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The Research and Application of Multiple Spindle Dynamic Follow to Improve CNC Thread Milling Products Precision

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Abstract

In this paper, a new control method is proposed. The SIEMENS 828D control system reads a feed axis machining of any one time processing, calculates the axis displacement data and draws the other two related linkage axis machining data. it through the PLC program of the control system written way R parameter is assigned to the other two related linkage of shaft processing program. Dynamic following effect of forming milling thread machining, reduce the product processing error, improve the product processing precision, technical indicators satisfy the similar foreign products.

Keywords*: 828D, R Parameter, Dynamic Follow Effect.*

1. Introduction

At present our country the overall level of special numerical control machining equipment and there are certain gaps when compared with the international advanced level [1-2]. Mainly displays in the numerical control equipment in the process of its use performance reliability and accuracy, *etc*[3-4]. As a result, the numerical control system research and development personnel must constantly optimize the structure of mechanical equipment and numerical control system control accuracy, find out the main factors affecting the whole machine machining precision and reliability of action, take concrete and effective measures, have developed a new control method, gradually narrowing the gap with the international advanced equipment [5-7].

The set of numerical control equipment for sichuan foreign domestic graphite electrode special processing equipment, is a special numerical control equipment for graphite electrode automatic processing, equipment of processing range: electrode length 1800mm - 2200mm, electrode diameter Φ350mm- Φ700mm. Its complete sets of equipment in the thread milling plane is responsible for the internal thread processing, at the ends of the electrodes so that travel through the corresponding electrode joint can connect each electrode, so products processing on both ends of coaxial degree, difference at four o 'clock, the effective diameter, accuracy requirement is very high[8-10].

The equipment control system consists of two sets of Siemens 828D numerical control system, the flat end of the equipment and the thread milling machining is controlled by CNC system of three feed servo motor, the rest is controlled by PLC system with auxiliary motion of the hydraulic cylinder for each station is carried out. Wire electrode to the milling station bracket after it in order to reach the working height, on both sides of the platform to go forward in position fixture clamping graphite electrode after two sets of numerical control system process started at the same time, each process is completed, loosen the clamps and processing platform back in place, bracket falling in place after the end of the station movement.

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As now, Equipment operation in the process, found that the effective diameter will be irregular change of large and small, the machining accuracy of unstable seriously influence the normal production of the products. With the company's technical personnel at home and abroad through the analysis, a cause of the error for the following two: (1) the processing platform and to control the hydraulic cylinder, the response speed of the platform in place to stop quickly enough, will produce a certain error, if there is a change of the hydraulic oil temperature, positioning error (compared to the first position of cutter location) will be bigger, then the process of each axis processing capacity is to positioning as a benchmark, the absolute value of a given as a result, the processing capacity of the tiny deviation caused the effective diameter of irregular change; (2) in the process of fixture clamping electrode in shaft up also have string (1-2 mm or so), flat end will not appear on both sides of the manufactured equipment, such as milling effective diameter wire processed products will appear this problem.

In this paper through the PLC program of the CNC system written way R parameter is assigned to the other two related linkage of shaft processing program, the thread milling machining dynamic following effect, reduce the product processing error, improve the product processing precision[11-12].

2. The Effective Diameter Change Reason of Mathematical Analysis

Electrode and the machining accuracy of joint directly affect the quality of electrode and joint connection, the connection quality of greater effects on the normal operation and electrode consumption of electric furnace. Electrode and the joint processing precision demand is higher, when connecting the two ends must be closely integrated, electrodes at the ends of the thread, taper thread taper machining accuracy, tooth angle, thread pitch and effective diameter, alignment, and difference at four o'clock on connection status is very important. Continuous processing equipment to run automatically after ten pillars electrode, poor product thread taper, four testing data are meet the requirements of foreign technology, only the electrodes at the ends of the thread around the effective diameter into irregular change, as shown as Figure 1, the partial products beyond the foreign technical standards (46-102 microns).

