

Cross Coupled Contour Error Compensation Technology

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Abstract. In order to improve the machining precision of multi axis CNC machine tool, contour error reduced by mechanical transmission and electric control factors, servo multi axis CNC machine adopted cross coupling parameter selection problem, stability is not strong and so on, this paper proposed a control method of cross coupled contour error compensation, control method of cross coupled contour error compensation based on a cross coupled contour error compensation the model, X axis, Y axis and Z axis of the simulation platform, Simulation results show that the simulation and experimental results show that control contour error compensation algorithm based on cross coupling error compensation method calculation process is simple, the contour error, the accuracy of interpolation control improved, meet the real-time, high-speed, efficient CNC system interpolation requirements, as well as NC interpolation in high reference significance.

1. Introduction

Motion control means in complex conditions, the control scheme and the predetermined instructions into the desired mechanical planning. The control of motion control system of the controlled mechanical movement to achieve precise position control, speed control, acceleration control, torque or force, as well as the mechanical quantity is controlled in the integrated control of [1-20]. CNC multi axis the motion control system, position closed-loop CNC system according to the interpolation results a position control instruction of each axis independently control the driving mechanical transmission mechanism corresponding to the final contour feed movement accurately. But in the actual process of NC system, interpolation according to the input data to calculate the value of each coordinate axis position command track, precision motion control system is often affected by the two aspects of mechanical and electrical control, contour error will inevitably exist [21-26]. The contour error is always the 3 error is the result of comprehensive effect. This paper from the perspective of geometry study and NC contour error analysis, analysis line contour, different curvature and arc contour curve contour error, and to explore the relationship between the tracking error and contour error.

Based on the contour error analysis of multi axis CNC machining machine tool, method of cross coupled contour error compensation is given a multi axis CNC system, through the establishment of CNC linkage machine contour error model. Finally, simulation results show that the control of contour error compensation algorithm using cross coupling error compensation algorithm, can greatly reduce



the contour error, improve the accuracy of interpolation control, also reduce the vibration of single axis CNC interpolation system, also has the reference significance in the process of NC interpolation in the other.

2. CNC multi axis machine tool profile control system

CNC multi axis machine tool usually contains two (including more than two) of the feed shaft, the movement of the feed shaft to produce the actual contour of the trajectory. The feed shaft includes servo system, mechanical drive, drive system and motion control system. Fig.1 is a single axis servo drive system with coupled contour control of the machine tool.

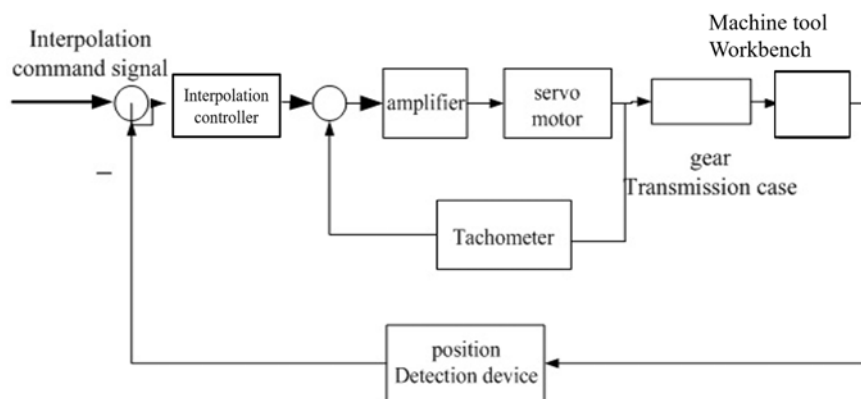


Fig 1. Single axis servo drive coupled contour control machine tool

Machine multi axis control non coupling profile CNC, is based on the single axis servo drive coupling machine contour control based gain link of each feed axis and feedback system and the error signal to control independently, to achieve control of contour accuracy.

Fig. 2 is a typical single axis servo drive coupled contour control machine tool block, formed by the feedback system.

