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Positioning Error Analysis and Compensation of Differential Precision Workbench

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Abstract: *Positioning error is a widely problem exists in mechanism, the important factors affecting machining precision. In order to reduce the error caused by positioning problem processing, based on the differential workbench as the research object, using the method of theoretical analysis and experimental verification, the analysis of positioning error mechanism and source of complete differential precision workbench error compensation, improve the accuracy of the device, provides a method for the application of modern machine tools. table.*

Key words: *Position error; Differential workbench; Compensation method*

I. Introduction

Precision measurement is one of the basis of the key about the common modern high science technology and it is one of the sophisticated industrial production. Scientific research occupies an extremely important position, has a broad application prospect. Precision and ultra-precision processing technology is one of the most important development direction of modern machinery manufacturing, is the modern aerospace, microelectronics, optical, robot, biology, medicine, and the basis for the development of advanced technology such as genetic engineering[1.].How to improve the positioning accuracy of machine tool is convenient and economic research topic in all aspects, now correct measure machine tool positioning and use appropriate error compensation method of positioning error compensation is the key to improve the machine tool positioning accuracy[2.].

II. The introduce of the differential precision worktable

This topic device using the upper and lower two levels of independent workbench superposition, choose Nanjing process equipment co., LTD. Nc-precision table as differential precision worktable system of upper and lower workbench, transformation model for SZHT4020T-P3[3.].Differential precision workbench trip 200 mm and 400 mm respectively, ball screw lead to 5 mm ,the whole differential workbench device is through a steel plate fixed on the upper base table, differential precision worktable by separate smooth guiding rail, precision of transmission system and the workbench, and absolute position measuring device is to use feedback linear grating grating measurement, receive differential workbench actual location and real-time feedback to the upper control system, and issue instructions for comparative analysis, and other functions.

Motion control card, which is the core of the system control, can control servo motor movement, can also

receive feedback signal, comparing the position error, feedback to the PC[4.].Ac servo motor is connected motion control card and mechanical transmission mechanism of signal transmission bridge,as a motor actuators,corresponding with their respective servo drive device,according to the instructions from the PC to complete the rotary motion, mechanical transmission mechanism to servo motor rotation movement into linear motion table, using the built-in rotary encoder to control feedback pulse data.

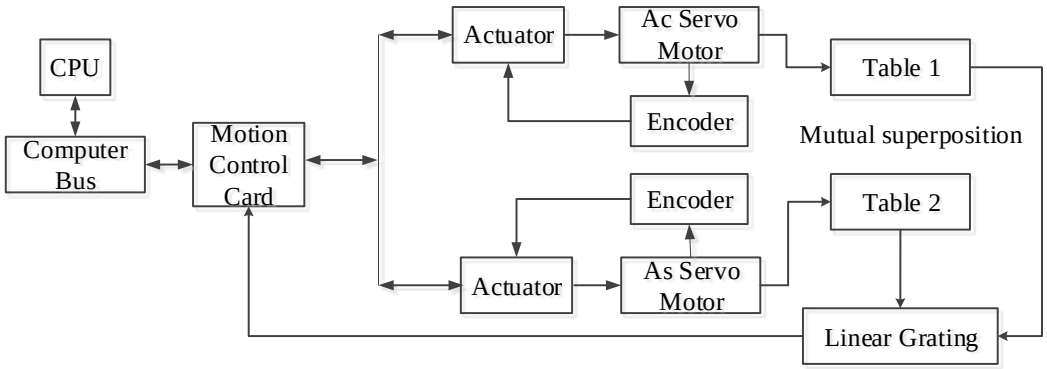

Fig.1 Overall design of system structure

III. The principle of differential motion analysis

Differential precision workbench using two workbench,similar to the macro and micro bench work.By applying the differential structure of two ball screw system,to reduce the positioning error of the differential system,realize the higher positioning accuracy,so as to realize the localization accuracy of mechanical system of equipment agency requirements[5.].Differential ball screw feed system principle of work is as follows:

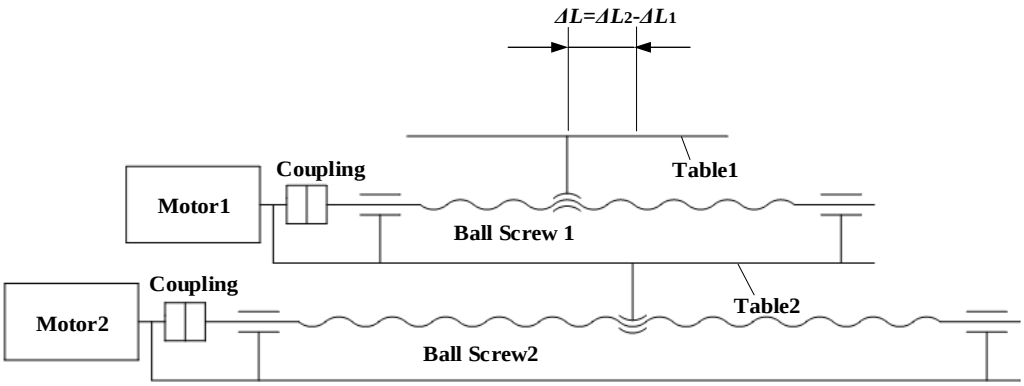

Fig.2 The principle diagram of the differential

The differential principle is: the movement of the table 1 and table 2 difference is relative to the ground displacement.Ac servo motor to receive after sending the instruction to the motion control system,in accordance with the instructions of the pulse,rotary motion to drive the ball screw,ball screw rotation of the motor can be converted to the linear motion of the workbench [4].In the process of differential,ball screw 1 and 2 direction is the same,the turning of the servo motor 1 and 2 are the same.The $\Delta L = \Delta L_2 - \Delta L_1$,Which is the output of the differential precision worktable.