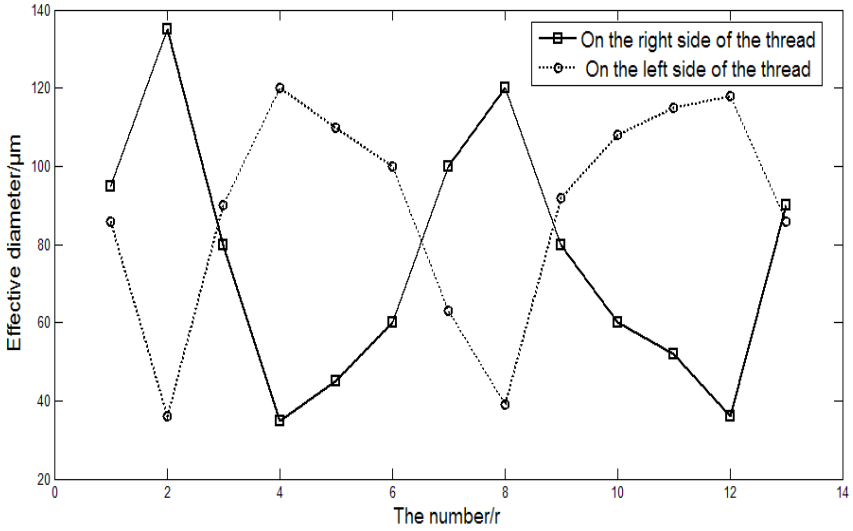

Figure 1. At the Ends of Electrode the Thread Effective Diameter Change Rule

Through internal thread section we found at the taper of the electrode taper thread for 9 ° 27 '44 ", there is no change in processing, and if there is a change thread flat end scraping the end/effective diameter will have corresponding change, as shown as Figure

2, then the corresponding thread if it flat end processing capacity effective diameter become smaller, whereas flat end runs small then the corresponding screw effective diameter larger, and their Proportional relationship：

ΔL: Δ Effective diameter = 1:6 (1)

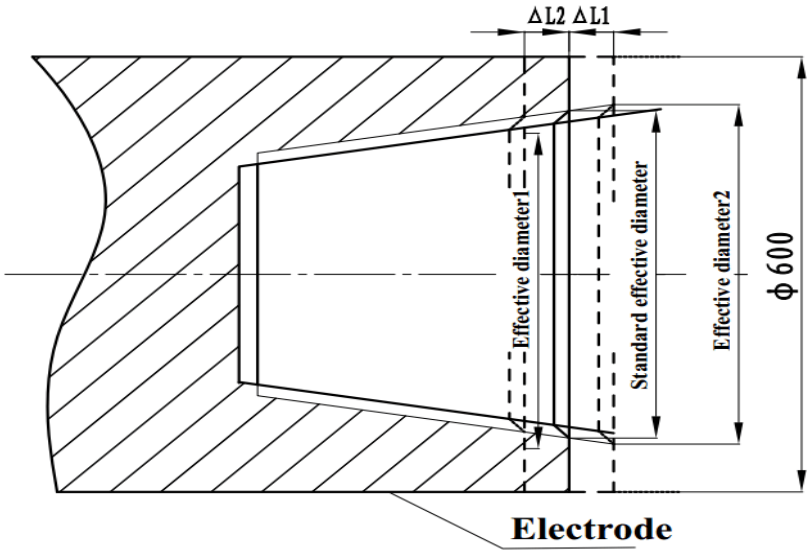

Figure 2. Electrodes Changes Flat End Processing Quantity and Effective Diameter Thread Profile

3. Equipment Modification Solution for Discussion

There are two kinds of equipment solution, the first solution is change the processing platform power systems by hydraulic cylinder to servo motor, such as servo control system response is fast, accurate, can improve the machining accuracy, make the products meet the export requirements, basic but equipment mechanical structure and hydraulic system reform time-consuming, laborious cost is very high also, company research decided to temporarily don't consider this plan; The second solution is after processing platform in place fixture clamping work piece, plus a flat end start processing location proximity switch, the spindle rotation started, flat end scraper machining axle (Y axle) servo motor forward, proximity switch above scraper act, the scraper slow small forward to flat end face, after the flat end scraper back to zero, in situ control system instant read Y coordinate values both axial displacement when scraper location proximity switch is the action, the coordinate value and the first standard processing the axis displacement data comparing, comparing values through the system after the systems internal PLC program calculation, assigned to the processing procedures involved in X axle and Z axle of thread milling special comb knife anchor point coordinates, ensure the thread milling thin knife biaxial linkage machining variation with flat end quantity changes and adjust, implementation and for the first time after each work piece machining of special knife close to the goal of qualified work piece, conform to the export standards. Due to the second retrofit scheme saves a lot of cost and time, and takes into consideration all the causes of error precision and do the processing of real-time dynamic follow adjust, so the decided to adopt the second set of solutions.

