Pilot handle valve automatic test bench

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Abstract. In order to test the performance of the pilot handle valve, the test system of the pilot handle valve is developed with LabVIEW measurement and control software, motion control card and XYZ three-axis servo motor. The oil contamination in the valve body is detected when testing the pilot handle valve. In view of the phenomenon that the flow is small and it is difficult to measure accurately when testing the pilot handle valve, the industrial camera is used for image processing and analysis of the leakage. Finally, the reliability of the test system is verified by theoretical analysis and experiment, which meets the requirements of the test-bed company and is accepted successfully.

1. Introduction

Pilot handle valve is an important hydraulic component widely used in construction machinery, which is widely used in construction machinery [1]. When the pilot handle valve is used as the actuator, the valve element must overcome the spring force, hydraulic force, friction, etc., which will lead to certain operation deviation [2]. These deviations will lead to poor linearity, long dead zone and increased valve leakage. Using the motion control card to control the XYZ three-axis servo motor can effectively simulate the manual action to measure the performance of the pilot handle valve. The traditional leakage test can only be judged by the human eye, and in the non-contact situation, visual detection can replace human eyes to judge the leakage of pilot handle valve quickly and stably.

2. System principle analysis

Meet the working conditions of the pilot handle valve, and the hydraulic system has a pressure control circuit. To simulate the working temperature of the pilot handle valve, the hydraulic system has heating and cooling circulation circuit [3]. Ensure the quality of hydraulic oil in the system, and the hydraulic system has oil pollution detection circuit. Improve the efficiency of the test, and clamp the tested parts with the pneumatic reversing valve.
2.1. Hydraulic system analysis

As shown in Figure 1, the hydraulic oil flowing from the test piece flows into the oil tank 1.1, and then is pumped into the oil tank 1.2 by the motor 2.1 through the filter 3.1. The circulating motor 2.3 flows the hydraulic oil. When the temperature is high, turn on the air cooler 4 to cool down. When the temperature is low, turn on the electric heating 14 to heat up. Main pump 2.2 provides the oil source for test, and the pressure is controlled by electromagnetic relief valve 6. When measuring the leakage of pilot handle valve, close cartridge valve 8.2, 8.3, 8.4 and 8.5, close cartridge valve 8.7, open cartridge valve 8.6, flowmeter 7.2 and beaker 10 to measure the leakage. 4 pilot handle valve ports open the corresponding cartridge valve, and flow meter 7.1 measures the flow of pilot handle valve. Open the cartridge valve 8.7 and use the oil stain detector 3.5 to detect the oil stain.

3. Construction of measurement and control system

In order to meet the test requirements of the pilot handle valve, the structure diagram of the measurement and control system is shown in Figure 2, which is composed of industrial computer, PLC, data acquisition card, pressure sensor, motion control card, flowmeter, industrial camera, oil pollution detector, etc. The analog signals of port P pressure, outlet pressure, force, output flow, tank temperature, etc. of the pilot handle valve enter the industrial computer through the PCI bus through the data acquisition card of the signal isolation module. Motor fault alarm, oil tank high and low level alarm signals are transmitted to the upper computer by PLC. The leakage image is collected by industrial camera and entered into industrial computer. The control system is divided into manual operation and automatic control test of entity button. The output executive components are servo motor, proportional relief valve, electromagnetic reversing valve, heater, air cooler, etc. Through the signal acquisition, the output results of the actuator are detected to form a closed-loop control, so that the automatic test process can run smoothly and safely.
4. Design of measurement and control system

The test system software adopts virtual instrument technology, using labview12.0 software of Ni company as the development tool, which can be completely customized according to the user's requirements. The software has a good reliability, ease of use, accuracy and so on to filter the collected data, and according to the idea of virtual instrument, it carries out a modular and hierarchical structure design.

The 4 ~ 20mA current signal from the pressure, displacement, flow and force sensors of the system is transmitted to the pci-1710u acquisition card of Advantech through the signal isolation module to enter the industrial computer. The test bench needs to test the basic performance of the pilot handle valve and meet the automatic performance test \([4]\). The test system is divided into manual station test system and automatic station test system.

In automatic test, the motion acquisition card is controlled by LabVIEW software to control the motion of XYZ three-axis servo motor. In leakage test, the image collected by real-time industrial camera is analyzed by LabVIEW. The proportional relief valve is controlled by PLC Analog output module to regulate the pressure of pilot handle valve P port, and the particle number of hydraulic oil is detected by oil pollution detector according to NAS standard. The feedback temperature of the temperature sensor forms a closed loop to control the temperature of the hydraulic oil, and the feedback pressure of the force sensor and the z-axis servo motor form a closed loop control to simulate various operations.

In manual test, the main pump motor, P port pressure and circulation motor are controlled by entity button, and the test information is transmitted to the upper computer by acquisition card.

5. Software design of measurement and control system

The software communicates with users through human-computer interface. As shown in Figure 3, the interface is divided into data display, file processing, test oil path monitoring, display setting, parameter setting and test operation.

Data display: display all kinds of key test data information in various ways (including numerical display, range display, pointer display, chart real-time display).

