Test-system design for hydraulic solenoid valve of a certain aircraft

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Abstract: Based on the test requirement of hydraulic solenoid valve (YDF-16) of a certain aircraft, the test-system of YDF-16 is designed. The test-system consists of a pneumatic unit, a control measure unit and a software unit. It can be used to test the performance parameter of the YDF-16. The test-system is fulfilled the needs of aircraft repair factories and achieves good results in application.

1. Introduction
In order to improve the reliability of the aircraft control system, the aileron and horizontal tail control system can realize the automatic conversion of manpower and hydraulic, main system and power system. The aircraft YDF-16 is an accessory of the aileron and the flat tail control system, which is mainly used for the conversion of the aileron control manpower and hydraulic control, the main hydraulic system of the flat tail control and the power hydraulic system. If the YDF-16 is stuck, the transition "suspended" or oil leakage and other problems occur, the state transition of the flat tail and aileron control system will not work normally, which will lead to serious flight accidents. The test system of the YDF-16 of an aircraft is designed according to the working characteristics of the YDF-16, the operation manual of accessories and the repair standard of aircraft accessories. The system is a comprehensive test equipment with computer control, solenoid valve working state monitoring, solenoid valve parameters acquisition and processing technology. Its function is to detect the YDF-16 of a certain aircraft control system in real time, and it can also be extended to the performance detection of different YDF-16s.

2. Working principle and testing content of YDF-16

2.1. Working principle
The structure of the YDF-16 of this type of aircraft is shown in Figure 1.
It is mainly composed of shell, oil distribution plunger, piston, control plunger, bow frame, movable iron core, fixed iron core, electromagnetic coil, breaker, etc. There are three connectors on the shell, connector a is connected with high pressure, connector b is connected with oil tank, and connector c is connected with aircraft hydraulic booster.

When the left coil is powered on, the movable iron core moves to the left and pushes the control plunger to the left limit. The right side of the oil distribution plunger communicates with the oil return circuit. Under the action of the spring, the left side of the oil distribution plunger pushes the oil distribution plunger to the right limit, so that the connector a communicates with the connector c, and the high-pressure oil flows to the booster. The control system is hydraulic power assisted operation.

When the right coil is electrified, the movable iron core moves to the right, pulling the control plunger to the right limit, the right side of the oil distribution plunger communicates with the oil circuit, the right side of the oil distribution plunger overcomes the left spring force under the action of the oil pressure, pushes the oil distribution plunger to the left limit, closes the connector a, and at the same time, makes the connector c communicate with the connector b, and the operation system turns to direct manual operation.

2.2. Testing content
According to the working characteristics and technical standards of the YDF-16 of this type of aircraft, its performance test includes:

2.2.1. Sealing test
Plug the connector c, connect the connector b with the oil return circuit, add 315kgf / cm² hydraulic pressure to the connector a, turn on and off the electromagnet, keep for 6 minutes each, and no oil leakage is allowed at each connector.

Plug the connector c, add 135kgf / cm² hydraulic pressure to the connector a and B, disconnect the electromagnet, and keep it for 6 minutes. No oil leakage is allowed at each connector.
2.2.2. Working performance test

Add 20 kgf/cm² hydraulic pressure to connector a, so that the right coil of the solenoid valve is energized, and the outlet pressure is not indicated; when the left coil is energized, the outlet pressure of connector c is equal to the inlet pressure of connector a. Repeat the test 3-5 times.

Add 210 kgf/cm² hydraulic pressure to connector a, adjust the return oil pressure to 30 ± 5 kgf/cm², switch on the solenoid valve for 3-5 times, the oil distribution valve shall work together accurately, and the piston rod of the actuator shall be evenly retracted or extended without blocking.

2.2.3. Internal oil leakage test

The working oil temperature is 20 ± 10 ℃, plug the connector c, add 210 kgf/cm² hydraulic pressure to the connector a, connect two coils respectively, and measure the oil leakage of the connector b after the accessory works together for 1 minute, which shall not exceed 50 cm³ for 3 minutes.

3. Composition and working principle of test system

The test system is designed to simulate the real working environment of the tested accessories, so as to prepare for the measurement of its performance parameters. The test system is mainly composed of three parts: hydraulic system, computer control system and measurement and control software.

