Development of Measurement and Control System of Bearing Performance Test-Rig Based on PLC Control

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Abstract. With the progress of science and technology and the continuous development of social economy, the traditional manual production is gradually replaced by modern equipment production. As the most important part of modern equipment, bearing is the guarantee of normal operation of modern equipment. In order to ensure the normal work of the bearing, it is necessary to conduct real-time measurement and control of all aspects of the bearing performance. The purpose of this paper is to promote the establishment of bearing test bench under PLC control technology, to realize data collection and monitoring of bearing performance, to promote the scientific nature of bearing test, so as to continuously improve bearing technology and help the development of social production. Firstly, PLC control technology is briefly introduced in this paper. On this basis, a specific scheme is proposed to realize the measurement and control system of bearing performance test bench, and the reliability of the system is tested by system equilibrium model algorithm. Experiments in this paper show that the system can realize real-time monitoring of bearing performance and ensure the scientificity and accuracy of bearing performance test.

Keywords: PLC Control, Bearing Test-Bench, Measurement and Control System, System Equilibrium Model

1. Introduction
With the continuous improvement of scientific and technological level, modern production has been promoted, and modern equipment has gradually penetrated into all walks of life. The emergence of modern equipment promotes the automation of production and the maximization of economic benefits. At present, many enterprises begin to replace manual production with modern equipment. However, as the structure of modern equipment is very complex, it is easy to cause damage if the long-term production, especially the damage of key parts will not only bring huge economic losses, but also threaten the safety of personnel, a series of problems.

Bearing is a key part in the work of modern equipment, whose main function is to fix and reduce the friction coefficient of load, which has been widely used in various industries [1]. Although the development of bearing manufacturing technology in China has made continuous progress,
actual application of bearings, even bearings with excellent functional technology will have problems after continuous rolling, thus hindering the operation of the whole equipment [2-3]. In order to solve this problem effectively, a set of equipment is needed to test the performance state of the bearing. Bearing test bed can accurately evaluate the performance of various aspects of bearing with the help of relevant experiments, and provide reliable evaluation data, laying a foundation for the improvement of bearing technology [4-5]. Therefore, it is particularly important to study the measurement and control system of bearing performance test bed based on PLC control. Domestic and foreign scholars have carried out relevant research on bearing in a long time ago. Experimental research on bearings abroad is relatively early, and some achievements have been made [6]. The experiments mainly analyzed and simulated the actual working conditions of bearing by means of different technologies, which promoted the development of bearing test contents to a certain extent. Since the beginning of last century, bearing industry has been developed in China. Due to the low technical level, there are relatively few researches on bearing performance, and it has been gradually developed in recent years. Through a comprehensive comparison of the data, it is found that most of the current bearing performance experiments stay on the study of bearing performance under manual control [7-8]. Few studies have involved the research of bearing performance under PLC control technology and other automatic control technology. Therefore, this research needs to be further improved from this aspect.

In order to promote the establishment of bearing test bench under PLC control technology, to realize the data collection and monitoring of bearing performance, to promote the scientific nature of bearing test, so we can continuously improve bearing technology. First of all, the PLC control technology is briefly introduced in this paper. On this basis, a specific scheme is proposed for the realization of the bearing performance test bed measurement and control system, and the reliability of the system is tested by means of the system equilibrium model algorithm [9-10]. Experiments in this paper show that the system can realize real-time monitoring of bearing performance and ensure the scientificity and accuracy of bearing performance test. The research in this paper has not only promoted the continuous development of bearing technology, but also laid a certain theoretical foundation for future related researches [11].

2. Method

2.1 PLC Control Technology
PLC control technology can realize automatic control, in essence is a logic controller that can be programmed. With the continuous maturity of PLC control technology, it has gradually been widely applied in the industrial manufacturing process. Generally speaking, online programming of PLC automatic control system can be realized with the help of computer network technology [12-13]. The composition of PLC system is complicated, mainly composed of the following parts, namely input and output modules, control hardware and storage. The key to the application of PLC control technology in related industrial software and systems is the logical control of the mechanical function. The process of this logical control includes output, refresh, execution program and sampling input. The controller is the most critical hardware facility in the practical operation of PLC and plays an irreplaceable role. Generally speaking, the operation of PLC controller is realized through the communication interface, and on this basis, effective control of external devices is realized [14-15]. As far as the application of PLC in industrial manufacturing is concerned, this technology breaks the traditional industrial manufacturing mode, reduces the input of manpower and promotes the rapid improvement of efficiency. Therefore, the application of PLC control technology to the measurement and control system of bearing performance test bed can realize real-time monitoring of bearing performance, help to find problems in time and make modifications, which is conducive to the further improvement of the performance of the measurement and control system.

2.2 System Equilibrium Model
The main purpose of the system equilibrium model is to promote our understanding of the classical
measurement and control system model. Through this model, we can make full use of relevant data collection to grasp the operation status of the system and take defensive measures according to the actual operation of bearing facilities. The error between actual time and perceived time of bearing performance detection is referred to as stochastic system equilibrium. Set up A system network communication A, and the actual time required for A certain part of system a ∈ A to detect the bearing performance under the system network flow xa is expressed by ta, which is also called the detection function. The detection time is proportional to the system network traffic, which is consistent with the general detection law. The continuous accumulation of detection function integral of each part is the system equilibrium objective function, and its specific formula is as follows:

\[ \min Z = \sum_{a \in A} f^w a(t_a(w))dw \]  

(1)

Where, f represents the system flow, t represents the system detection time, x represents the serial number of each part of the system, and a represents the bearing number. The detection function is a direct reflection of the system detection law, which is usually a nonlinear law. By optimizing the above model, a more standard model can be obtained. The specific formula is as follows:

\[ t_a(x_a) = t_f \left[ 1 + 0.15 \left( \frac{x_a}{C_a} \right)^4 \right] \]

(2)

Where, Ca represents the overall detection capability of system a, and 0.15 and 4 in this model are not fixed. This optimized model can further predict and analyze the bearing performance detection law. The use of the system equilibrium model takes into account the actual demand of bearing performance test bed, and on this basis, reasonable Suggestions are made for the improvement of bearing technology, and various situations in bearing performance work are taken into account.

