Optimization of Control System for Propelled Mining Hydraulic Support

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Abstract

This article briefly describes the working principle of the commonly used hydraulic support, then sums up the selection principles and improvement measures of each component from the control system, analyzes the existing hydraulic control system circuit, proposes a floating double-directional lock circuit, and optimizes the control circuit, and use FluidSIM software to simulate its feasibility.

Keywords

Hydraulic support, Fully mechanized mining, Floating two-way lock, Fluid SIM.

1. Introduction

The problem of underground support and shielding of coal mines has always been an important issue that hampers the efficient and safe production of coal. The birth and development of comprehensive mechanized mining with hydraulic supports as the main equipment is a revolution in the history of coal mine production. It not only improves labor and safety conditions, but also lays the foundation for the rapid increase in coal production and efficiency. Comprehensive mechanization of coal mining is a strategic measure to accelerate the development of coal industrialization in China, greatly increase the efficiency of coal mining work, and realize modern industrialization of coal. Fully-mechanized coal mining not only has large output, high efficiency and low cost, but also can reduce physical labor and improve the working environment.

2. Mine hydraulic support control system optimization

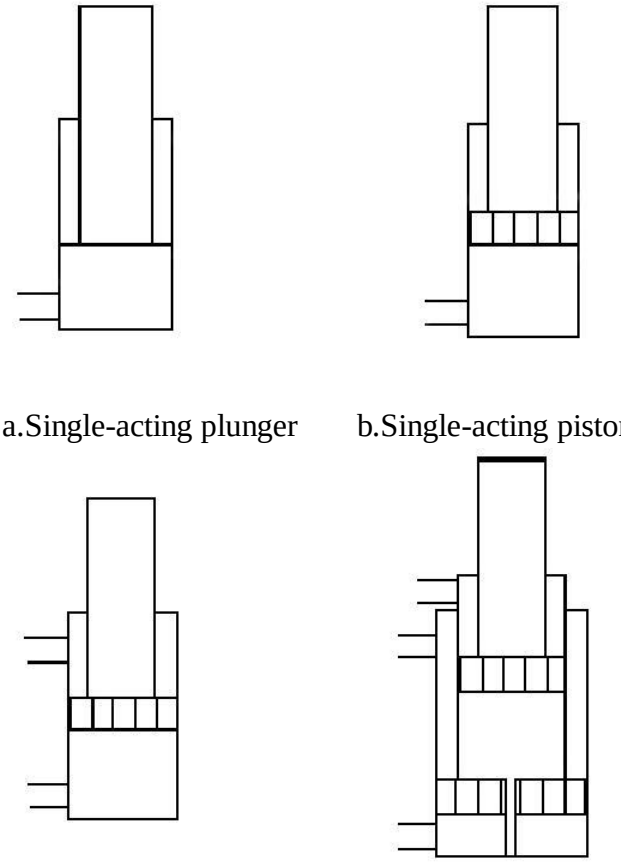
The moving parts of the hydraulic support are different numbers of columns and jacks, and different operations are used to achieve such actions as lifting the column, lowering the column, moving the frame, and pushing and sliding. Although the types and quantities of hydraulic cylinders for hydraulic supports are numerous, their hydraulic systems are parallel systems that use multiple actuators.

2.1 Main hydraulic components

2.1.1 Column

The hydraulic support column is a component that connects the top beam of the support and the base, and it receives the load of the top plate. It is the main bearing component of the support. The column has enough strength, reliable work, long service life and so on. Columns are divided into single-acting columns and double-acting columns according to different actions. They can be divided into piston-type and plunger-type according to different structures. They can be divided into

single-retractable and double-retractable columns according to their different types of expansion and contraction. The typical type of column is shown in Fig. 1.



a.Single-acting plunger b.Single-acting piston

c. Double-acting plunger d.Retractable

Fig. 1 Column type

2.1.2 Pilot check valve

The pilot-operated check valve is the main control and adjustment component of the hydraulic support. During the lifting of the hydraulic support, the pilot-operated check valve opens positively to allow the system to rise. When the hydraulic support works normally, the pilot-operated check valve acts as a reverse cutoff to maintain system pressure. When the hydraulic support is lowered, the pilot-operated check valve opens in the opposite direction to realize the unloading of the system, and at the same time, the shock vibration of the system can be reduced, and the performance of the system is directly determined.

