Design of Remote Hydraulic Teaching System

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Abstract. In this paper, a set of remote hydraulic teaching experiment system is designed and developed based on the demand of teaching experiment of hydraulic related courses in colleges and universities, which can enable teachers or students to conduct experiment operation on the field hydraulic testing platform at the remote client, so as to facilitate teachers and students to carry out hydraulic teaching experiment and research. The main contents of this paper are as follows: according to the requirements of hydraulic servo control system related to the teaching experiment, the experimental project of remote hydraulic teaching experiment system is determined. Through the analysis and comparison of C/S and B/S software system architectures, the remote monitoring scheme based on B/S mode is determined. Completed the design of the hydraulic circuit of the hydraulic test bench, developed the field measurement and control system based on LabVIEW, and built the remote monitoring system based on B/S mode. The development of the remote hydraulic teaching experiment system was completed. The input signal response experiment and load characteristic experiment of the valve-controlled motor electro-hydraulic speed servo control system were carried out on the remote client to the field hydraulic experiment platform, and the experimental results were analyzed. The experimental process and results have reached the expected target and meet the demand of remote hydraulic experiment.

1. Introduction

At present, most of the hydraulic teaching experimental systems used in domestic universities are QCS003, QCS008, jsx-a, ys-21 and other hydraulic comprehensive experimental platforms developed in the 1980s and 1990s. This type of hydraulic test system uses gauges, flow meters, stopwatches and other instruments to measure the experimental data, which need to be manually read and recorded. Due to the influence of instrument precision and human factors, the system has the disadvantages of large error, low sensitivity and complicated operation, so it is inconvenient to record dynamic experimental data. We are based on the above reasons, in order to meet the needs of hydraulic teaching experiment and scientific research, a university commissioned to develop a set of remote hydraulic teaching experiment system based on network control, so that users can carry out experimental operation and real-time monitoring in the remote client. [1]
2. Design of hydraulic test bench

2.1 Hydraulic circuit design

According to the teaching experiment and research demand of hydraulic course entrusted by the project, the remote hydraulic teaching experiment system developed in this paper is used to carry out relevant teaching experiment and research of hydraulic servo control system. According to its characteristics, the designed hydraulic circuit is shown in figure 1.

Figure 1. Hydraulic circuit of test bench

The system hydraulic circuit is composed of three parts: valve controlled hydraulic cylinder module, valve controlled hydraulic motor module and hydraulic oil source module. The valve controlled hydraulic cylinder servo control system consists of electro-hydraulic servo valve, hydraulic cylinder and loading module. The valve controlled hydraulic motor servo control system consists of electro-hydraulic servo valve, hydraulic motor and loading module. Hydraulic oil source module includes system oil source, pressure regulation, oil filtration and oil cooling module. Besides, pressure sensor, displacement sensor, force sensor and torque tachometer are also arranged in the system.[2][3]

2.2 Structure and overall layout of the test bench

The hydraulic test bench is composed of two parts: the hydraulic system and the electric control system. In order to avoid the influence of oil leakage on the electric control system during the experiment, the system is designed with a separate structure to separate the hydraulic system from the electric control system. The overall structure of the test bench is shown in figure 2.
3. **Design of on-site measurement and control system**

The field monitoring system of the remote hydraulic teaching experiment system is located in the field monitoring layer of the overall structure. According to the testing and control requirements of the remote hydraulic teaching experiment system, the field measurement and control system based on LabVIEW virtual instrument technology is designed. LabVIEW virtual instrument technology is, in essence, a concept of integration of software and hardware, and LabVIEW in the drive and the application of two level, and computer, instrumentation and communications technology together, offers a variety of standard I/O interface, and help users to integrate the different manufacturer production of measuring equipment to the system, make full use of the flexibility of software and computer powerful data processing ability, reduce the complexity of the system.[4] The field measurement and control system adopts the control form of upper computer and lower computer, with ipc as upper computer, PLC (programmable logic controller) as lower computer, and RS485 serial port communication between ipc and PLC (programmable logic controller) through communication cable. The overall architecture of the on-site measurement and control system is shown in figure 3.

