The Electrical and Mechanical Alignment and Accuracy Detection of Numerial Control Machine Tool

XU Liang-xiong, ZHOU Xiang
Department of Electromechanical Engineering Wuhan Technical College of Communications, Wuhan 430065, P. R. China

Abstract: *In the work of numerical control reformation of general machine tool, the installation and debugging of machine tool is a crucial part. For the C6132 machine tool, and make the use of electrical and mechanical alignment, parameter adjusting, numerical control lathe accuracy debugging and performance examination has been used to finish a series of tailing in the work of numerical control reformation of general machine tool. In this paper, the detailed process of electrical and mechanical alignment, parameter adjusting, numerical control lathe accuracy debugging and performance examination has been demonstrated, meanwhile, the specific operational approach of these work programs has been discussed. Therefore, the present results provides essential reference and approach for the numerical control reformation of general machine tool.*

Key words: electrical and mechanical alignment; parameter adjusting; numerical control lathe accuracy debugging and performance examination

1 Introduction

In the work of numerial control reformation of general machine tool, machine tool´s installation and debugging is essential. The paper takes the numerial control reformation of C6132 general machine tool for example, states machine tool´s electromechanics uniting and adjusting, parameter adjusting, numerial control lathe accuracy debugging, method of performance examination and the result after the reformation [1~3].

2 Machine tool electromechanics uniting and adjusting

Electromechanics uniting and adjusting mainly includes various operatinal tests, function tests, void operation, stress tests and it inspects whether the numerial control reformation satisfies the needs.

2.1 Examination before void operation

Appearance inspection is needed before machine tool is powered on. The inspection items are assembly quality of the parts of the machine tool, and they need to work properly when are powered [4,5].

1) Use 0.03 mm filler gauge to check out important fixed faying faces. The standard is the filler gauge cannot plant in. Use 0.03 mm filler gauge to check out the edge of the slide guide face. The depth should be smaller than 20 mm. The important fixed faying faces need to check out include the faying face between headstock and lathe bed, the faying face between turret base and sliding plate, the faying face between tail-bed and tail-bed base, the faying face between lathe bed and lathe bed(joint lathe bed), the faying face between steel guide rail and basic parts.

2) Whether each box and each operational part is oiled, the oil level in the box should not below the standard oil level line. Whether the cooling bin contains enough cooling liquid and whether hydraulic unit and automatic intermittent lubrication device holds enough oil that corresponds the oil pointer. Whether every switch and every component works properly in the electric control box. Whether every plug-in mounting integrated circuit plate is ready. Once centralization lubrication device is powered, every lubri-

Received 7 December 2011

cation part and lube rail should be filled with lube.

2.2 Various operatinal tests of the machine tool

1) Tool rest manual operatinal tests. Make the tool rest move along *X* and *Z* axes manually and one-way approach motion. Test the precision of manual operation, since this operation needs to be used in processing tool setting.

2) Tool rest inching tests. Make the tool rest move first-slowly-then-quickly in inching condition and process ratio transformation.

3) Principle axis transformation tests. Principle axis transformation tests should follow the transformation command in the introduction manual.

4) Axis overrun tests. Each axis needs to do the overrun tests in both positive and negative directions. There are two protections for machine tool overrun. One is software protection for storage limits, the other is hardware protection. Once overrun, controller will give an alarm and the overrun state will be shown on the screen. Furthermore, Hydraulic unit will be powered off. Otherwise, the protection is invalid, it will damage the mechanical components [6,7].

2.3 Machine tool multifunction tests

1) Machine tool functional tests. Test the flexibility and stationarity of machine tool motion and reliability of machine tool function. The method is that using the buttons, switches, manual manipulation to test the function of the machine tool.

2) Test the start, foreward, backward, stop(braking included) of the principle axis continuously. The tests should be no less than seven times and revolving speed is arbitrary.

3) In the high, meduim, low speed transformation tests of the principle axis, error between normal value and show value should be under 5%.

4) We should be starting, feeding, and stopping the CNC machines continuously, and we select the feeding alternatively. Let's do the work to feed into the trial continuously and fastly in the *X* and *Z* axis of the whole trip. Additionally, quick trip should be larger than 1/2 full stroke, direction and continuous operation shall not be less than seven times additionally.

5) Let's do the high, middle and low feeding transformation test in the *X* and *Z* axis on the trip.

6) Turret translocates in the positive and negative direction and reverses the direction of the translocation of the clamping test.