4. The Design of Multiple Spindle Dynamic Follow CNC System

4.1 Equipment Hardware Structure Transformation and Debugging of the Flat end Processing

First we install a proximity switch above processing platform's the flat end of the scraper , triggered by the movements of the proximity switch CNC system PLC program reads the Y axle coordinates, also as a starting of flat end action, proximity switch action after flat end scraper in accordance with the procedure of processing slow forward certain processing volume suspended for a period of time, the rotation of the work piece in a week, after the completion of the flat end processing, flat end scraper retreated in situ zero.

After the completion of the CNC system's hardware, First of all, we set all levels of reduction ratio. For the feed shaft, the pitch of the screw and the reduction ratio are the only conditions for determining the coordinates. When the servo motor is directly connected with the lead screw, the reduction ratio of the servo motor and the lead screw is 1:1. CNC system slowdown than the default value is 1:1. When the screw and servo motor reducer connection, need to accurately set the reduction ratio of the numerator and denominator. When the reducer is composed of multi-stage gear, the final reduction ratio equal to all levels of deceleration than molecular product at all levels than the deceleration ratio denominator product, namely:

$$\frac{MD31050}{MD31060} = \frac{n1}{m1} \times \frac{n2}{m2} \times \ldots \times \frac{ni}{mi} \quad (2)$$

And then we debug the program which the flat end of the scraper arrive at the fixed point to stop. Since the Y axle is starting from the situ zero to stop when the proximity switch act, the Y axle of the processing program can't give a displacement, you need to edit a subroutine, when the subroutine of processing program is execution, then the Y axle servo motor in accordance with the specified direction and speed forward. The proximity switch access to the CNC system I/O input terminal, the system built-in PLC program editor as shown below:

```
NETWORK61// Flat end began to processing position (Y) take effect
LD SM0.0
A I4.1
= DB2800.DBX1001.1
```

The third the program triggers the fast I/O signal that can be received by the subroutine in NC data, so adjust machine tool data $MN_FASTIO_DIG_NUM_INPUTS MD10350 = 2 for the fast input I/O signal points to take effect, Then establish the name PD as the subroutine of the Y axle in place to stop. The subroutine as shown below:

```
ID=1 EVERY $A_IN[10]==0 DO POS[Y]=400 FA[Y]=1000
WHEN $A_IN[10]==1 DO DELDTG(Y)
WAITP(Y)
CANCEL(1)
M17
```

Finally, the subroutine added into the machine program. When spindle started and the X axle arrived processing position, the PD subroutine executive, Y axis forward to stop to the switch action position, in this position as flat end processing start position, according to the machining process to process, after the Y axle and the X axle and to return to the origin, flat end processing is over. The machine program as shown below:

```
DIAMOF                    //Radius programming
G90                       //Absolute programming
```



```
G94                    //Spindle speed mm/rev
M04 S4.0               //Spindle starting speed 4 rev/min
G1 X-109 F1800         //X axis positioning
PD                     //Y axis positioning
G91                    //Relative programming
G1 Y1 F150             //Y axis 1mm
G4 F30                 //Pause for 30 seconds
G1 Y0.3 F150           //Y axis 0.3mm
G4 F50                 //Pause for 50 seconds
G90                    //Absolute programming
G0 Y0                  //Y axis return zero
M05                    //Spindle stop
G4 F2                  //Pause for 2 seconds
M53                    //Waiting for the other side to finish the processing
M02                    //Program end
```

4.2 Establishment of Dynamic Relationship between Milling Thread and Flat End

In order to achieve data validity, according to the machining axle movement direction, we can set up a milling thread coordinate system. The angle between the axis we can draw milling thread processing X axle and Z axle is 99 027 '44 ". In order to find the thread milling machining with flat end processing dynamic relationship, the thread milling follow flat end processing changes and changes, the formation of automatic compensation effect, we need to linkage X axle and Z axle synthesis for Z ' axle such as shown in Figure 3, the motion direction and the Y axle is the same, so that every time the flat end processing and the first flat end processing out of the comparison deviation corresponds to Z' axle and draw conclusions about the amount of axial variation in processing the Z 'axis, by calculating the assignment to the processing program in X axle and Z axle machining change quantity.

