Research and Simulation of Differential Control System Based on AMEsim Preparation of Magnetorheological Elastomers

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Abstract

Is discussed by combining two two-way valve and damping hole of differential circuit, analyses the characteristics of the pressure, flow rate, and set up the primary circuit in the AMEsim software model, its reliability is simulated.

Keywords:

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Two-way valve, Differential circuit, AMEsim.

1. Introduction

Hydraulic transmission system which has been widely applied in a speed control circuit for the hydraulic cylinder differential control circuit, the essence of which is two cavity hydraulic cylinder is connected with the hydraulic oil, at the same time using the difference on both ends of the piston area, the hydraulic cylinder rod cavity discharge all the oil into the hydraulic cylinder and rodless cavity, with small capacity hydraulic pump to achieve the fast movement of the piston, reduce the auxiliary time, improve production efficiency[1]. Cylinder differential connection, one approach is to achieve the fast movement differential control circuit which are now commonly used alternately one-way valve control mode, the two three-way valve control mode, and using the OP type three four-way reversing valve in the valve differential circuit, but the above three kinds of complicated circuit structure, fluid resistance and pressure loss is big, if can use two-way valve combined with damping hole of differential circuit, the corresponding fast, simple structure, improve the work efficiency reduce the cost of manufacture, use and optimize configuration of the hydraulic system[2].

2. Circuit Composition and Working Principle Analysis

The differential control circuit of hydraulic cylinder is to return the oil from the piston rod cavity to the non-rod cavity of the hydraulic cylinder, thus increasing the flow of the non-rod cavity and increasing the extension speed of the piston rod. Using two-way valve and damping hole with absolute motion of components of the model as shown in Fig. 1, because of the two-way valve (unilateral valve) is only one variable LiuKou, must be used together with a fixed orifice, to control the cavity pressure, used to control the differential hydraulic cylinder. The valve core moves relative to the valve body and the valve housing is connected to the rack.

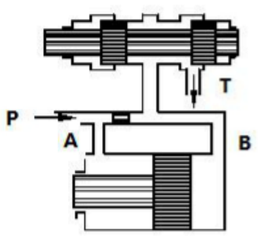

Fig. 1 Structure diagram of the two-way valve

According to the flow formula of fixed damping hole

$$q = c_q A_T \sqrt{\frac{2\Delta p}{\rho}} \tag{1}$$

In the formula: c_q—Flow Coefficient;

A_T—Flow area, m2;

Δp—Differential pressure across the orifice, N/m2;

ρ —Oil density, kg/m3;

When the control valve does not slide, there is no liquid flow in the orifice, ie the flow rate is zero, so the pressure difference across the orifice is zero. At this point, the oil source enters the two chambers of the hydraulic cylinder and the cylinder is formed at the equivalent pressure P_s. Differential circuit, piston movement, piston rod extending, reaching the end of the stroke; when the external force moves the valve core to the left or right, the fluid in the rodless cavity of the hydraulic cylinder flows back to the tank through the T port, and most of the oil source fluid enters the tank. The rod cavity pushes the piston to move. The piston rod is retracted. A small part of the liquid flows through the orifice and the piston chamber and the liquid flows back to the tank. The hydraulic cylinder completes the telescopic movement.

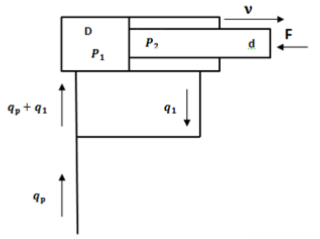

Fig. 2 Equivalent circuit of differential state of hydraulic cylinder

In the differential circuit, as shown in Fig. 2, the pressure in the hydraulic cylinder is less than that of the hydraulic cylinder, which can overcome the load and stretch out. According to the force balance condition of piston, there is

$$p_1 A_1 - p_2 A_2 = p_3 = F \tag{2}$$

In the formula: A_1, A_2—It is known that the hydraulic cylinder has no rod cavity and the effective area of the rod cavity

p_1, p_2—The hydraulic cylinder has no rod cavity and pressure of rod cavity

F—The hydraulic cylinder load is known

p_3—Total thrust of hydraulic cylinder

When the piston moves with the velocity V, the hydraulic cylinder has the oil fluid flowing through the damping hole, and the oil flowing out of the hydraulic pump flows through the hydraulic cylinder without the rod cavity. The pressure of the rod cavity p_2 should be greater than the pressure of the no-bar cavity p_1. According to the flow characteristics of the liquid, there is

$$p_2 - p_1 = \Delta P \tag{3}$$

Therefore, if the pressure loss of the liquid is neglected, there is

$$\begin{cases} p_2 = p_1 = p_p \\ p_3 = F = p_1 A_1 - p_2 A_2 = \frac{1}{4}\pi d^2 p_1 \end{cases} \tag{4}$$

As can be seen from formula (4), the hydraulic thrust of the hydraulic cylinder differential circuit is less than the hydraulic thrust of the non-differential circuit of the hydraulic cylinder ($P_1 = p_1 A_1$). According to the characteristics of hydraulic cylinder differential circuit, there is

$$q_1 = q_p + q_2 \tag{5}$$

$$q_p = q_1 - q_2 = (A_1 - A_2)V$$

or

$$V = \frac{q_p}{A_1 - A_2} = \frac{4q_p}{\pi d^2} \tag{6}$$

It can be seen from formula (6) that the speed of the differential circuit of the hydraulic cylinder is greater than that of the non-differential loop of the hydraulic cylinder ($V = \frac{q_p}{A_1}$), so it can realize the rapid movement of the hydraulic cylinder piston.