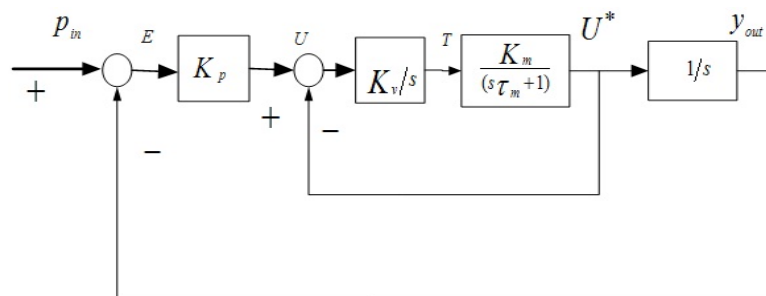


Fig 2. Control block diagram of the single axis servo drive

The position loop gain K_p is the gain of the speed loop; the gain of the servo motor K_v is the initial position of the input signal K_m quantity; the position P_{in} of feedback signal y_{out} quantity; the torque coefficient of the motor S_n is a constant.

$$\phi(s) = \frac{V^*(s)}{U(s)} = \frac{K_v K_m / S_n}{s^2 + (1/S_m)s + (K_v K_n / S_n)}$$

Supposed,

$$\omega_m^2 = K_v K_m / S_n, \xi = 1/2 X_m S_n \text{ Then:}$$

ξ Is damping coefficient, ω_m is natural frequency.

Analysis of the characteristics of three coordinate contour system:

$$\phi(s) = \frac{\omega_m^2}{s^2 + 2\xi\omega_m s + \omega_m^2}$$

$$K1 = K_v = 0.1 \quad K_m = 0.25 \quad S_n = 0.1 \quad \omega_m = \sqrt{K_v K_m / S_n} = 0.5$$

$$\text{When } K2 = K_v = 0.25, K_m = 0.1, S_n = 0.1, \omega_m = \sqrt{K_v K_m / S_n} = 0.5.$$

Make two contour curves $K1 = K_v = 0.1$ and $K2 = K_v = 0.25$, as shown in Fig. 3.

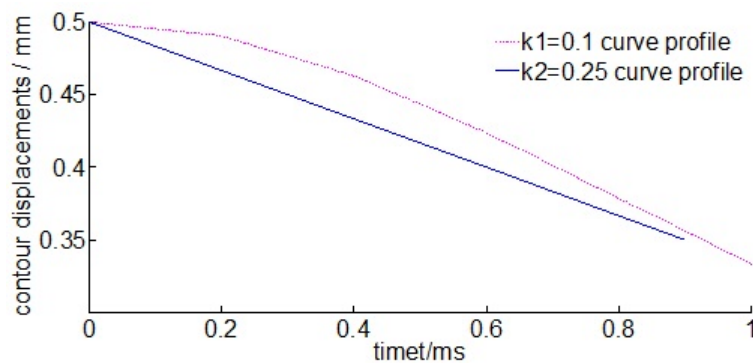


Fig 3. Comparison of $k1=0.1$ and $k2=0.25$ curve contour

3. Experiment simulation and analysis

The tracking error curve of Fig. 4 ~ 6 x , y , z axis, tracking errors are within the range of $10 \mu\text{m}$, that single axis control strategy used in this study has good tracking accuracy. Figure 9 is the three axis platform before and after the improvement of spatial linear trajectory contour error curve; Figure 10 is 10 s with 100 N disturbance after the linear trajectory curve contour error of three axis platform.

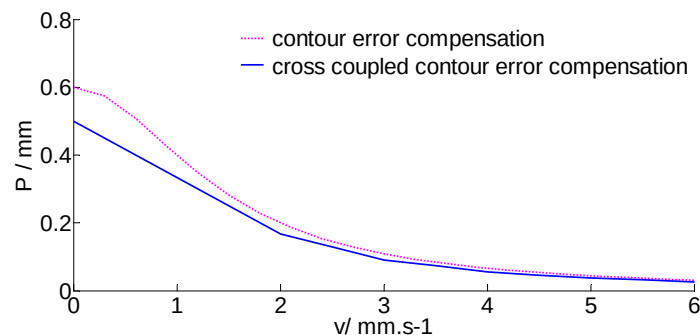


Fig 4. Contour error map

In order to ensure the chord error and normal acceleration is controlled within the allowable range of circumstances, only to feed acceleration constraints that feed speed with maximum feed speed and interpolation, the proposed algorithm can perform the interpolation with the maximum feed rate, achieve optimal interpolation accuracy and speed, thereby improving the interpolation precision and efficiency.

4. Summary

This paper discusses NURBS curve and its character and calculating methods of correlation parameter. A new NURBS interpolation algorithm is developed. Some calculating missions which can be completed in the pretreatment phase. The determination of constrained feed step length based on chord error controlling and feed acceleration controlling can be adjusted automatically. It can control interpolation error and feed rate in the allowable range at the same time, achieve maximum feed speed under the condition that the interpolation accuracy and impact on machine tool are all in controlling range, acquire optimization between interpolation accuracy and feed rate. The simulation results show that the algorithm is correct; it is consistent with a NURBS curve interpolation requirements.

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