# Research on Design of Orbital Suspension Chain Transportation System

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## Abstract

In order to better adapt to the working conditions, the filling hydraulic support should not only have a reasonable structure design, but also have a stable and reliable hydraulic system and hydraulic components. At present, the hydraulic control system of filling support has many problems, such as many kinds of valve components, high manufacturing precision, long conveying distance of hydraulic system and poor working environment. Therefore, this paper firstly analyzes the working principle of hydraulic support of filling support, and then simulates the main control loops of column and sliding frame with AMESim software. The designed filling support fluid is verified by analyzing the speed, acceleration, displacement and pressure change curves of the two main control loops. The pressure control loop meets the working requirements and is stable and reliable.

## Keywords

Filling stents; hydraulic system; AMESim; pillar.

## 1. Introduction

The hydraulic system of filling hydraulic support is designed as pump cylinder open system. The high-pressure emulsion output from pump station is connected with main control loop such as column and jack through high-pressure hose and pipe connecting head[1-4]. The valve parts are controlled to open to realize the required action requirements of filling hydraulic support, and the functions of supporting and sliding frame are completed. Hydraulic system is mainly composed of power mechanism, operation mechanism, actuator and auxiliary mechanism. Hydraulic pump is the power source of hydraulic control system, takes emulsion as working medium, and hydraulic cylinder of each component is the original part of the system. The control mode of the adjacent brackets is the same, which is connected with the main loop pipe through the globe valve, but it is independent in control. When a bracket fails, it can be maintained independently, which has little influence on the hydraulic control system. The main characteristics of hydraulic control system of filling support are: large pressure supply of hydraulic system; complex hydraulic control system, a variety of valve components; high manufacturing accuracy of hydraulic components; long conveying distance of hydraulic system, poor working environment. Therefore, it is necessary to analyze the hydraulic control system of the hydraulic system of the filling hydraulic support.

## 2. Working principle analysis of filling support hydraulic control system

The filling support can be moved automatically by the power provided by the hydraulic pumping station. Pumping station outputs emulsified liquid with pressure through the main inlet pipe to the filling support. Under the control of the valve group, the oil transmitted by the pump station can be transported to the jack working chamber such as pillar, push, guard, gangue, tail beam, movable side guard plate, and then drive the pillar and Jack to expand and shrink to fill the support. Required action state. The filling hydraulic support supports roof beams through columns to maintain roof stability and reduce subsidence. When the roof slips or leaves the layer, the pressure of the top beam increases and the force is transferred to the column, so that the pressure of the lower chamber of the column increases[5-7]. When the pressure is greater than the pressure of the relief valve, the emulsion is ejected from the relief valve to complete the relief, and the pressure decreases so that the column shrinks to achieve the landing frame. However, the pressure on the adjacent support is not necessarily lower than the rated pressure, so the roof subsidence pressure on the support will be transferred to the adjacent support roof beam, reducing the force on the support. When the pressure in the lower chamber of the column drops below the predetermined value of the safety valve, the column will return to normal working state, continue to provide initial support for the roof beam, and then support. Top plate.

## 3. Key circuit analysis of filling support hydraulic control system

### 3.1 Column basic control loop

(1) control principle

The new roof will be exposed when the hydraulic support moves one step. In order to ensure the safety of the filling mining face, the pillar should be immediately lifted. The solenoid directional valve is in the right position, the main inlet pipeline is opened, the liquid flows through the hydraulic control one-way valve to the lower chamber of the column, the upper chamber returns the liquid, and the bracket lifting column makes the roof beam cut and support into the initial support stage; when the reversal valve is in the middle position and the roof pressure increases, the pressure of the lower chamber of the column increases and the resistance increases continuously, when the pressure of the lower chamber is greater than the safety valve. Preset pressure relief, maintain the pressure stability of the lower chamber to avoid damage to components, and can support the roof smoothly; when the end of mining need to move the frame, the reversing valve should be left, the liquid through the hydraulic control one-way valve flow to the upper chamber of the column, the lower chamber back to the emulsion chamber of the pump station, the support column contraction landing frame. In this regard, the simulation loop designed is shown in Figure 1.