3. Loop Dynamic Simulation

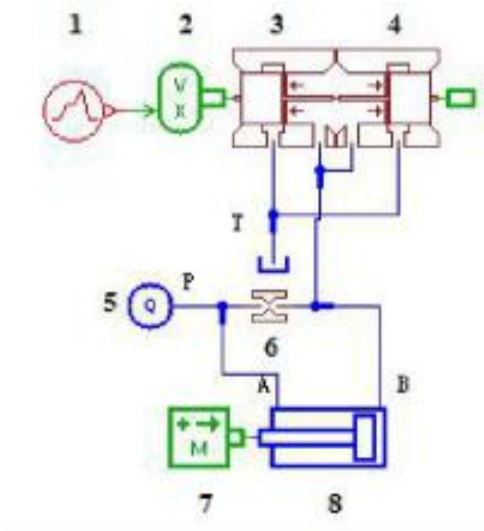

Fig. 3 models established in AMESim.

Table 1 component parameters

Element number	parameter	The set value
1	Number of stages	3
	Output at start of stage 1	100
	Output at end of stage 1	100
	Duration of stage 1	5
	Output at start of stage 2	0
	Output at end of stage 2	0
	Duration of stage 2	5
	Output at start of stage 3	-100
	Output at end of stage 3	-100
	Duration of stage 3	5
5	Number of stages	1
	Flow rate at start of stage 1	2
	Flow rate at end of stage 1	2
6	Equivalent orifice diameter	1

AMESim is a system for the simulation of the hydraulic system simulation software, this paper USES the characteristic of the hydraulic components library and machine shop model to build the two two-way valve combined with damping hole of differential circuit. After the relevant parameter setting, the motion response of the hydraulic circuit can be observed. The initial parameters of the main elements in the simulation model loop are shown in table 1.

In AMESim circuit model is set up as shown in Fig. 3, cell 1 is the control signal of the valve core displacement, is the role of component 2 dimensionless data into the displacement and velocity, component 3, 4 represent the ring opening, sharp edge throttling valve core convex shoulder model, component 5 is used to simulate the system flow, element six is a damping hole, 8 hydraulic cylinder components, components 9 is quality, load simulation system.

4. Simulction Results and Analysis.

After setting the parameters in the model, enter the simulation mode and run the simulation to get the displacement simulation curve of the hydraulic cylinder as shown in (4).

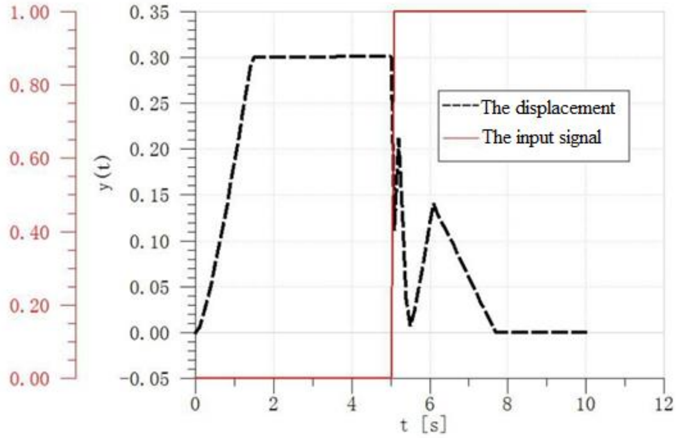

Fig. 4 displacement simulation curve of the two-pass valve control system.

Can be seen from Fig.4: t = 0 s ~ 5 s, when the control valve without sliding, no liquid flow in the damping hole, which is q = 0, it is concluded that ΔP = 0, the oil into the hydraulic cylinder's two cavity, under pressure from equivalent hydraulic cylinder differential connection, the piston movement, the piston rod out, after reaching trip still; T =5s~10s, hydraulic cylinder piston rod is at rest position; T = 10 s ~ 15 s, when the external force to make the valve core movement to the left or right, the piston through t mouth cavity liquid flow back to the fuel tank, oil source most fluid into a cavity, drive piston movement, the back of the piston rod, a small number of piston cavity liquid will merge with the liquid flows through damping hole back to the fuel tank, hydraulic cylinder complete telescopic movement, the simulation result is correct.

5. Summerizes

By two two-way valve is presented in this paper combined with damping hole hydraulic differential circuit composed of model, through professional hydraulic dynamic simulation software AMEsim analyzes the movement characteristics of the circuit, it can be seen that the loop motion performance is good, can realize the rapid movement of the hydraulic cylinder piston. The results show that the hydraulic circuit has the following working characteristics: 1) the differential circuit is suitable for the small load short-range fast moving circuit, and has less interference; 2) compared with other differential circuits, the hydraulic circuit has high transmission efficiency and can save cost.

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