The Design of Electric Control System of Proportional Electromagnetic Valve Test Bench

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Abstract—**For high precision detection of hydraulic proportional solenoid valve pressure, sealing properties and steady pressure characteristic performance indexes, independently design a solenoid valve performance testing platform, which has a high level of automation. Its core based on PLC controller and touch screen, it makes power units, hydraulic integrated block, test valve installation disc, and other components as its control object, and adopt the input and output module to make up an open structure supervisory computer control system to realize data preprocessing, sensor linearization and nonlinear compensation, scale transform, the limit alarm function processing engineering, digital controller, meeting the proportional solenoid valve testing requirements. The article describes in details the constitute of test platform of electronic control system, work principle and the realization of the function of each part.**

Keywords-proportional electromagnetic; detection; control object; digital controller

I. INTRODUCTION

Electro-hydraulic proportional solenoid valve as the premise control components of electro-hydraulic shift valve, the control accuracy, response speed and linearity of the high and low oil pressure is stable or not, and output will directly affect the dynamic performance of power level valve core, and then affect the control of the oil pressure, has important influence on the quality of the shift gears valve. Shift valve has experienced the development from the high-speed switch electromagnetic valve to the electro-hydraulic proportional solenoid valve. High-speed response switch electromagnetic valve has simple structure, cheap, strong ability to resist pollution, but due to its control principle is through the PWM signal to continuously open and close the pulse oil pressure of the ball valve hydraulic output, control frequency is limited, and because the control mode belongs to discrete control rather than a continuous control, has the characteristics of discrete and nonlinear, which brings difficulty to precise control. Due to the shortcoming of the high-speed response switch electromagnetic valve, proportional electromagnetic valve applied in the shifting control circuit, proportional electromagnetic valve because of its pressure, sealing characteristics and steady state pressure characteristics, will increase the demand for proportional solenoid valve products in the department of petrochemical industry, electric power, metallurgy, chemical industry and urban construction. Therefore, the proportional solenoid valve testing is particularly important. For a long time, solenoid valve performance testing method is to use simple manual testing, the test platform for testing personnel demand is high, the

strength of the operating personnel is very big, speed is more slow, especially in terms of accuracy, the effect is not very satisfying. Research and development with independent intellectual property rights, with high level of automation solenoid valve performance testing, will have important significance of the productivity and automation degree.

II. TEST PRINCIPLE AND SYSTEM COMPOSITION OF PROPORTIONAL ELECTROMAGNETIC VALVE CHARACTERISTIC

Hydraulic proportional valve test board mainly includes power units, hydraulic integrated block, test valve installation plate, electric control system, etc., among them, the power unit, hydraulic integrated block, the test valve installation disc and each element as the control object, electronic control system consists of PLC and touch screen, realizing to control and detect the controlled object, system assembly drawing as shown in figure 1:
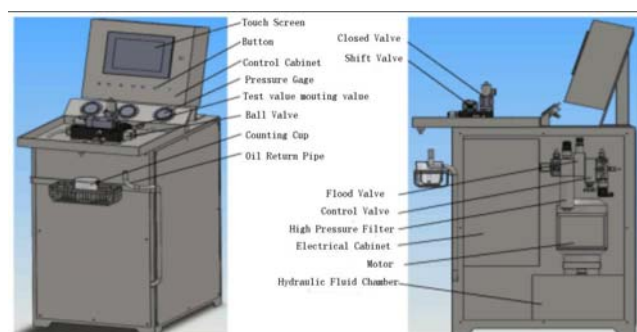