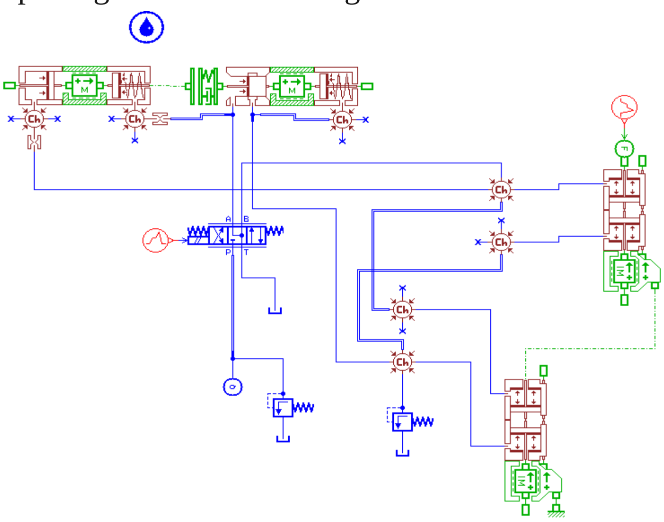
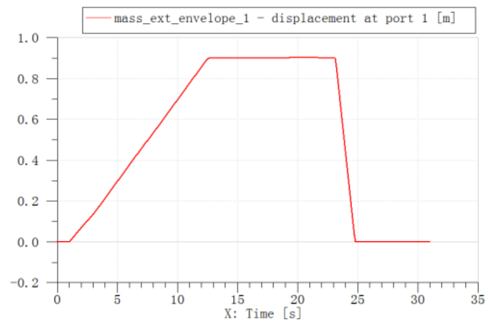
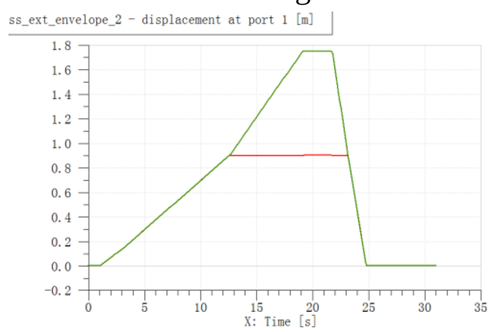


Fig.1 Column control circuit

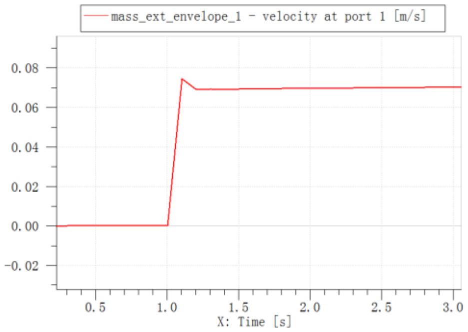
(2) simulation analysis of column control loop

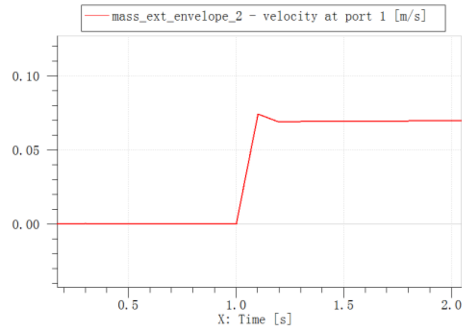
The hydraulic control circuit is equipped with large flow electromagnetic directional valve, hydraulic control one-way valve and safety valve to maintain hydraulic stability. According to the requirement of hydraulic system of filling support, the diameter of the first column is 230/220 mm, the diameter of the second column is 180/160mm, the total stroke of the column is 1790 mm, the resistance-increasing mass block is 100 kg, the safety valve is 31.5 MPa, the output flow Q of the pump station is 200 L/min, the control signal is 100, the lift column simulation is 17.3 s, the drag-increasing simulation is 3 s, the total simulation is 31 s. The simulation step size and allowable error are given. The simulation results of the lifting process of the column are shown in Figure 2 below.



