# Study on current characteristic detection method of hydraulic solenoid valve in nuclear power plant

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**Abstract.** In this paper, a set of electromagnetic valve current characteristic test system is designed to improve the reliability of the trip solenoid valve in the field steam turbine system of nuclear power plant. The test system starts from the field requirements, working principle of solenoid valve, software control and other aspects to complete the pressure suppression function of the hydraulic test system and the functions of data acquisition, storage, display, playback and so on. The test system is composed of a hydraulic system and an electrical control system. The system verifies the reliability of the tested object by detecting the important parameters of the solenoid valve, calibrating the current characteristic points, calculating the characteristic parameters, and judging whether the test is qualified. The test results show that the system has been successfully applied in nuclear power field, meets the needs of the site, and works well.

## 1. Introduction

The solenoid structure is shown in Fig. 1. Solenoid valve P port is the oil inlet, T port is the oil outlet, under normal conditions, A port, T port is usually closed, when the solenoid excitation, A port, P port is conductive.

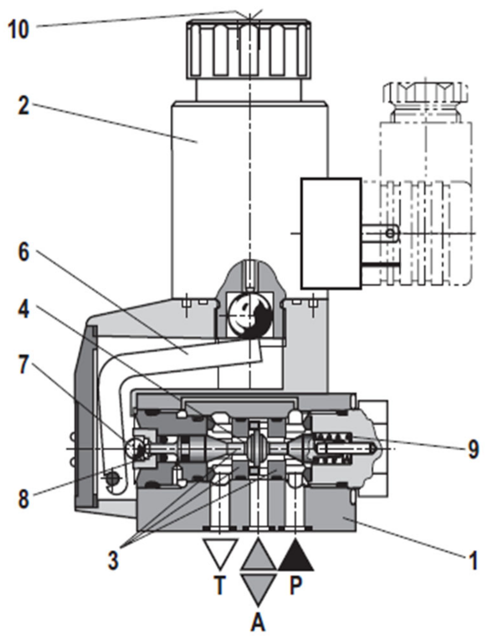


**Figure 1.** Solenoid Valve Diagram.

According to the working principle and technical standard of the jumper solenoid valve in the field steam turbine system [1-2], and in combination with the field conditions, the off-line test system of the solenoid valve is designed. Characteristic parameters such as current ratio and operating time are calculated. Firstly, the pressure of outlet A and outlet P of the solenoid valve in Fig. 1 is checked. Secondly, the current curve of the solenoid valve in on-off state is tested, and the characteristic parameters are recorded again [3]. Finally, the current curve fluctuation graph of the coil during the switching process of the hydraulic solenoid valve is calculated by drawing [4].

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## 2. Composition and function of test system

### 2.1 Hydraulic system

The system is composed of hydraulic oil pump, pressure transmitter, pressure gauge, ball valve, stainless steel pipeline, test solenoid valve, oil tank, etc. The main function of this system is to complete the pressing function of the hydraulic test platform. The system works under certain pressure by hydraulic oil pump, which makes the stainless steel pipeline form a high pressure working environment. The pressure transmitter completes the measurement of pressure throughout the pipeline.

### 2.2 Electric control system

The system is composed of upper computer, high-speed acquisition card, etc.

1) High-speed acquisition card: to achieve the system's data collection and control functions.

2) Develop Hose Computer through programming, including display module, control module, data processing module, collection module, storage module and alarm module.

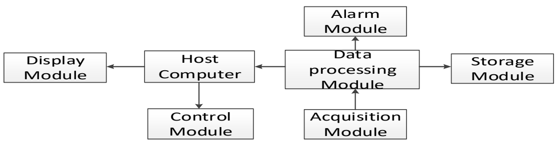


**Figure 2.** Diagram of electrical control system

The upper computer controls the pressure of the pipeline system by the oil pump through the control card. The current characteristic curve of the test solenoid valve is collected by the high speed acquisition card and uploaded to the upper computer. The upper computer calculates, processes and stores the collected information through the test software. At the same time, the upper computer can automatically judge whether the test solenoid valve is normal based on the measured data. The upper computer can also output relay control signal through the control card to control the start and stop of the measured solenoid valve. In addition, the system set up interlock protection, when the pipeline pressure is higher than the maximum working pressure, the program will automatically disconnect the hydraulic oil pump power supply, so that the pipeline pressure does not continue to rise, in addition, set the overflow valve higher than the set value for pressure relief.

After the start of the program, real-time test the level signal of the tank, judge if the filter is blocked or needs to stop in an emergency, etc. In case of an emergency, the program control automatically disconnects the power supply of the hydraulic oil pump and stops the pressure.