2.1.3 Safety valve

The safety valve is also called a constant pressure valve. It is combined with a pilot-operated check valve and is an indispensable control valve for the hydraulic support. The safety valve is an important element that enables the stand to maintain its balanced working characteristics and scalability, and it is under high pressure for a long period of time. The regular operating state of the stent depends on the gradual increase of pressure on the roof and the extremely slow sinking of the roof rock. If the safety valve seal performance is not good, it can not guarantee that the stent reaches the designed working resistance. Therefore, the safety valve is required to be sensitive to the action, the valve opening pressure and the closing pressure difference are very good, there is a certain amount of unloading opening, the seal is reliable and the work is stable, there is no shock phenomenon, there is a long service life, the structure is simple, easy to disassemble and install.

2.1.4 Control valve

The control valve is a switch that controls the hydraulic cylinders to move in and out of the oil circuit so that the column can perform various actions. Therefore, it requires high sealing performance, reliable work, and convenient operation. The function pass and the number of positions of the control valve must meet the motion requirements of the support. When the function of the control valve is generally at the stop position, all the passages should be returned to the liquid, which is equivalent to the "Y" function. Therefore, the control valve should have a high pressure inlet and a low pressure return port. Valves according to different control, can be divided into manual control, hydraulic control, electronic control and electro-hydraulic control of four, according to the principle of action can be divided into reciprocating and rotary type two.

2.2 Ordinary locking circuit

2.2.1 Working principle

The hydraulic circuit of the shelter type bracket generally adopts the ordinary two-way lock hydraulic circuit as shown in Fig.2. The hydraulic circuit is composed of a balance jack, a safety valve, an ordinary two-way lock and a reversing valve.

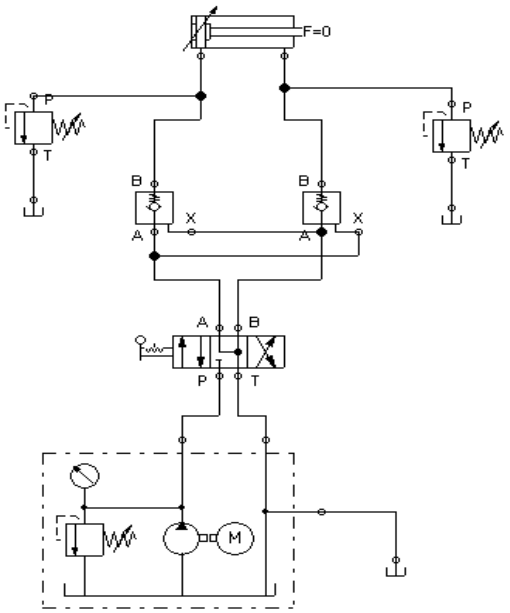


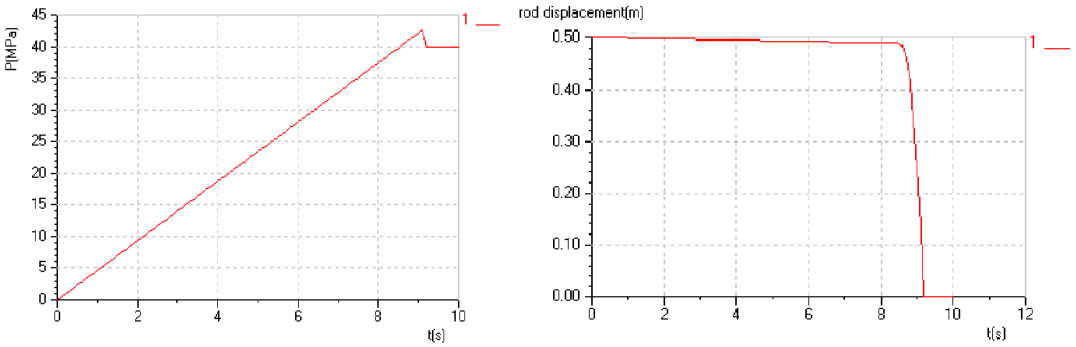
Fig. 2 Ordinary hydraulic two-way lock circuit