7) The performance of the sealing, lubricating and cooling of hydraulic, lubrication and cooling system is good and does not leak.

8) The clamping, releasing, flexibility and reliability of chuck are good.

9) The performance of reversible, stopping and transmission of spindle is good.

10) The feeding of low, medium, high of feeding mechanism and rapid transformation are normal.

11) The commands of machine features digital to do the test should be flexible and reliable.

12) Into the process to coordinate over, MDI, position display, back to the reference point should be reliable and the program number to display and retrieval, procedures to suspend, program to delete, straight cutting cycle, linear interpolation, thread cutting cycle, cutting cycle taper, arc cutting cycle, the tool position compensation and pitch compensation, clearance compensation and other functions should also be reliable and flexible [8].

2.4 Empty running test of machine

1) The running test of primary campaign organization of spindle. Without cutting state, we test the running time of the spindle of temperature diversification and unload power. There are three gear speeds of the machine and the variable speed and full speed running time is not less than 2 minutes. Other the maximum speed is not less than one hour, so that the spindle bearings achieve stable temperature. The temperature of the spindle bearings can not exceed 70 ℃.

2) The test of continuous load operation. We do the continuous movement and rotation test by the CNC program instructions of all the features (without cut-

ting state). The exercise time is not more than 15 minutes. We must stop when each cycle completes and simulate the work. The time of parking is less than a minute. The CNC machines must run 48 hours to 72 hours continuously (according to customer's different requirements) [9].

2.5 Try cutting of machine

The CNC machines manufacture components according to the appropriate processing standard and custom standard after the motion accuracy and the geometric accuracy are satisfied the requirements and detecte the performance of the CNC machines after the transformation. We must test the CNC machines in load station and do the necessary finishing to check the stability of its accuracy.

The mechanical and electrical joint harmonic of transformation of CNC machines is finished after the above five tests met the requirements.

3 The adjustment of system parameters of machine

3.1 The enactment and adjustment of the parameter of the axis

P01 ~ P25 system parameters which related to the coordinate axes, driving characteristics adjust the parameters of these systems to help the normal operation of the machine [10].

1) Parameters P01 ~ P04 limit in X, Z axis of the positive and negative values to the soft limitation, the maximum $-8\,000$ mm and $+8\,000$ mm.

2) P07, P08 the backlash parameter set backlash of X, Z axis. The maximum setting is 10.0 and the unit is pulse.

3) X-axis and Z-axis machine tools are used as a reference point of the limit switch gear switch and switch reference point benchmarks when P11, P12-bit parameters are established. G00 (parameters set by the DA98A) move to the reference point when the reference position return. The machine slows down when touched to the deceleration switch gear. The axes stop when the motion reaches close to the switch. Reference point accuracy is ± 1 pulse when the machine reach reference point.

3.2 Drive parameters to set and adjust

1) X, Z axis maximum programmable cutting feed rate, cutting feed command (G01, G02, G03) without acceleration and deceleration control, 24-parameter are set by X-axis servo motor of the machine's actual take-off frequency.

2) Z-axis parameters for the thread lift speed is Z-axis cutting down the amount of the adjustment speed.

3) G00 way from the landing speed control is set by the DA98A parameters on the 1st to 29. As shown in Figure 1.

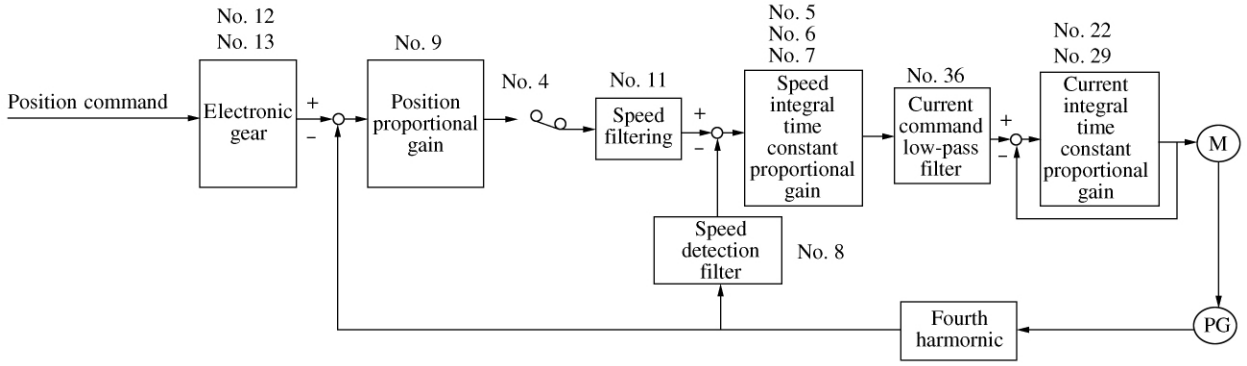

Figure 1 DA98A servo drive parameters to adjust

4 The test of commissioning and performance of machine

According to machine instructions, we add the lubricants to parts of the machine after completion of power to machine connection. Then you can debug the precision to the parts of the machine. Please follow the steps.

