Construction of hydraulic chuck reliability test platform by ARM DSP dual-core system

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Abstract. To improve the data acquisition speed and accuracy of hydraulic chuck reliability test, a dual-core data acquisition system with ARM and DSP is constructed in combination with their respective characteristics. Taking full advantage of DSP's fast operation speed, arm is suitable for interface, control and display, so as to realize high-speed and high-precision data acquisition and real-time online data processing, as well as various real-time data acquisition and information exchange functions.

1. Introduction
The reliability of the main functional components of CNC machine tools directly affects the reliability level of the whole machine \(^{[1-2]}\). As an important key part of CNC machine tool, it is important to study the reliability of hydraulic chuck to improve the MTBF (Mean Time Between Fault) level of CNC machine tool. By establishing the reliability test platform, simulating the actual working conditions in the laboratory, inducing or accelerating the failure of hydraulic chuck, and measuring its related indexes, finding out the factors of the failure, statistics the fault data and establishing the fault model, the reliability of the component can be improved.

1.1. Basic function of hydraulic chuck test platform
The test platform should include the following basic functions:
- To establish a functional relationship model of the clamping force under different rotating speed and different oil supply pressure (simulating oil pressure loss due to fault) , and to measure the errors of radial run-out and end run-out of hydraulic chuck.
- To test the wear situation of the front and back end of the claw, which can be accelerated artificially when the clamping instability occurs. The mathematical model of the wear state of the clamping claw and the fault of the hydraulic chuck is established.
- To test the temperature and distribution of distribution system when the axial fault is excited. The relationship model between temperature of distribution pair and stuck fault is established.
- To the collect analog signals such as force, displacement, temperature, vibration, and then show these digital signals on the same platform. At last a reliability model is established.

1.2. Structure of hydraulic chuck test platform
The principle of hydraulic chuck reliability test system is shown in Fig. 1.
Fig. 1 Schematic diagram of hydraulic chuck reliability test system

The test system is mainly composed of three parts: mechanical system, data acquisition system and control system, as shown in Fig. 2. The data acquisition system employs DSP ARM dual-core scheme to make full use of the advantages of DSP and ARM to realize high-speed and high-precision data acquisition and real-time online data processing [3-5]. DSP is used to collect high speed and high precision signals, such as temperature, oil pressure, vibration and so on, especially the high frequency vibration data can be calculated and analyzed in real-time, and its spectrum features can be obtained by on-line Fourier transform, so as to deal with further fault identification in the future. Human computer interaction module is mainly managed by ARM core. By porting the Linux operating system to the ARM core, the user can manipulate the Linux system to obtain the data of each sensor and sending commands, realize all kinds of data real-time acquisition and information exchange, including data management, display and storage, as shown in Fig. 3.

Fig. 2 Hydraulic chuck reliability test platform
2. Reliability test design and data analysis

2.1. Test design
Using test conditions which are far higher than normal use, the test design can accelerate reliability test \(^\textsuperscript{[2,3]}\), quickly expose product design and production defects, collect more product reliability information in a limited time, so as to shorten the development cycle and reduce the test cost.

By using this platform, the data collection and fault monitoring of XX type hydraulic chuck (100 samples) were carried out for 6 months.

2.2. Data analysis
The loss clamping force: 98 chucks had no obvious faults, and the change of clamping force (oil pressure) with rotational speed was not obvious within 6 months recorded by the test system, as shown in Fig.4.

For the faulty chuck No. 2 and No. 18, the clamping force (oil pressure) showed a sudden downward trend due to oil leakage in the joint of the oil road, and finally had to stop the test. Among them, the No. 2 chuck failed at the second month with 500 rpm speed; the No. 18 chuck failed at the third month with 1000 rpm speed, which is shown in Fig.5.
Temperature rise of chuck hydraulic system: during the six-month operation, the temperature was only affected by the temperature on the same day, so that the temperature fluctuated steadily, shown in Fig.6.

2.3. Reliability model
Fault-prone components are 4 joints of the hydraulic system, because the four joints are serial relations, that is, if one of them fails, the whole hydraulic chuck system will fail. Therefore, by setting the reliability of the four joint components is the same $R$, then the reliability of the series system is as follows:

$$R_s = 1 - \prod_{i=1}^{4}(1 - R) = 1 - (1 - R)^4$$

The results of this monitoring show that the usually fault in hydraulic system is the loss of oil pressure caused by the failure of pipe joint, which leads to the decrease and fluctuation of clamping force, which result in the periodic axial run-out of the work-piece being clamped.

3. Conclusion
The hydraulic chuck reliability test platform with ARM and DSP dual-core as the core of data acquisition system is constructed, which makes full use of the advantages of DSP and ARM to realize high-speed and high-precision data acquisition and real-time data processing, in order to realize
all kinds of data real-time acquisition and information exchange. Finally, the reliability test of a batch of chuck is carried out and its reliability model is established.

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