When the reversing valve is in the left position, the left one-way valve in the figure is opened and the piston rod cavity is supplied with liquid. At the same time, the liquid-controlled one-way valve control fluid opens the right one-way valve, and the piston cavity returns liquid to extend the piston rod; When the three-position four-way reversing valve is in the right position, the right one-way valve is opened and the piston chamber is supplied with liquid. At the same time, the liquid-controlled one-way valve control fluid opens the left one-way valve, and the piston rod chamber returns fluid and the piston rod retracts. In this way, under the different median positions of the three-position four-way reversing valve, the action of the piston cylinder is realized, and locking is performed to prevent liquid return.

2.2.2 Dynamic performance analysis

An ordinary two-way lock control loop model is constructed in the Fluid simulation software Sketch mode. The stage of simulation is the process of lifting the column from the column to the top of the roof beam and compacting it. In this process, the reversing valve of the jack is in the neutral position, ie the two-way lock is locked. The main parameters of the system components are set in the Parameters mode: the pump's flow rate is 560L/min; the jack's bore diameter and rod diameter are 245mm and

195mm respectively; the set pressure of the safety valve is 40MPa. Simulated operation in the run mode, the pressure curve and the piston displacement curve of the valve of the ordinary two-way lock safety valve are obtained, as shown in Fig. 3 .



a. Pressure relief valve pressure curve b.Hydraulic cylinder piston displacement curve

Fig. 3 Ordinary locking circuit dynamic characteristics

2.2.3 Shortcomings and weaknesses

At present, this kind of circuit is commonly used in the lifting circuit of the hydraulic support. Due to the constant pressure increase of the safety valve in the continuous pressurization of the piston chamber of the hydraulic cylinder, the frequent opening of the safety valve may cause an excessively high working condition of the top plate of the hydraulic support, which brings about a great potential safety hazard. At the same time, due to the frequent rise and fall of the downhole column, the safety valve will frequently leak fluid, exhausting the piston rod stroke and damaging the jack.

2.3 Floating two-way lock loop

2.3.1 Working principle

The floating two-way lock loop is composed of two parts, as shown in Fig. 4, that is, two identical back pressure check valves are added to the common two-way lock loop. The set pressure of the back pressure valve is 25 Mpa, and the set pressure of the safety valve is 40 MPa. When it is necessary to achieve the column-lifting action, the high-pressure lock is automatically opened and the piston is operated under the low pressure lock setting pressure limitation. In the process of not reaching the set pressure, the piston chamber is constantly pressurized, and when the set pressure is reached, the low pressure lock is opened and the piston chamber is relieved of pressure in a timely manner.

2.3.2 Dynamic performance analysis

A floating two-way lock control loop model is constructed in the Fluid simulation software Sketch mode. The stage of simulation is the process of lifting the column from the column to the top of the roof beam and compacting it. In this process, the reversing valve of the jack is in the neutral position, ie the two-way lock is locked. In the Parameters mode, set the main parameters of the system components: the pump flow rate is 560L/min; the jack diameter and rod diameter are 245mm and 195mm respectively; the set pressure of the safety valve is 40MPa, and the low pressure lock setting pressure is 25MPa. Simulated operation in run mode, the pressure change curve of the two-way lock safety valve port and the jack piston displacement curve are obtained, as shown in Fig. 5 .