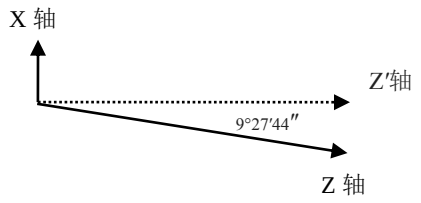

Figure 3.The Milling Thread Processing Coordinate System

According to the angle, we can get the change of the axles as shown below:

$$\text{X axle}: Z' \text{ axle} = \text{tg}\,(9°27'44'') \approx 0.167 = 1:6 \quad (3)$$

$$\text{X axle}: \text{Z axle} = \sin\,(9°27'44'') \approx 0.165 = 1:6.082 \quad (4)$$

$$\text{X axle}: Z' \text{ axle}: \text{Z axle} = 1:\ 6:\ 6.082 \quad (5)$$

The Y axle displacement and Z 'shaft displacement of volume is 1:1 relationship, so through changes in the flat end processing of the data, we can obtain and thread milling related X axis and Z axle processing volume changes, in order to achieve thread milling biaxial linkage processing dynamic follow the flat end processing data changes and moving state adjustment, to ensure that the products meet the requirements of foreign customers quality.

4.3 Realization of the Dynamic Following of the Dual axles Milling Machine

4.3.1 The Change Value of the Displacement of the Y Axle of the System

As a new method of numerical control machining, first of all we start the device manually adjust the X axle to reach the processing position, the Y axle is moved to the proximity switch is lit, and the current Y axis coordinate value is set to the R20 parameters, as the standard processing basic data. Each time the device starts the system PLC first reads the R20 parameter value to the variable DB1200.DBD3004, and when the flat end motion starts the Y axle scraper moves to the starting point of the switch, the system reads the Y axle coordinate value, and compares the R20 parameter values to the MD104.

4.3.2 The System Calculates the Change Value of the Milling Thread and is Assigned to the Z Axle and X Axle Displacement of Machining Program

The MD104 of the change value of the displacement of the Y axle is written to the R21 parameters by the system PLC program, the system PLC program block diagram as shown in Figure 4, and then through the milling thread processing program by the axis of the proportion of the X axis Z axis change, adding to milling thread positioning and processing data.

