \times 45^\circ\), and the value range of \(Y\) is \(1\)–\(8\). For example, \(T4\) represents the No. 4 tool position on the upper level of the tool post, at the position of the tool post axis at \(180^\circ\), and \(T16\) represents the No. 6 tool position at the lower level of the tool, at the position of the tool post axis at \(225^\circ\), and the remaining tool positions are on the tool post axis. The position can be deduced by analogy, so the detection of the tool position of the tool post can be realized with an external incremental pulse encoder. The hydraulic motor drives the tool post to rotate, and by controlling the flow of the hydraulic motor, the motor can quickly rotate to find the tool and slow positioning. \(840D\) system has power-down retentive user variables, such as \_ZSFR variable, the data in the variable will not be lost after power-off. Store the position of the current tool position of the tool post in this type of variable. After the power is turned on, the data is read from the variable to obtain the position information of the current tool position, which solves the problem that the incremental pulse encoder cannot remember the position before the power failure. Current tool position number.

4. Setting of tool post rotation following axis

The indexing of the tool post is driven by a hydraulic motor. To display the indexing angle of the tool position on the screen, the tool post must be set as the rotation follow axis of the system. The external incremental pulse encoder (1024 lines/revolution) of the inner diameter tool auxiliary tool post is connected to the X442 interface of the driver to detect the indexing angle of the tool position, and the parameters shown in Table 1 should be set.

| Parameter number | Numerical value | Remarks |
|------------------|----------------|---------|
| MD1000           | B1             | Define the tool post as B axis |
| MD20700          | 4              | Display the position value of the tool holder on the display |
| MD30300          | 1              | Set the B axis as a rotation axis |
| MD30132          | 1              | Set B axis to follow axis |
| MD30320          | 1              | B-axis 360° display |
| MD30200          | 1              | Number of encoders |
| MD30342          | 1              | Encoder is independent |
| MD30200          | 1024           | Number of pulse encoder lines |

After the above settings, the position coordinates of the B axis (tool holder) will be displayed on the display. When the tool holder is rotated and indexed, the position coordinates of the B axis (tool holder) will change, and the current position of the tool holder can be clearly known. coordinate.

5. The design of the tool change subroutine

Set the tool post as a rotating follow axis, and the tool change control is to index the B axis. The method of combining NC and PLC is used to realize the tool change control. The indexing direction of the B axis, the deceleration positioning width and the in-position judgment need to be calculated and controlled by the \(840D\) NC, and the judgment result is transmitted to the PLC through the H function. The PLC makes the tool post execute the corresponding action to change the tool according to the judgment result of the NC. The tool change subroutine TOOL is designed, and the subroutine TOOL is called with the T instruction. The flowchart is shown in Figure 3. The variable \_ZSFR[0] saves the position value of the current tool position; the variable R12 obtains the position of the current tool position by reading \_ZSFR[0]; the variable R15 stores the position value of the target tool number, according to the position value of the current tool position and The position value of the target tool position calculates the rotation direction of the B axis, and transmits it to the PLC through H1 to quickly rotate and find the tool; use the system variable \_Y AA_MM[B] to read the current position value of the B axis, when the deceleration positioning width is reached (generally away from The target tool number position is within \(\pm 5^\circ\)) through H2, the deceleration signal is transmitted to the PLC to rotate slowly, and when the target tool position is reached, the in-position signal is transmitted
to the PLC through H3 to stop the motor rotation; the tool post is dropped and locked. After that, update the value in the _ZSFR[0] variable to ensure that it is consistent with the position of the current tool position.

6. Debugging of reference point approach

Use the power-down retentive user variable to save the position value of the current tool position. After the power is turned on, the current tool position position information can be obtained by reading the variable. However, the current tool position position value is displayed as a random number when it is turned on for the first time, and the reference point needs to be returned. Establish the correct positional relationship. The reference point of the B axis (tool post) is set on the No. 1 tool position. After returning to the reference point, the current tool position number is No. 1, the angle is 0, and the current tool position position value is written into the variable _ZSFR[0] . The variable _ZSFR[0] is refreshed after each tool change, so that the value in the variable _ZSFR[0] is consistent with the current tool position value, and there is no need to return to the reference point after turning on the machine.

The B axis (tool holder) adopts a convenient magnetic switch method to return to the reference point. A metal block is installed on the No. 1 tool position of the tool holder axis, and a proximity switch is installed on the tool holder. In the reference point mode, when the hydraulic motor drives the tool post to rotate to the No. 1 tool position, the proximity switch sends a one-turn signal, which is connected to the Z-axis drive X432 interface (BERO signal interface); when the system receives the BERO signal, the hydraulic motor stops rotating, the B-axis reference point return has been completed, the reference point mark is displayed on the left of the B-axis on the display, and the position coordinate is displayed as 0. During debugging, the relative position of the proximity switch and the metal block should be adjusted so that the tool post can be locked down at the position where the BERO signal is sent. The B-axis reference point return needs to set the parameters shown in Table 2.

| Parameter number | Parameter value | Remarks |
|------------------|-----------------|---------|
| MD34200          | 2               | Back to reference to BERO mode |
| MD34100          | 0               | The coordinates are displayed as 0 after returning to the reference point |
| MD34104          | 1               | The search function is enabled during follow-up |
| MD34000          | 0               | Return to reference point without stop |

The tool change PLC program controls the loosening and locking of the tool holder, the forward and reverse rotation and deceleration of the hydraulic motor according to the H function signal sent by the NC. The peripheral interface control circuit of the tool change PLC is shown in Figure 2. The corresponding interface data blocks of the H1, H2, and H3 functions of the 840D system in the PLC are DB21.DBW140, DB21.DBW14.146 and DB21.DBW14.152. When there is a TXX tool change command, the data block DB21.DBX60.1 (tool function has changed) is set to 1; when the tool needs to be changed, first lock the electromagnet YA5 to lose power, and the tool holder is released, and then according to DB21.DBW140 The value drives the hydraulic motor to rotate forward (or reverse) quickly to find the tool. When it reaches the deceleration width range, DB21.DBW14.146 is 1, and YA3 is energized when the tool is searched in the forward direction (or the YA4 electromagnet is activated when the tool is searched in the reverse direction. Electric), after the speed control valve, the tool post is slowly rotated and positioned. When it reaches the target position, DB21.DBW14.152 is 1, YA1, YA2, YA3, YA4 are powered off, the motor stops rotating, and the YA5 electromagnet is energized and locked. When the hydraulic cylinder is tightened, the tool post is dropped and locked. After the lock is in place, the proximity switch SQ1 sends out a signal, and the tool change is completed.
7. Conclusion
After the above-mentioned debugging, the auxiliary tool post of inner diameter tool can forward and reverse high-speed tool finding and slow positioning, realizing tool change. After the transformation, the working time of the machine tool is more than 18h per day, the machine tool is fast and reliable, the positioning accuracy is high, the failure rate is low, the use effect is good, and it meets the requirements of servo tool rest control. The combination of NC and PLC is used to control tool change, which simplifies the PLC program and is convenient for debugging. The application of the following axis to the tool post control makes full use of the functions of the CNC system, saves system hardware configuration resources, improves the cost-effectiveness of the CNC system, and reduces the cost of transformation. This research idea has practical guiding significance and reference value for technical personnel engaged in related work.

Acknowledgments
Science and technology project of Shandong Huayu Institute of technology in 2020:Research on the improvement of inner diameter tool auxiliary tool rest of economical NC lathe(2020KJ14).

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