3. Measurement and Control System Operation Test Experiment

To establish the measure and control system in order to ensure accurate and reliable performance of bearing test rig, improve bearing fault detection probability, to further promote the bearing performance of ascension, this article with the aid of Multisim7 software test measurement and control system of the experiment, the software application in the detection experiments can decrease the difficulty of experiments so as to shorten the test time. The test experiment takes the measurement and control system as the main test object, and involves the comprehensive test of the system, including the test of fault detection time, fault detection probability, response time, system stability and system efficiency. It also includes the testing of hardware and software facilities of the measurement and control system. Firstly, a comprehensive understanding of the test and control system of bearing performance test bed is established by consulting relevant data, and the main contents and methods of testing are established. Secondly, with the help of Multisim7 software, the part mentioned above should be detected. In the process of detection, the influence of other factors must be eliminated to the maximum extent. Meanwhile, the methods and steps of detection should be standardized to improve the operation technology of detection, so as to ensure the accuracy and scientifficity of experimental results. Finally, the data is analyzed with the aid of Excel tool and the data table of measurement and control system detection is drawn, so as to realize the visual reflection of measurement and control system detection results.

4. Discuss

4.1 Realization of Bearing Performance Test Bed Measurement and Control System

(1) Software implementation of measurement and control system

The software of the measurement and control system mainly consists of three parts, namely PLC control technology software, WinCC upper computer control interface and WinCC Flexibel touch
screen interface. PLC control technology software is the main dynamic control software, the control software can achieve the data preparation of different devices, including programming, configuration, debugging and other work can be completed with the help of PLC control technology, so as to achieve the overall control of the control technology on the system. The specific workflow of the technology is to realize the communication between the parts of the system by means of programming software. Then the label is created with the help of OPC server. Finally, write and debug the main warfare program under PLC control technology. WinCC upper computer control is the main control system of the upper computer for real-time monitoring. The display content of WinCC upper computer control mainly includes the status of the lubrication control system, the frequency conversion controller of bearing work and the main situation of ROTORK electric actuator opening control the three aspects. These three aspects have an important impact on the performance of the bearing, so its content must be displayed. The WinCC Flexibel touch screen interface USES WinCC flexible2008 as configuration programming software. After the main information of bearing performance is generated and displayed on the interface, the operator can use this software to customize. At the same time, the operator can predetermine the upper and lower limits of the bearing fault judgment. The software can prompt the bearing fault type in real time according to the operator's presupposition, and output the protection control signal according to the predetermined scheme.

(2) Hardware implementation of measurement and control system

The hardware of the measurement and control system mainly includes two parts, namely the equipment data acquisition system and the control system. By setting up the hardware platform in the measurement and control system, the real-time monitoring of the main part can be realized, and the prompt warning signal can be sent once the fault occurs. The monitoring of hardware platform mainly includes real-time monitoring of motor control system, loading system and monitoring system. On the main structure of the bearing performance test bed, the tester and the motor with a power of 315kw are respectively installed. PLC control, as the upper computer of the control system, can effectively control the frequency converter equipment, voltage controller and electronic actuator through PLC control. When building the hardware platform of the measurement and control system, try to use the existing hardware of the enterprise to build it, so as to improve the utilization rate of the equipment.

4.2 Test and Control System

Through the above experiments and with the help of the system equilibrium model algorithm, the following conclusions can be drawn: the bearing performance test bed measurement and control system based on PLC control can realize the comprehensive accurate detection of the bearing performance, and can provide strong data support, is a completely reliable measurement and control system. The specific experimental data are shown in table 1 and figure 1. The data in the chart are the results of the author's experimental arrangement.

| Table 1. Test indicators and results of the measurement and control system |
|------------------|-----------|---------|---|---|
|                  | Value     | Mark    | Proportion | Score |
| Participate in the Situation | 1 | 95 | 79.89% | 82 |
| Satisfaction     | 5         | 91      | 76.18% | 86 |
| System Status    | 10        | 84      | 71.54% | 83 |
| Actual Effect    | 15        | 96      | 89.17% | 81 |
| **Final score**  | **89.5**  |         |          |     |

*Data came from the in-depth analysis of financial data in the experiment
As can be seen from table 1, the performance of the detection system is generally qualified, with a comprehensive score of nearly 90%, making it a relatively reliable detection system. However, from the data in figure 1, we can find that the development of the measurement and control system has not yet achieved the desired effect, and there is still room for further improvement.

5. Conclusion
The establishment of measuring and controlling system of bearing performance test bed can meet the requirements of specific test process, and can help all parts of the equipment to realize remote communication, so as to realize the comprehensive collection and control of bearing working data, reduce the probability of bearing failure, and ensure the normal operation of all kinds of modern equipment. Of course, with the continuous progress of related technology, the test and control system of bearing performance based on PLC control proposed in this paper will be constantly improved.

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