4.1 The debugging of the geometric precision of machine

Placed in the machine based on the coarse adjustment, we do the fine adjustment to further on the machine. Mainly do the fine adjustment to the machine bed level and then move the parts of machine, next observe the level of the parts in the whole itinerary changes, and adjust accordingly to ensure the accuracy of the machine geometry within the allowable range.

4.2 The test of the basic performance of machine [1]

1) Machine/system parameter adjustment

Adjust the performance and characteristics depending on the machine.

(1) Adjust the parameters including rapid traverse speed and feeding speed on the axis.

(2) Adjust the addition and subtraction constant of the whole feeding axis.

(3) Adjust the control parameters to the spindle.

(4) Adjust the parameters of tool changers.

(5) Adjust the parameters of other auxiliary devices.

2) Forward reverse start and stop function of spindle

(1) We select the low, medium and high gear in the handle mode and start or stop the spindle for five times consecutively forward reverse to test its flexibility and reliability of operation and to check whether the load table shows the power requirements.

(2) MDI mode enables the spindle by the low speed gradually increased to the maximum allowed speed and check the speed is normal. Usually shown the error does not exceed the speed 10% of the machine and check the spindle speed while observing the spindle noise, vibration and temperature is normal. The total noise can not exceed 80 decibels.

(3) We operate the spindle stopping continuous for more than five times to check its flexibility and reliability of spindle stopping.

3) The manual inspection of axis of machine

(1) Each axis of the low, medium and high feed and rapid movement, the proportion of detected movement are correct when we operate by manual and the movement is smooth and without noise.

(2) We check the fast-moving and feeding rate which are normal by MDI mode through the G00 and G01F function.

4) The inspection of electric turret

Electric turret in manual and automatic tool changers process is flexible and strong.

(1) We check the manual operation, manual tool change electric rotary tool holder in the process whether is flexible or strong.

(2) We check the automatic operation of electric rotary knife automatic tool change process whether is flexible or strong.

5) The inspection of machine limitation and the mechanical zero

(1) The reliability inspection of hard and soft limitation of the machine. Soft limitation determined by the system parameters; hard limitation determined by the limitation switch. Generally we operate in the limitation of the axis position. Therefore, the reliability of travel switch determines the reliability of the hard limitation.

(2) We check back to the origin of the axis of the accuracy and reliability by back to the machine zero with homing.

6) The inspection of other auxiliary devices of machine

Cooling systems and the circuit of lighting systems are working properly.

4.3 The test of the stability of machine

The stability of CNC is an important index in NC systems. If CNC machine works time does not remain stable, the precision changes continuously measure the workpiece and modify the size in the process will reduce efficiency and fail to reflect the advantages of CNC machine tools. In order to fully check the reliability of the machine functions, NC machines must automatically load or no-load test for a longer period of time after stallation and commissioning of CNC machine tools. Automatic run-time executes according to the national standard GB9061-88 provisions. The specific content requirements the NC machines run 16 hours continuously (including 16 hours). During the automatic operation, any failure should not occur (not including human error), and the troubleshooting time can not exceed 1 hour, or test again.

4.4 The test of accuracy of machine [12~14]

1) The test of geometric accuracy of machine

The geometric precision of the CNC machine is a key comprehensive index to reflect the key mechanical components and geometry errors after assembly. The inspection method and detection tools are similar for the basic performance of CNC machine and general machine tools. That each should be independently verified. Detection tool used in the test items than the accuracy of high precision level. Test items are:

(1) X, Z axis perpendicular degrees.

(2) Spindle axis parallel to the surface of the bed rail degrees.

(3) Crate in the Z-axis slide movement straightness.

(4) Axial and radial of spindle.

2) Machine tool positioning accuracy test

The positioning accuracy of CNC machine tools is the axis machine that can achieve position accuracy. It can determine eligibility according to positioning accuracy of the measured value of the machine can. Its contents are:

(1) The axis precision linear motion.

(2) The repeat positioning accuracy linear motion.