![Figure 3. Overall structure of field measurement and control system](image)
4. Design of remote monitoring system

The remote hydraulic experiment teaching system is designed in B/S mode, and the system architecture is divided into three layers: field monitoring layer, service layer and remote customer layer. Teachers and students can access the server layer through the browser in the remote client. The server acts as the transit point and uses the TCP/IP communication protocol to communicate with the on-site monitoring layer. According to the overall architecture design of the remote hydraulic teaching experiment system mentioned above, the remote monitoring system is the remote monitoring website on the server layer.[5]

According to the actual demand of the remote hydraulic teaching experiment system, the remote monitoring system consists of the experiment management system and the hydraulic experiment system. Among them, the experiment management system is used for user management and experiment reservation, and it is required to establish a matching user database and experiment reservation database when interacting with the field hydraulic experiment platform. The hydraulic test system module is used for data exchange with the field hydraulic test bench and corresponding remote hydraulic test project, depending on the type of its function will be divided into the test bench status display (Ⅰ), feedback (Ⅱ), the static data, real-time data display (Ⅲ), image monitoring (Ⅳ) and test bench operation (Ⅴ), a total of five parts, as shown in figure 4. The overall architecture of the remote monitoring system is shown in figure 5.
In the remote monitoring system, the experiment management system manages users' access rights and experiment appointments by setting the database on the server layer. The state display of the test bench, real-time data feedback and operation of the test bench are bound to the variables in the local library of LabVIEW measurement and control software of the field monitoring layer in the form of NI Shared variables. Static data display mainly shows some fixed pictures and documents in the remote monitoring system. Relevant data are stored in the server layer, which can be realized by HTML5 static web page development technology. The network surveillance camera transmits the data stream of the scene to the server layer through the TCP/IP protocol.

5. Analysis of remote hydraulic teaching experiment

In order to verify the control performance of the valve-controlled motor speed servo system and directly reflect the control effect of the remote hydraulic teaching experiment system, the system sets the response experiment of sine wave, triangle wave and square wave as the input signal.

5.1 Sinusoidal signal input response experiment

At the remote client, input sinusoidal waveform signal with amplitude of 50r/min, bias of 100r/min and frequency of 0.05Hz to the system, and observe its response curve. The above operation was repeated on the field hydraulic experiment system to carry out sinusoidal signal input response experiment. The response curve and error curve of the system are shown in figure 6 and figure 7 respectively.

![Figure 6. Input response curve of sine waveform of the system](image1)

![Figure 7. Error curves of sinusoidal waveform input of the system](image2)

5.2 Input response experiment of triangular waveform signal

At the remote client, input a triangular waveform signal with amplitude of 50r/min, bias of 100 and frequency of 0.02Hz to the system, and observe its response curve. The above operations were repeated...
on the field hydraulic experiment system to carry out the input response experiment of triangular waveform. The response curve and error curve of the system are shown in figure 8 and figure 9 respectively.

![Figure 8. Input response curve of triangular waveform of the system](image8)

![Figure 9. Error curve of input of triangular waveform of the system](image9)

5.3 square wave shape signal input response experiment

At the remote client, input a squared-wave signal with an amplitude of 50r/min, a bias of 100 and a frequency of 0.02hz to the system, and observe its response curve. The same operation was repeated on the field hydraulic experiment system to carry out the experiment on the input response of square wave. The response curve and error curve of the system are shown in figure 10 and figure 11 respectively.

![Figure 10. System input response curve of square wave](image10)
Figure 11. Error curve of system square wave input

It can be seen from the above experimental results that the valve controlled motor servo system can track typical signals such as sine wave, triangle wave, square wave and so on within a certain error range at the network control end and the field control end, and the actual speed of the hydraulic motor lags behind the input signal. Due to the influence of network delay and other factors, the control effect of field hydraulic experiment system is better than that of remote network control, and its error and lag time are smaller.

6. conclusion

The remote hydraulic teaching experiment system is developed, and the related experiment of the valve controlled motor electro-hydraulic speed servo system is carried out on the remote client to the field hydraulic test bench. The experimental results show that the remote hydraulic teaching experiment system developed in this paper can realize the remote monitoring of the field hydraulic test bench at the remote client and meet the needs of the remote hydraulic experiment.

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