FIGURE I. ASSEMBLY DIAGRAM

In the hydraulic electric control system, industrial controller PLC must go through input/output interface and process channels to be connected to the controlled object. Input/output interface is a bridge for controller to exchange information with external devices, it includes input interface and output interface, in the process of system operation, the exchange of information is frequent. Process channel is the connected channel of information transmission and transformation which are set up between the controller and the controlled object, it includes analog input channel, analog output channel, digital quantity input channel, digital quantity output channel. Various parameters of the controlled object are sent to PLC controller through analog input channel or digital quantity input channel, the results of the controller after dealing with the calculation and the simulation are sent to the controlled object through analog output channel or digital

output channel, realizing the control of the controlled object. Touch screen and PLC controller use serial interface mode, use the standard data exchange interface, SCADA software with the function of the system supervisory control and data acquisition, makes communications in an indirect way through DDE and OPC internal data exchange center and hardware devices. Communication lines use the RS—422A, the full-duplex works, the advantage of RS—422A is using balance drive and difference reception mode, fundamentally eliminate the signal ground. This drive is equivalent to two single side drive, their input are the same signals, and the output of the drive is opposite to another one. When interference signal as a common mode signal appears, the receiver is receiving differential input voltage. As long as the receiver has enough resistance to common-mode voltage range, it can identify the two signals and receive and transmit information. Remote communication between two points is realized by using the RS – 422A, need two pairs of balanced differential circuit forming full-duplex transmission circuit.

Electric control system based on the touch screen + PLC controller as the core, the input and output module channel is adopted to form the supervision and control system with an open structure. Touch screen epistemic machine is mainly used for processing of unreal-time control, realizing the original process information and other parameters, according to the mathematical model or other approaches for describing the production process, automatically changing the set point in PLC controller which is working by way of direct digital control, thus making the production process remain the optimal working condition, at the same time serving as the movement of the object state display interface. PLC controller completes the function of the measurement data preprocessing, flow sensor and pressure sensor linearization and nonlinear compensation, scale transform method, the limit alarm function processing, digital controller of the project. The structural block diagram of the composed supervision and control system is shown in figure 2.
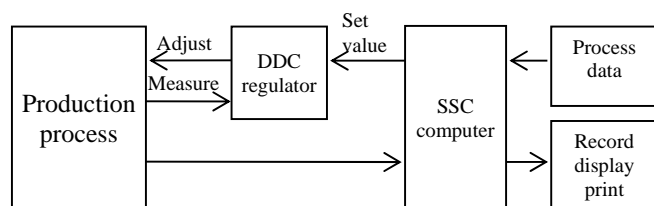

FIGURE II. THE SUPERVISION AND CONTROL STRUCTURE DIAGRAM

III. THE ENGINEERING IMPLEMENTATION OF DIGITAL CONTROLLER

This design is to design proportional electromagnetic valve characteristic test platform which is based on programmable logic controller (PLC), in the project implementation of digital controller, 6 steps of the given value and controlled quantity handling, deviation handling, the realization of the control algorithm, controlling quantity processing and automatic/manual switching technology should be included, the schematic diagram is shown in figure 3:
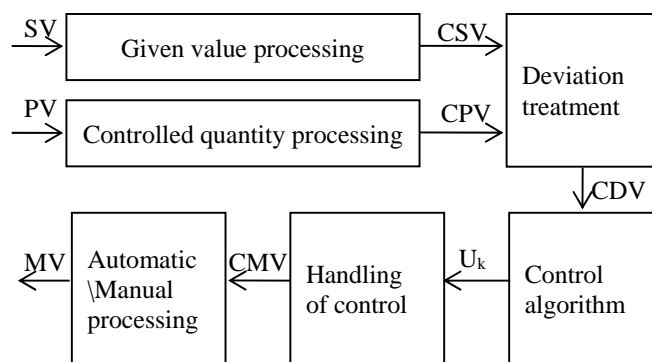