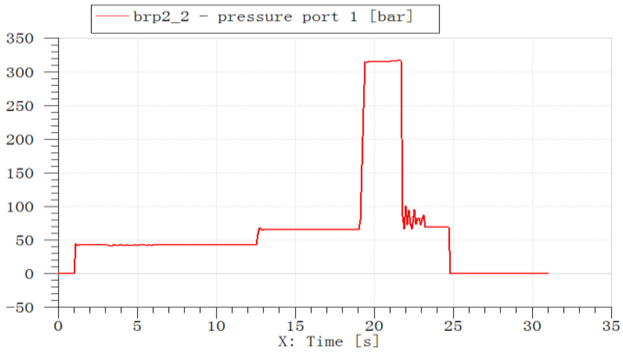




(a) Displacement curve of first column (b) Total column displacement curve




(c) The velocity curve of the first column (d) Two column speed curve drawing




(e) Pressure curve of column space

Fig.2 Simulation curves of column control circuit

As shown in Fig. 2, the simulation curve of the control loop of the column is shown, and the simulation buffer stage of the 1s system is designed in the simulation. When the column rises, the velocity of the first stage rises to 0.07 m/s because the valve body is impacted by high-pressure liquid, and then keeps stable. The piston rod extends steadily for 11.5 s. When the velocity of the secondary column rises to 0.07m/s in the initial stage, it keeps stable. The overall displacement of the secondary column rises to 1790mm at about 18s, and the stage of the secondary column ends. After entering the stage of increasing resistance, the displacement remains unchanged for 3 seconds. When the pressure of the lower chamber of the column increases to 31.5 MPa, the support roof beam supports the stability of the roof. After entering the column drop column stage, the reversing valve is in the left position, the column pressure drops rapidly with a certain hydraulic impact, and then completed in about 25 seconds down column. From the above graphic data, it can be concluded that the electro-hydraulic reversing valve, 31.5 MPa safety control valve and the hydraulic control one-way valve selected in the column control circuit meet the working requirements under the above design parameters, and the hydraulic control system remains stable. In addition, it is concluded from the diagram that the fluctuation is obvious in the simulation opening stage of the column, and the lower chamber of the column can be reasonably enlarged to reduce the impact and improve the stability of the hydraulic control system.

### 3.2 Transfer jack control basic circuit

(1) control principle of moving frame and pushing slip

The sliding and shifting loop controls the moving frame and the scraper conveyor to move forward through the manual reversing valve. When the bracket needs to be moved, the reversing valve is arranged on the right, and the high pressure liquid enters the pushing jack cavity through the one-way valve, and flows out from the lower cavity to return to the tank, so that the filling bracket is moved with the scraper conveyor as the support point. Subsequently, the filling hydraulic support moves a step behind the lifting column, to achieve good support for the roof of the support roof beam, the control valve in the left valve position, high-pressure liquid directly into the jack chamber; the upper chamber fluid flow through the directional alternating valve and back to the jack chamber, to achieve differential connection, the use of small pressure can complete the push-slip condition. At this point, the scraper conveyor is pushed to the coal wall with the support as the fulcrum. The simulation model of the sliding and moving control loop is designed as shown in Figure 3.

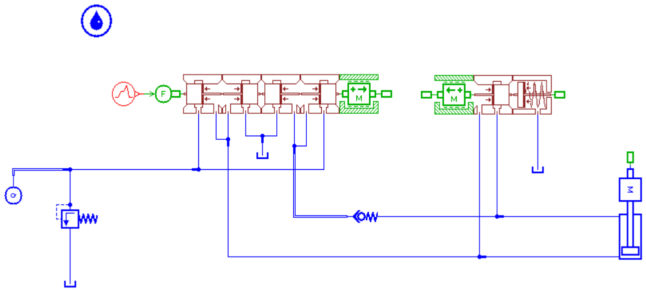
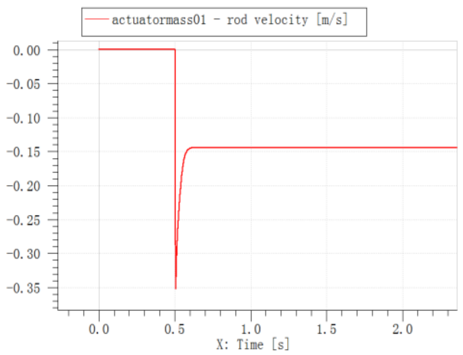