3.1. Principle of hydraulic system

The composition and principle of the hydraulic system are shown in Figure 2, mainly composed of oil tank, hydraulic pump, oil filter, accumulator, overflow valve, manual switch, pressure gauge, pressure regulating valve, tested parts, actuator, etc. Its function is to establish and transform the test conditions for the system. During the test, the oil inlet and outlet of the tested parts a, B and C are controlled. At the same time, D/I and D/O board are used to collect the data of oil filter working state (alarm) and temperature sensor working state (over temperature) and control them in time. The required pressure and flow of the tested YDF-16 are set, adjusted and measured by the overflow valve, pressure regulating valve, standby electric valve, and pressure and flow sensors in the hydraulic system through the D/O, D/A and a/D boards of the industrial computer. In order to facilitate the measurement of the internal oil leakage of the accessories, when the oil return circuit is closed, the tension sensor is used to sense the small change of the pressure, so as to reflect the oil leakage.

In order to detect the stability of the working state transition of the tested parts, the standby electric valve and the tested parts are used to work together to control the extension and retraction of the actuator, and the stability of the state transition of the tested parts is reflected by observing the movement stability of the actuator. In order to control the flow of multiple oil return paths in different measuring States, a flow limiting valve and a flow sensor are set up in the system.
3.2. Principle of computer control

It is mainly composed of data acquisition input part, industrial computer, data conversion output part, relevant power equipment, etc. The input part of data acquisition consists of pressure sensor, flow sensor, temperature sensor, digital analog signal conversion board, switch signal conversion board, timing/counter, and corresponding connection test circuit. The data conversion and output part is composed of multi-channel Dido board, digital analog conversion board, terminal board, electromagnetic parts of various kinds of solenoid valves, oil pump motors, oil temperature regulation and other accessories, as well as connection conversion circuit. The industrial computer is connected with a keyboard, a mouse, a printing device, and internally equipped with a measurement and control software, which can trigger the digital to analog conversion board to work. During operation, the measurement and control software completes the conversion of various states of YDF-16 and the collection, conversion, adjustment and output of various data of solenoid valve according to the predetermined scheme. The test data can be reflected on the display equipment of the test bench in time, and can be printed and analyzed if necessary.

The measurement and control software is developed by using Visual Studio 2013 software running under Windows 7 system. The software interface is simple and easy to operate. Various state transformations of YDF-16 are displayed in the form of table menu, which can be switched by clicking the mouse. Meanwhile, various state test results are displayed in the form of table on the other side of the interface, and the test results can be printed with the print button, which is convenient for users to analyze and save.
4. Main technical problems to be solved

4.1. System pressure and flow control scheme
According to the operation manual, accessories repair standard and relevant test requirements of various solenoid valves of military aircraft, the sealing performance, working performance and other parameters of YDF-16 are tested under specific pressure and flow conditions. The industrial computer is used as the controller to control the pressure sensor and the pressure regulating valve according to the predetermined change rule by using the measurement and control software, so as to realize the PID control of the pressure parameter of the YDF-16; the flow sensor and the overflow valve are controlled to realize the PID control of the flow parameter of the YDF-16.

4.2. Hydraulic system adopts hydraulic integration technology
According to the characteristics of high detection frequency of YDF-16, the test device of YDF-16 is required to be convenient for moving and maintenance. This test system installs the hydraulic components on all sides of the oil circuit block by integrating the hydraulic oil circuit block. The hydraulic components can be installed in plate type and plug-in type, such as the oil return filter, single direction valve, throttle and pressure regulating valve, which form the oil return hydraulic integrated block. By this way, the requirements of light weight and good maintainability of the testing device are realized.

5. Conclusion
Since the test system was delivered to the aircraft repair shop in 2011, more than 50 pieces (sets) of 10 batches of products have been repaired. The test and application prove that the test system has the characteristics of automatic and manual conversion, accurate test results, good safety performance, portable and so on. It solves the problems of low test efficiency, easy pollution and damage of the tested parts of the existing test equipment in the factory. The test system is widely used in the army and repair shop, which is of great significance to improve the repair efficiency of YDF-16 accessories,
ensure the safety of accessories maintenance, and shorten the time of aircraft returning to the factory for overhaul.

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