(3) The linear motion axis precision machine back to the zero return.

(4) The rotary precision of turret.

3) The inspection of cutting precision of machine

The test machine cutting precision and its essence is the geometric accuracy of machine tools and precision in cutting the overall test, also known as dynamic accuracy test. Its can be divided into individual cutting accuracy test and overall test specimen.

(1) Accuracy of individual tests include straight line cutting accuracy, precision cutting plane, arc roundness, cylindricity, tailstock sleeve axis of the slide plate moves parallel and thread detection.

(2) Comprehensive test specimen cutting accuracy test is based on the content of the individual, including most of the individual design of a workpiece cutting content-parallel test to determine the accuracy of cutting machine tools.

5 Conclusions

The mechanical and electrical joint harmonic and precision detection of CNC machine are extremely elaborate and complex. The tast is complex and heavy and there is a basic work after the transformation of CNC machine. The production efficiency has been greatly improved after detection of electrical joint reconciles the accuracy of CNC machine tools to make a qualified. At the same time, similar equipment for technological transformation provides a great reference value [15].

References

[1] Wang G Q, *Research and development of automatic programming system for CNC flame cutting*. Tianjin: Tianjin University, 1 ~ 63, 2009 (In Chinese)

[2] Guan X Y, *Research on analysis method of dynamic characteristics for spindle system of NC machine tool*. Modular Machine Tool and Automatic Manufacturing Technique, (4): 1 ~6, 2010 (In Chinese)

[3] Zhen S Z, *C650 type lathe to improve the electrical control circuit design*. Machine Tool Electric Apparatus, (3): 57, 2004 (In Chinese)

[4] Song J W, Yang L, *Discussion of fault diagnosis and exclusion of NC machine tool return reference point*. Modular Machine Tool and Automatic Manufacturing Technique, (10): 60 ~ 63, 2008 (In Chinese)

[5] Zhao X J, *Development of the CNC system for the Mc FP 4TC*. Tianjin: Tianjin University, 1 ~ 58, 2010 (In Chinese)

[6] Deng C Q, *The reformation and electric control design for X712 type numerical control mill machine*. Modular Machine Tool and Automatic Manufacturing Technique, (10): 90 ~ 91, 2006

[7] Zhang H, Guo R F, Geng C, *et al*, *Study on software architecture of ONC system based on multi-agent system*. Modular Machine Tool and Automatic Manufacturing Technique, (6): 52 ~ 56, 2011

[8] Shi L P, *The CNC manufacturing of planar double-enveloping worm pair based on lathe reshaping*. Modular Machine Tool and Automatic Manufacturing Technique, (7): 78 ~ 80, 2010 (In Chinese)

[9] Li J Z, *The compensation and analysis of pitch error for NC machining tools*. Modular Machine Tool and Automatic Manufacturing Technique, (2): 98 ~ 101, 2010 (In Chinese)

[10] Wang Z, Zhao A G, Zhao D Y, *et al*, *Comprehensive analysis of the positioning precision of CNC*. Machinery Design and Manufacture, (9): 132 ~ 133, 2010 (In Chinese)

[11] Liu S H, Ye W H, Tang D B, *et al*, *Fuzzy comprehensive evaluation for the performance of a numerical control machine tool based on the analytic hierarchy process*. Journal of Shandong University (Engineering Science), 40 (1): 68 ~ 72, 2010 (In Chinese)

[12] Gao Q W, *Measures of improving the accuracy of CNC machine tools*. Journal of Anyang Institute of Technology, 9 (2): 13 ~ 14, 2010 (In Chinese)

[13] Zhu S X, *Application research of CNC precision detection and improvement*. Manufacturing Technology and Machine Tool, (7): 133 ~ 136, 2010 (In Chinese)

[14] Li J Z, *An effective approach for NC machining tools accuracy test*. Modular Machine Tool and Automatic Manufacturing Technique, (5): 60 ~ 62, 2010 (In Chinese)

[15] Zhang Y Q, *Real-time video monitoring system for CNC machining process of DNC based on ARM9*. Modular Machine Tool and Automatic Manufacturing Technique, (7): 40 ~ 42, 2010 (In Chinese)

Brief Biographies

XU Liang-xiong is a senior lecturer in Wuhan Technical College of Communications. His research interests include in the sensor and detection technology, motor control and programmable logic controller. xlxxj12@163.com

ZHOU Xiang is an assistant lecturer in Wuhan Technical College of Communications. Her research interests include CNC principles and machine tool control.