Test oil way monitoring: monitor the value of each sensor on the test oil way, the on-off status of each ball valve and solenoid valve, and have the function of prompting and handling the corresponding fault conditions, so as to ensure the safety of the system and personnel.
Data file processing: the test data and chart curve recorded in this test can be saved separately, and the historical data file can be browsed and read when using.

Display settings: this part can set the information distinction and annotation of the test curve in the interactive interface, and select and save the curve to be displayed.

Parameter setting: it can save the setting of routine parameters (including the product information of the tested piece, such as model and number) entered before the test process parameters (such as pressure, flow, temperature, valve on-off, XYZ coordinates of triaxial servo motor test point, etc.).

Test operation: including the selection of test items, test start, test stop and test handling methods.

5.1. Servo motor control

The motion control card is used to control the motion of servo motor in XYZ direction. During the test, it is necessary to align the corresponding test points and control the servo motor to reach the corresponding points accurately, so it is necessary to control the position of the motor. At the same time, prevent the command motor from operating up and down at the same time. The procedure is shown in Figure 4.

In order to make the displacement more smooth, To make the displacement smoother call the motion control card's dmc_PtsTable function and dmc_PvtMove function. The displacement curve of the function is shown in Figure 5.
Figure 5 displacement curve of servo motor

When the control motor is displaced in the z-axis direction, it will be subject to resistance when the z-axis is pressed down on the pilot handle valve, and it will receive thrust when the z-axis is up, which will cause the displacement in the z-direction to fluctuate and affect the test results, so it is necessary to filter out the fluctuation part, as shown in Fig. 6 and Fig. 7. We adopt the average filtering method of anti pulse interference. This method adopts a group of queues to get the average value after removing the maximum value and the minimum value, continuously sampling n data, removing a maximum value and a minimum value, and then calculating the arithmetic average value of n-2 data.

6. Pilot handle valve performance test
The distribution of pilot handle valve provided by Ningbo Hydraulic Co., Ltd. is tested for control characteristics, leakage, oil contamination of valve body, pressure loss and other characteristics. During the test process, the whole test system is highly automatic, reducing the operation error of personnel, the performance of each part of the test system is stable, and the test efficiency and accuracy are effectively improved.

6.1. Control characteristic test
When the system pressure is 32 bar, test the pilot handle valve to get Figure 8. The abscissa is the moving distance of the valve core, and the ordinate is the pressure. It can be concluded from the figure that when the displacement is 0-1mm, the pilot pressure is 0. When the displacement is around 1mm, the pressure suddenly increases to 7bar. In the stroke of 1-6mm, the pressure increases linearly with the displacement. When the pressure suddenly increases to 32bar when the attachment is 6mm, the
maximum pressure is reached. When the hysteresis of the valve in the figure is less than 1.5 bar, it conforms to the characteristics of the regulating spring of the pilot handle valve.

6.2. Oil contamination detection of valve body

Due to the high accuracy required for testing the characteristics of the pilot handle valve, there is a high requirement for the contamination of the hydraulic oil in the test environment, as shown in Table 1. When the pilot handle valve is delivered from the factory, there are inevitably pollutants in the shell, so it is necessary to obtain the solid particles of the hydraulic oil when the valve body is tested. The accuracy level of the oil in the newly opened oil drum is nas9. Add a filter in the system, and the hydraulic oil from the dirty oil area needs to return to the oil tank through the filter [5].

Table 1 cleanliness requirements of common hydraulic components (nas1638)

| Component name: | Servo valve | Proportional valve | Pressure flow control valve | Directional control valve | Plunger pump | Vane pump | Gear pump |
|-----------------|-------------|--------------------|----------------------------|---------------------------|--------------|-----------|----------|
| Cleanliness     | 6           | 7                  | 8                          | 8                         | 7            | 8         | 75.4     |

As shown in Figure 9, when measuring the characteristics of the pilot handle valve normally, the oil pollution is monitored at the same time, and the oil pollution particle number of the valve body at that time is displayed by transmitting it to the industrial computer through visa. The accuracy of the test can be ensured only when the corresponding contaminated particles meet the nas1638 standard.
6.3. Leak test
When the pilot handle valve leaves the factory, the fit clearance between the valve core and the valve hole, the sealing of the lower end of the plug rod, and the joint surface between the end cover and the valve body are all the reasons for the large leakage of the pilot handle valve [6]. In the factory test, the handle pilot valve with large leakage is often found out, but the pilot valve with a small amount of leakage is powerless, and the efficiency of using the naked eye to observe the valve leakage is too low. The test bench uses the leakage flowmeter to measure the valve with large leakage, and the measurement range of the flowmeter is between 0.07l/min and 0.75l/min. For the valve with less leakage, it can be regarded as Detect the amount of tubes per minute to measure the small leakage of the pilot handle valve. As shown in the figure 10, the industrial camera takes a picture of the test tube, and calculates the liquid level height through the edge algorithm.

![Figure 10 leakage test tube](image)

7. Conclusion
In this paper, a complete automatic test system of pilot handle valve is studied. The hydraulic principle and control principle of the system are described. The servo motor motion is precisely controlled by the motion control card, and the interference data is filtered out. Through the experiment, it is concluded that the test system can accurately and stably test the performance of the pilot handle valve, the test accuracy meets the requirements, the performance of the system is stable, the manual operation is effectively reduced, and the production efficiency is improved.

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