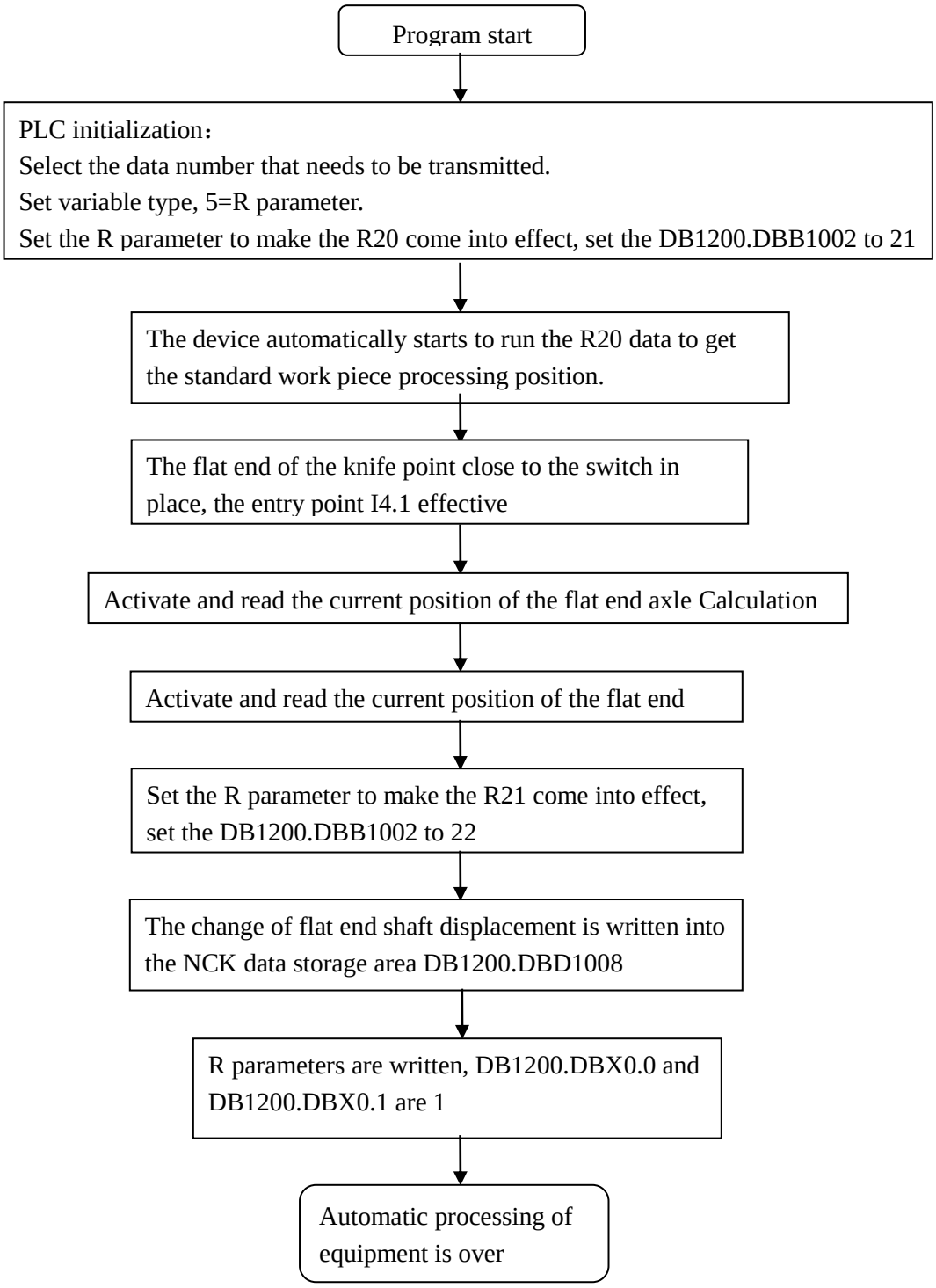

Figure 4.The System PLC Program Block Diagram

After the operation of the equipment, the changes in the processing of the flat end are recorded in real-time, and the accuracy of machining is ensured, and the effect of dynamic tracking is achieved. Milling thread processing procedures are as follows:

```
DIAMOF                                  //Radius programming
G90                                     //Absolute programming
G94                                     //Spindle speed mm/rev
M04 S2.0                                //Spindle starting speed 2 rev/min
G1 X-45.4 Z0 F1800          //The starting point of the Z X axle of the milling machine
G91                                     //Relative programming
R22=R21/6                               //R22 assignment
R23=R22*6.082                           //R23 assignment
G1 Z=-113+R23 X=-81+R22 F1800           //The starting point of the milling thread
M51                                     //Milling thread cutter starting
G33 Z1 X-8.75 I230                      //Milling thread machining
Z12 K6.47                               //Milling thread machining
G1 X15 F1800                            //The X axle cutter back
G90                                     //Absolute programming
G0 X0Z0                                 //X axle and Z axle return zero
M05                                     //Spindle stop
M02                                     //Program end
```

The internal backup of the data must be performed at the end of the debug! Once the CNC machine tools in the user field there is a hardware and software failure, the use of CNC machine tool factory when the backup data, can quickly restore the factory state of CNC machine tools. Data backup of CNC system can be divided into internal data backup and external data backup. Different types of numerical control system data of the internal backup method may be different, but the data of the external backup method is basically the same.

All of today's numerical control system uses microprocessor as the core part of the operation. The key device in the microprocessor is memory. The memory is used to hold the system software code, provide the register and save the operation data. Memory type read-only memory, electrically erasable read-only memory, dynamic memory and static memory. The system uses a read-only memory storage system software, dynamic memory for the system running memory, storage of user data with static memory, such as PLC applications, machine tools, cutting tools, fixed cycle, processing procedures, *etc*. The data of the static memory is maintained by the battery. When the battery power is insufficient, the numerical control system can produce the warning prompt this time numerical control system can not be cut off, need to change the battery immediately. All data will be lost if the information is lost in the numerical control system. Need to reload the backup data provided by the machine tool factory. If there is no backup data, it will cause great trouble to the user's use. A new generation of CNC system using flash technology, the so-called flash is an electrically erasable read-only memory. Flash memory can only store system software, and can store user data. This reduces the maintenance project of the numerical control system to replace the battery, As well as the loss of data caused by the failure of the battery to stop. Because the flash memory is written to a long time, the numerical control system can not do the real-time data of the user. The numerical control system uses the structure of flash memory and static memory. In flash memory, the system software code of the system, the default data, the backup data, the PLC application and the PLC alarm text are stored in the system.

