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Research Based on AMESim of Electro-hydraulic Servo Loading System

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Abstract. Electro-hydraulic servo loading system is a subject studied by many scholars in the field of simulation and control at home and abroad. The electro-hydraulic servo loading system is a loading device simulation of stress objects by aerodynamic moment and other force in the process of movement, its function is all kinds of gas in the lab condition to analyze stress under dynamic load of objects. The purpose of this paper is the design of AMESim electro-hydraulic servo system, PID control technology is used to configure the parameters of the control system, complete the loading process under different conditions, the optimal design parameters, optimization of dynamic performance of the loading system.

1. Introduction

The electro-hydraulic servo loading system is one of the main equipment in the aircraft design stage of semi physical simulation on the ground, with the loading process of various loads to simulate the aircraft in launching and flying in the process of the bear, in order to test the aircraft shell strength and other mechanical properties, and provide experimental data for the development of new aircraft, the performance of applications\footnote{1-2}. Because of the servo hydraulic control system is a force feedback system for simulating various loads in the simulation process, the electro-hydraulic servo loading system is a complex system which is very complex in the machine - electric - liquid, which relates to the comprehensive content of system dynamics, hydraulic transmission, control theory and computer control science.

2. Electro-hydraulic servo loading system principle and composition

2.1 Basic Principle of Electro-hydraulic Servo Loading System

Hydraulic servo control system is a kind of control system which is based on hydraulic cylinder mechanism. It can not only automatically quickly and accurately reproduce the input output variations, and can carry out amplification and to transform the input signal. The utility model has the advantages of small size, light weight, small inertia, high torque and high control precision\footnote{3}.

Electro hydraulic servo loading system, as a kind of hydraulic servo control system, can be divided into two categories according to the motion of the object. The first one is on the structure and material of the...
static and dynamic strength test loading system, known as static load or active loading, structure of the system is relatively simple, easy to realize correction; the other is to load the active motion of the object, called motion loading or passive loading, because this kind of system interference bearing object motion parameters, the system structure is complex, it is difficult to analyze and design.

FIGURE 1. Diagram of electro hydraulic servo loading system

The design of the electro-hydraulic servo system block diagram as shown in fig 1. It mainly consists of input, controller, servo valve, hydraulic cylinder, load and sensor. Stretching through the servo valve control hydraulic cylinder, so as to realize the load control, the load force sensor through the sensor installation, incoming input in the load test data of input data and the feedback data are compared, the difference re input to the controller, to achieve control of the servo valve flow.

2.2 Composition of Electro-hydraulic Servo Loading System
Electro hydraulic servo system is generally composed of the loading system and the load object, the executive component has a hydraulic cylinder and a hydraulic motor. The design of the hydraulic system is mainly composed of hydraulic pump, hydraulic cylinder, servo valve, servo controller, relief valve, force sensor, accumulator, filter, cooler and so on. In the AMESim to establish electro-hydraulic servo loading system hydraulic model, as shown in Figure2.

FIGURE 2. Hydraulic model of electro-hydraulic servo loading system
The electro-hydraulic servo loading system adopts closed-loop control, tension and pressure signal of You Li sensor loading hydraulic cylinder output, measured after feedback to the controller and input signal before comparing the error signal formed by PID controller after input to the servo valve, servo valve spool movement, increase or decrease the output force servo the output pressure and loading cylinder, the force sensor and the input error is reduced, and the hydraulic cylinder output force is equal to the input.
3. Simulation and analysis of electro hydraulic servo loading system

3.1 Simulation of Electro-hydraulic Servo Loading System

In this paper, the electro-hydraulic servo loading system, the use of AMEsim simulation software, the simulation model of the loading system the simulation analysis. According to the above calculation, the parameters of the hydraulic components are determined, the parameters of the components are set in the software, and the leakage of the oil is ignored.

The parameters of the hydraulic simulation system are set, as shown in table 1.

| Parameters of electro hydraulic servo loading system       |
|-----------------------------------------------------------|
| Rated current of servo value (mA)                        | 150 |
| Servo valve natural frequency (Hz)                       | 50  |
| Hydraulic cylinder rod chamber volume (cm³)              | 700 |
| Hydraulic pump speed (r/min)                             | 1450|

Set AMESim simulation time is 10s, the simulation step is 0.1s, select the following 3 groups of PID controller parameters: Kp=6, Ki=0, Kd=0; Kp=6, Ki=0.1, Kd=0; Kp=30, Ki=0, Kd=0. The hydraulic model of AMESim is simulated, and the influence of PID controller on the input signal is compared.

![FIGURE 3. System response of different PID parameters](image)

The response of different PID parameters to the system is shown in figure 3. You can see from Figure 3, the input pressure of 30N, when Kp=30, Ki=0, Kd=0, 2.7s in the system when the system reaches the specified value, but large overshoot and instability of the system; when Kp=6, Ki=0.1, Kd=0, 4.5s in the system is stable, and no overshoot. The error is 2N greater than the input value; when Kp=6, Ki=0, Kd=0, 4.3s in the system is stable, and no overshoot, steady-state error is 0.1N. The simulation result shows that the increase of the proportion coefficient Kp, can shorten the system response time, speed up the system response, reduce the steady-state error, but the proportion coefficient is too large, causing the overshoot will increase, not conducive to the stability of the system. Increasing the integral coefficient Ki can reduce the overshoot of the system and reduce the steady-state error of the system.

3.2 Effect of PID Value on Hydraulic Cylinder

Electro hydraulic servo loading system output force depends on the size of the hydraulic cylinder two large hydraulic pressure. The stability of the two chamber pressure of the hydraulic cylinder directly
determines the response time, overshoot and steady-state error of the output force, which mainly depends on the change of the hydraulic pressure of the hydraulic cylinder in the two chamber. As shown in Figure 4, $K_p=6$, $K_i=0$, $K_d=0$ pressure change curve of the two cylinder. You can see from chart of hydraulic cylinder pressure changes after $4.3s$, two cavity stabilized, rod chamber pressure is $2.7MP$, non rod chamber pressure of $1.5MP$, combined with the response of the system is shown in Figure 3, after $4.3s$, the stability of output power, and no overshoot, steady-state error is small.

![Figure 4. Kp=6, Ki=0, Kd=0 hydraulic cylinder pressure curve](image)

When $K_p=6$, $K_i=0.1$, $K_d=0$, the pressure change of the hydraulic cylinder system is shown in figure 5. The pressure of the hydraulic cylinder is increased, the pressure of the rod cavity is increased rapidly, and the pressure of the non rod chamber is kept constant.

![Figure 5. Kp=6, Ki=0.1, Kd=0 hydraulic cylinder pressure curve](image)

4. Conclusion
(1) Establish the hydraulic system diagram of the electro-hydraulic servo loading system, and analyze the response of the AMESim system.
(2) Using different PID control parameters to simulate the system, the optimal control parameters are obtained, and the influence of different parameters on the force response is analyzed.
(3) Under different parameters, the size of the pressure change of the rod and the rod cavity of the hydraulic cylinder is obtained, and the optimal PID value is obtained.
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