From the simulation results, it can be seen that in the process of pressurizing the piston chamber of the jack, the ordinary two-way lock circuit reaches the safety valve opening pressure and is unloaded, and the floating two-way lock loop safety valve does not reach the opening pressure. From the jack piston displacement curve can also be seen, the ordinary two-way lock hydraulic circuit, the jack in the piston cavity safety valve to open after the lifting of the load condition began to retract, and the floating two-way lock hydraulic circuit starts to retract after the low-pressure lock is opened, which effectively reduces the centralized loading time and avoids the opening of the safety valve.

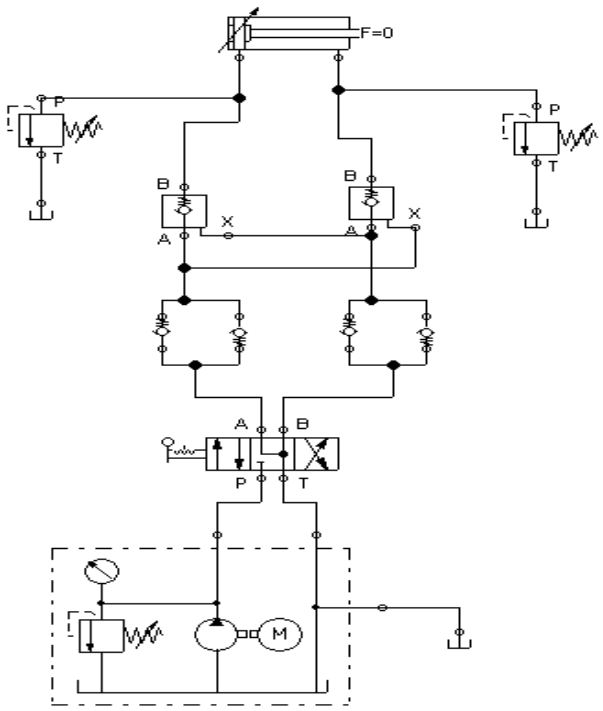
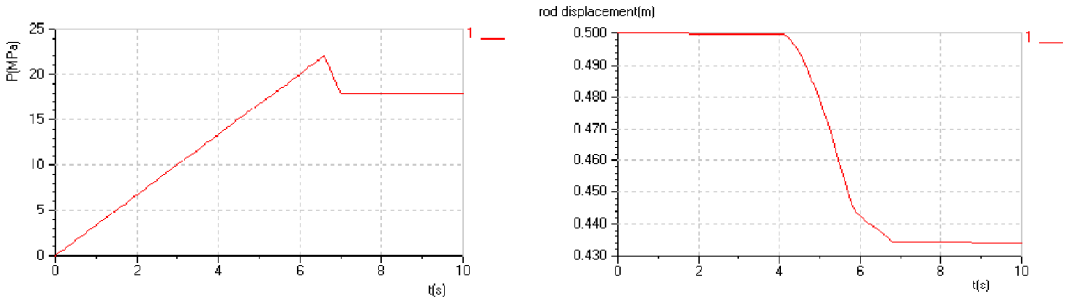


Fig. 4 Floating hydraulic double lock circuit



a. Pressure relief valve pressure curve b. Hydraulic cylinder piston displacement curve

Fig. 5 Floating locking circuit dynamic characteristics

3. Conclusion

This article analyzes and improves the existing hydraulic support from the aspects of hydraulic control loop optimization. For the control system of the push-type bracket, there is a common phenomenon that the safety valve is frequently opened with the pressure in the piston chamber during the use process. An improved design proposal is put forward, and the hydraulic two-way lock hydraulic circuit replaces the ordinary hydraulic two-way lock circuit. In the FluidSIM simulation software, each type of loop is modeled separately and the loops are simulated under the same parameters. The simulation results show that the floating two-way lock circuit does not reach the opening pressure during the pressurization process of the piston chamber, and can effectively solve the problem of centralized loading of the load-bearing parts of the piston cylinder during the initial stage of column uplift.

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