All user data such as tool parameters, zero offset, processing procedures, *etc*. Information in the working area, which is maintained by high energy capacity. There are many advantages of using capacitance to keep data information. Capacitor charging time

is short; there are no charge battery life problems. The use of semiconductor technology to produce the static storage has very low power consumption. Even if the capacitor can be used for a long time to save the data. In general, the energy storage of the high energy capacitor is enough to keep the information of the static memory in a month's time.

5. Conclusion

This paper introduces the method of shaft dynamic tracking, make full use of the good controllability and data exchange of 828D numerical control system, realize the purpose of dynamic tracking and correction, and improve the machining accuracy. It also provides some experience for the special processing equipment in the country.

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References

[1] Q Zhanqing. “Electrical control technology[M]”, IEEE Transactions on Power Delivery, vol. 10, no. 224 **(2005).**
[2] W. Gang. “Debugging, use and maintenance of CNC machine tools[M]”, IEEE Trans on Automatic Control, vol. 3, no. 57 **(2005)**.
[3] E. T. Jeung, T. H. Kim, H. B. Park.H, “Output feedback Controller Design for Linear Systems with Time-varying Delayed State”, IEEE Trans on Automatic Control, vol. 43, no. 7 **(1998)**.
[4] SIEMENS (China) Co, Ltd. 840D SL/828D.SINUMERIK, vol. 7, no. 102**, (2013)**.
[5] Siemens (China) Co. Ltd. automation and Drives Group S7-200PLC[M]. vol. 5, no. 307 **(2005)**.
[6] Z. Yongfei, “Electrical control of numerical control machine tool[M]”, IEEE Trans on Automatic Control, vol. 56, no. 518, **(2006)**.
[7] Z. Zhiyi, “Mechanical and electrical drive control[M]”, IEEE Trans on Automatic Control, 6,118 **(2015)**.
[8] W. Zeyun, S. Xiaoyun, “Simulation calculation on the deployment of deployable space cable-pole structure[J]”, IEEE Trans on Automatic Control, vol. 8, no. 200, **(2005)**.
[9] H. Yinquan, “Application of Flexible Punching Technology in Ammunition Production[J]”, IEEE Trans on Automatic Control, vol. 20, no. 506 **(2006)**.
[10] Z. Jianguo, S. Duo, “Reliability of space flexible mechanisms[J]”, Journal of Beijing University of Aeronautics and Astronautics, vol. 2, no. 50, **(2006).**
[11] H. Qingquan, C. Ying, “Virtual Prototyping Simulation for the Coordinated Work of Engine and Torque Converter[J]”, Journal of Beijing Institute of Technology, vol. 2, no. 40, **(2004)**.
[12] L. Xiaoxia, H. Changzhong, Z. Hua, “The Dynamic Modeling of Flexible Manipulator with the Method of Finite Element[J]”, Journal of Benxi College of Metallurgy, vol. 3, no. 205,**(2004)**.
[13] S. Yongping, “Simulation Analysis of Valuetrain of Automobile Engine[J]”, IEEE Trans on Automatic Control, vol. 20, no. 506,**(2005)**.
[14] Y. Miao, Z. Ji. “Dynamics model of rigid-flexible coupling for a five degrees of virtual axis machine tool[J]”, IEEE Trans on Automatic Control, vol. 5, no. 226, **(2003)**.
[15] H. Xiaoguang, Z. Jianqi. “Numerical analysis for chaos motion of manipulator system[J]”, IEEE Communications Magazine, vol. 43, no. 92, **(2005)**.
[16] M. Yukun, J. Ce, L. Yanlong, H. Zhiguo, “ADAMS and the application of it in the dynamic simulation analysis of automobiles[J]”, IEEE Communications Magazine, vol. 41, no. 102, **(2004)**.
[17] L. Shang, J. Xinli, J. Yanhong, L. Bo, “Dynamic Analysis on Flexible Cage in High Speed Cylindrical Roller Bearing[J]”, IEEE Trans on Automatic Control, vol. 15, no. 446, **(2010)**.
[18] Z. Guangpeng, S. Wenhao, H. Yumei, H. Dejin, “Modeling and Analysis Method of Dynamical Characteristics for a Whole Machine Tool Structure[J]. Journal of Shanghai Jiaotong University, 206 **(2001)**.

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