FIGURE III. DIGITAL CONTROLLER ENGINEERING IMPLEMENTATION SCHEMATIC DIAGRAM

For computer control system of test-bed, manual operator can be used as a backup computer operation. When the switch is in the automatic position, control quantity MV outputs by D/A, at this moment the system is in normal way of computer control, it is called automatic state (HA);Conversely, when the switch is in the manual position, the computer will no longer undertake control tasks operating remotely on actuators through manual operation outputting 0 ~ 10 m ADC or 4 ~ 20 madc signal by operation personnel, which is referred to as a manual state (HM).In order to realize no balance operation and undisturbed switch from manually to automatically, in manual mode, although there is no algorithm calculation, the set value(CSV) should be made to track the controlled quantity(CPV), at the same time the historical data should be cleared to zero such as the moment before the sampling value of e (k - 1) reset, and the controller a moment before the output value of u (k - 1)should be made to track manual control quantity .In this way, once it is switched automatically and the controller the moment before the output value of u (k - 1) is equal to the amount of manual control quantity at the switching moment, the continuity of the controller output control quantity can be guaranteed. When it is switched from automatically to manually, as long as the computer applications work properly, the undisturbed switching can be guaranteed automatically. When it is switched from output maintaining state or security output state to normal auto matical working state, the undisturbed switching is also needed, similar measures can be taken for this. Of course, all of this need a corresponding hardware circuit to cooperate.

Using the digital controller above, can not only form single loop control system, but also form a cascade, feed forward, pure lag compensation (Smith), and other complex control system, the last two systems should be added compensator operation module. Using the control module and the combination of various functional operation module, can form various control system to meet the requirements of proportional solenoid valve control.

IV. TEST CONTROL PROCESS OF HYDRAULIC PROPORTIONAL ELECTROMAGNETIC VALVE CHARACTERISTIC

According to the technological requirements, the touch screen takes the real-time interpolation calculation to process curve, gives the signal, start the pump at the same time,

through receiving of PLC then operates output, outputs the analog quantity signal, it is sent to the proportional solenoid valve through the amplifier, proportional electromagnetic valve receives the size of the digital controller output value to control the opening degree, and the change of the electromagnetic valve opening will bring the change of the flow, and pressure will be changed too. The pressure signal detected by the pressure sensor and flow signal detected by the flow sensor are switched through A/D, then will be sent to PLC after dealing with by the data acquisition program, digital filter program and scale transformation process. According to the requirements of voltage endurance characteristics, sealing properties and steady pressure performance of hydraulic proportional electromagnetic valve, the testing method of performances are as follow:

1) voltage endurance experiment: After installing the tested valve to test bed, dry oil around, keep the tested valve body and installed valve plate clean. Test platform has switched the rated pressure to 3MPa, (if you want to increase the pressure, shut off ball valve 15.1, 15.2, remove the protective cap of overflow valve 8, adjust the stud, clockwise for rise, counterclockwise for low, after the adjustment, tighten the protection cap, open the ball valve 15.2), hold pressure for 5min and observe whether the oil spill.

2) sealing test: remove the oil return pipe of testing valve plate, place measuring cup for leakage at its outlet, Offer the shift valve 24v and keep it open fully for 5min, observe the leakage rate and record the data. Then power the tested valve off for 5min, observe the leakage rate.

3) Steady pressure performance test: adjust the overflow valve 14 of simulated loading pressure to 1.5 MPa (the factory has been set, if you want to change, open the ball valve 15.1, close ball valve 15.2, 15.3, then adjust the overflow valve 14, clockwise for increase, counterclockwise for reduction), provide the tested valve with different signals, under each of the input signal value, keep it for 1min, collected the outlet pressure of tested valve. When providing the tested valve with signals, it is suggested to rise gradually, then lower gradually, the pressure curve of the tested valve can be measured.

V. CONCLUSION

The operation of this system is simple, use and maintenance is convenient, performance is reliable; Using by digital technology controlled way, improved the quality detected accuracy of the hydraulic proportional electromagnetic valve; improved the working conditions, without manual operation, eliminated the human factors; it is easy for modern management and product quality analysis; using tables, graphs, curves are more intuitive, and has function of printing output.

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