The movement volume can be calculated by the following formula:

$$\Delta L = \frac{\theta}{2\pi} \times \varepsilon = \frac{k \cdot n}{2\pi} \times \varepsilon \qquad (1)$$

Among them: θ is the angular displacement of the servo motor. ε is the guide of the ball screw. n is represent for the number of the pulse instruction. k is the proportion co-efficient of the servo system.They have related to the servo system hardware structure.

According to the principle of the ball screw differential diagram: $\varepsilon_1, \varepsilon_2$ are the upper and lower two pairs of the ball screw lead. n_1, n_2 are the numbers of the feeding pulse of control system. k_1, k_2 are the ratio of the servo control system. The respectively actual amount of the each instruction displacement of table and table 2:

$$\Delta L_1 = \frac{k_1 \cdot n_1}{2\pi} \times \varepsilon_1 \tag{2}$$

$$\Delta L_2 = \frac{k_2 \cdot n_2}{2\pi} \times \varepsilon_2 \tag{3}$$

The micro-displacement of differential workbench is:

$$\Delta L = \Delta L_2 - \Delta L_1 = \frac{k_2 \cdot n_2}{2\pi} \times \varepsilon_2 - \frac{k_1 \cdot n_1}{2\pi} \times \varepsilon_1 \tag{4}$$

IV. The Positioning error compensation method

Differential positioning error compensation method, the differential sampling precision worktable transmission end position, to get the actual samples values and compare the ideal value,the design of reverse error correction of differential system compensation, eliminate differential positioning error,error compensation principle as shown in the figure below:

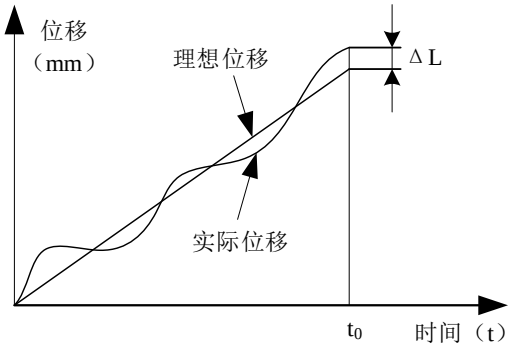

Fig.3 Position error compensation workbench principle

The error of the differential workbench is:

$$\Delta L = x - \frac{\theta}{2\pi} P_h \tag{5}$$

Among them: ΔL is the position error of system; x is the actual displacement measured by the man. θ is the transmission angle of ball screw. P_h is the lead of ball screw.

As mentioned earlier,differential precision workbench is divided into upper and lower two levels of workbench with journey of 200 mm and 400 mm respectively.Motion control card initialization parameter to 5 mm sampling spacing for the unit,each pulse value of 0.5 μm .Respectively on two levels bench sampling the same point,comparing multiple sampling.We can get the position precision of table1 and table 2,under the differential form.

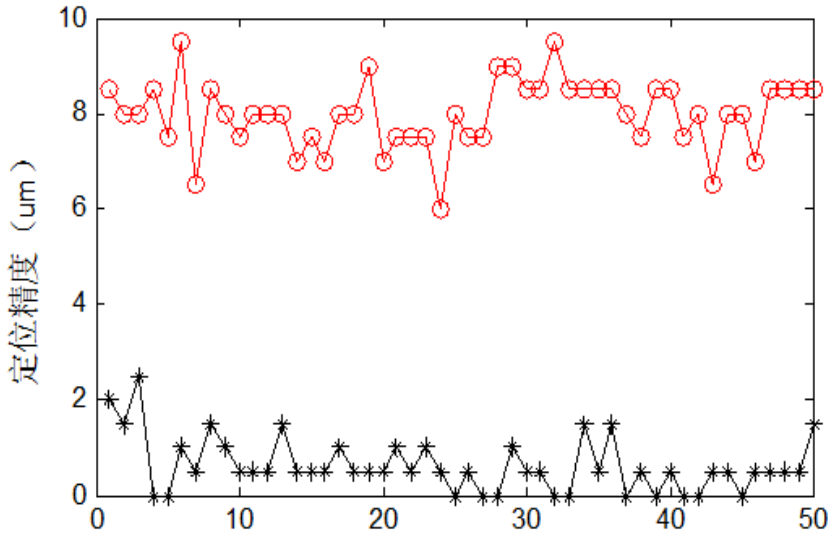

Fig.4 The sampling point positioning accuracy of differential workbench

Differential precision worktable controlled by motion control card, completed the differential movement, table1 and table2, respectively under 150 mm 300 mm trip biggest positioning error respectively 15 μm, 8 μm (40 pulses and 24 pulses).Because there is a cumulative pitch error, with experimental measurement analysis for many times. error of guide way and bearing, etc., as the error of the differential workbench have the tendency of increase with the increase gradually. Through the analysis of the third chapter, we know, precision grating and the parallelism workbench and lead to differential table 1 error change is bigger, the abbe error is discussed, along with the increase of the displacement error is gradually increased.

V. Conclusion

Through the above theoretical research and experimental analysis differential positioning precision worktable compensation is realized. To explore the differential movement form error compensation method, improve the system precision and sensitivity, to engineering application provides an effective method to improve the precision of table. The method can be applied to the existing conditions of different structure design and the appropriate compensation method to satisfy the whole system of high precision and large travel requirements, and for the design of micro-feed mechanism to provide a new train of thought.

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