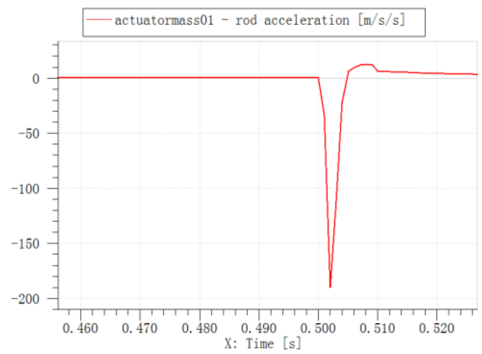
Fig.3 Jack in control circuit

(2) simulation analysis of moving jack

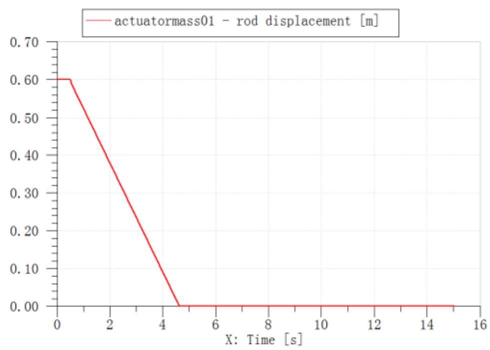
The hydraulic cylinder diameter is 160mm, the piston rod diameter is 105mm, the working distance is 600 mm, the mass is 80 kg. When the signal of the reversing valve is 100, 0.5 s, the operation begins, the time is 15 s, the simulation step is s, and the allowable error is allowed. The simulation of the moving frame process obtained by the standard calculator mixing error is shown in Figure 4.




(a) Frame velocity



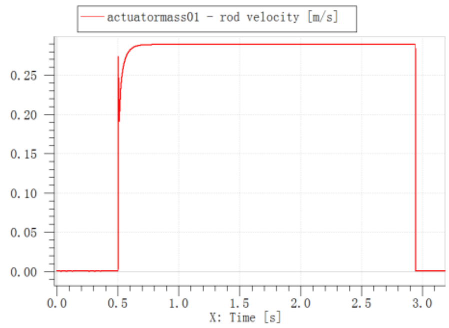

(b) Frame acceleration

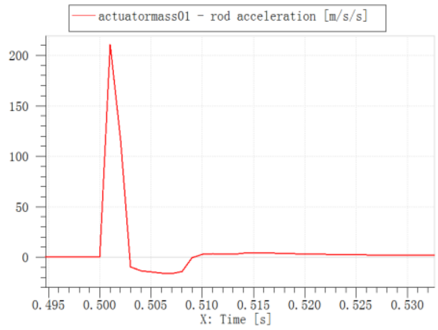



(c) Displacement of frame

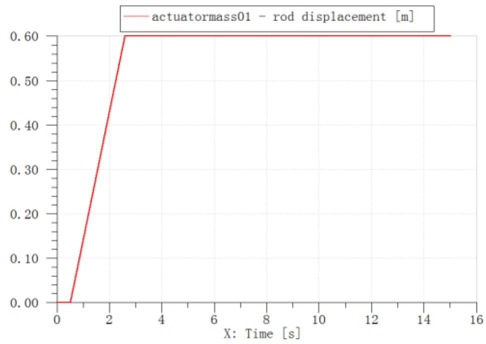
Fig.4 Simulation of moving frame process

According to the simulation curve of frame shifting in Fig. 4, the system appears short-term oscillation under the influence of reversing valve and one-way valve at the initial stage, and the small peak value has little influence on the whole frame shifting process. The moving speed rises to 0.15m/s at 0.6s, and the acceleration tends to be stable after a short vibration between 0.501 and 0.510. The moving speed is 0.15m/s after 0.5s, and the moving time is 4.6s at 0.6m. In addition, differential connection is adopted in the push-slip process, and the input signal of the directional valve is -100. The simulation results of the control loop are shown in Figure 5.




(a)Sliding speed simulation diagram (b)Sliding acceleration simulation diagram




(c) Sliding displacement simulation diagram

Fig.5 Simulation curve of sliding process

The velocity and acceleration oscillated for a short time at about 0.5s, then the acceleration remained stable. The sliding was carried out at the speed of 0.29m/s, and the whole sliding process was completed at about 2.5s. As shown in Figs. 3-27 and 3-28, the simulation model of the push-over jack is stable as a whole, and only in the initial stage of the simulation, when the hydraulic impact produces a small vibration, the overall simulation meets the design requirements.

## 4. Conclusion

By analyzing the working principle of the filling support and simulating the control loop of the filling support with AMESim software, it can be concluded that the electro-hydraulic reversing valve, the three safety control valves and the one-way hydraulic valve selected in the control loop of the filling support meet the working requirements, and the hydraulic control system keeps stable, while the pillar simulation opens. The stage fluctuation is obvious, and the lower chamber of the column can be reasonably enlarged to reduce the impact and improve the stability of the hydraulic control system in the design. The simulation model of the push-jack is stable as a whole, and only in the initial stage of the simulation, the hydraulic shock produces a small vibration, and the overall simulation meets the design requirements.

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