## 3. Software Control Design

### 3.1 Real-time testing process

Test the coil current curve fluctuation during the solenoid valve switching process. Solenoid valve P port is pressure medium inlet, this system is oil inlet, and A port is solenoid outlet, connecting downstream equipment. T is the oil return port. The pressure of the P and A ports of the solenoid is tested by installing a pressure sensor, and the measured solenoid is rated at 24VDC by programmed power supply. Current characteristic test interface. As shown in Figure 3.

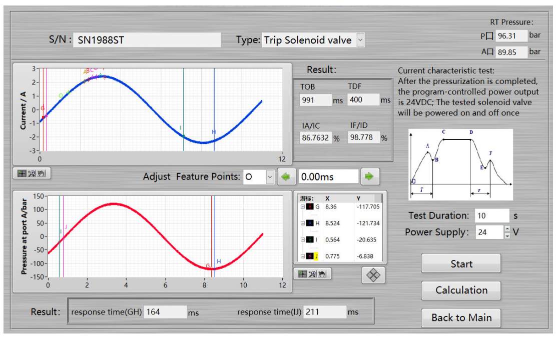


**Figure 3.** Current characteristic test interface

Operation steps:

1) Install the test solenoid valve, start the program to start the test, run the software to start the hydraulic test system, set up the pressure of the hydraulic system first, and keep at 150 bar (factory set 150bar, can increase or decrease the test pressure as required by the test)
2) Set alarm parameters, set IA/IC and action time TOB limits respectively. When the test results are outside this range, the program sets automatic alarm.
3) Set the supply voltage of the solenoid valve to 24VDC;
4) Manually open the test solenoid P-port ball valve and keep the test solenoid A-port ball valve closed;
5) Real-time test the pressure and current of the P and A ports, and observe the real-time change of the curve through the interface of Figure 3.
6) Set the test time, such as 10s, with a duty cycle of 50%, to control the solenoid valve to be tested to power on for 5S and power off for 5s, to view the current curve and the pressure change curve of port A in real time;
7) After one test, manually adjust the characteristic points of the current curve, and mark the position of each point (A~F) according to the current characteristic curve table of the solenoid valve in Fig. 4. The computer automatically calculates the current ratio IA/IC and the action time TOB and other characteristic parameters, and judges whether the test is qualified according to the set alarm value. Measure the current characteristic parameters of the solenoid valve 5 times in succession. The average value of 5 measurements is the current characteristic parameters of the test solenoid. Save the test results to the database.

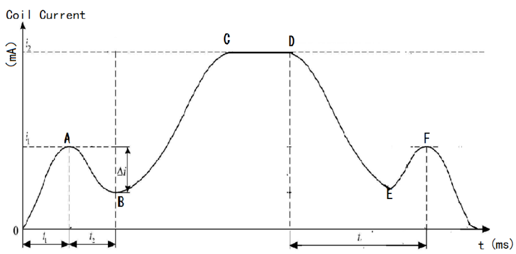


**Figure 4.** Chart of solenoid current characteristics

### 3.2 History Playback

The program has a history playback function to export the test data from the database to the display interface for experts to view the test data of solenoids. The playback interface is shown in Figure 5, where you can continue to adjust the feature points and calculate the relevant parameters. The response time can also be adjusted according to the pressure curve at port A and the report can be saved and exported.

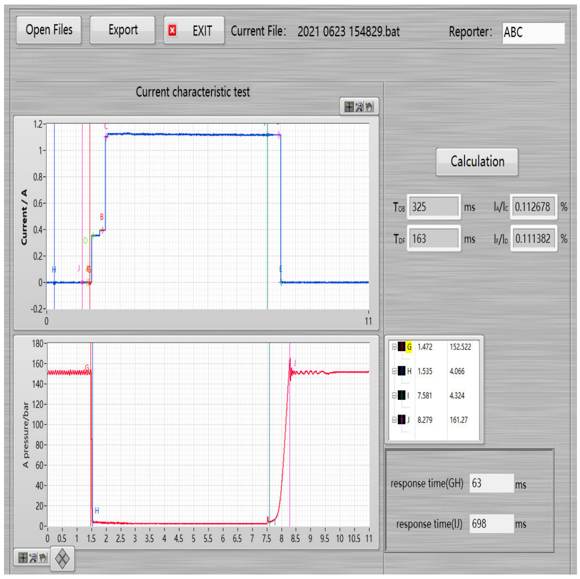


**Figure 4.** History playback interface

## 4. Conclusion

In this paper, the test platform of the hydraulic solenoid is set up, and the real-time data of the current of the hydraulic solenoid and other parameters related to the current are detected, so that the abnormal situation of the hydraulic solenoid can be accurately analyzed. The performance of the solenoid valve is determined in real time by the test results, which provides data support for the overhaul of the steam turbine system in nuclear power plant, and provides guidance for the determination of the availability of the solenoid valve in nuclear power site.

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