Optimal Design of Synchronization of Column Hydraulic Lifting System for Mine Hydraulic Hoist

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Abstract

The mining hydraulic lifting device is the latest equipment for the decomposition and composition of underground coal mining equipment. It can quickly and safely disassemble and assemble the underground comprehensive mining equipment, replacing the manual operation of the traditional hoist. The traditional way of working has reduced the labor intensity of workers and improved safety, and has been widely used in coal mines. In the various actions of the mining hydraulic lifting device, the most core and most critical technology is to achieve the synchronization in the lifting process of the column. The level of synchronization performance has a crucial impact on the smoothness of the load lifting and the protection of the lifting equipment. This paper is mainly aimed at the continuous optimization of the column hydraulic lifting system, and seeks various more perfect methods to make the synchronization more and more high, and prepare for the subsequent issues.

Keywords

Mining hydraulic lifting machine; column hydraulic lifting system; synchronization.

1. Introduction

With the development of science and technology, China's coal mine production is gradually expanding to scale and intensification, and the application of comprehensive mechanization is the only way for modern coal mines to achieve high production and high efficiency, promote the safe development of coal mine production, and obtain good economic and social benefits.

According to statistics, the total weight of equipment that needs to be transported when moving in China has reached about 11500T, of which the weight of hydraulic supports has grown to 74T, the number of brackets has increased from 100 to nearly 180; the total weight has increased from 1500T to over 10000T. The disassembly, handling and laying of these large and heavy equipments challenge the traditional downhole lifting method. Therefore, it is especially important to move the underground equipment quickly. The mining hydraulic lifting solves this problem very well.

The mining hydraulic lifting machine selects the appropriate lifting point to hook the lifting equipment, and uses the lifting of the column and the lifting jack to complete the lifting of the underground coal mine equipment (mainly for the hydraulic support). The equipment is lifted to a certain height, and it is transported to a specific location or a specific handling device by using a jacking jack to complete the handling of the coal mining equipment.

2. Brief introduction of hydraulic system to achieve lifting machine action

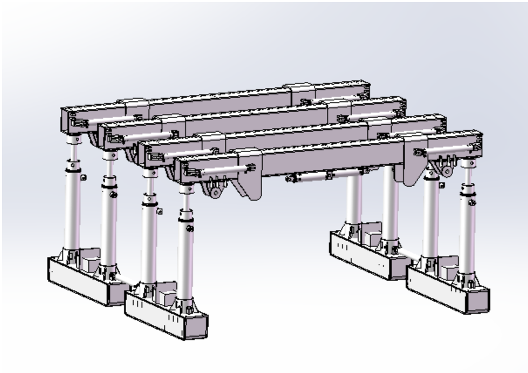


Figure 1 General view of mining hydraulic lifting machine

The operation sequence of the mining hydraulic crane lifting machine. First, the pumping station moves the jack laterally and the longitudinally moving jack to supply liquid, so as to move the lifting point of the lifting machine to the hook position of the lifting device. Immediately after the pump station supplies oil to the lifting point jack, the hook is lowered, so that it can just hook the lifting equipment. After hooking up the lifting items, the pumping station supplies oil to the column and prepares to start lifting the items. During this series of movements, the pumping station supplies oil to each designated jack in turn, and there is no simultaneous movement of different jacks. The most important part of the whole process is the synchronization problem during the lifting process of the column. The better the synchronism of the column, the smaller the eccentric load problem during the lifting process and the smaller the load damage to the top beam. In this paper, various synchronization loops are combined and analyzed, and a set of synchronous loops that are more in line with this system are obtained. In addition, the application is mainly described below for the design of synchronous loops.

3. Design of the synchronous loop of the column

3.1 Brief description of the synchronous loop

The function of the synchronous loop is to ensure that the displacement of two or more hydraulic cylinders in the system is the same or at the same speed [1] [2]. Obviously, there are requirements for both of these systems. In multi-cylinder hydraulic systems, there are many factors that affect the accuracy of the synchronization. For example, the load on the hydraulic cylinder, leakage, frictional resistance, manufacturing accuracy, structural elastic deformation, and gas content in the oil will make the motion unsynchronized. Synchronous loops should try to overcome or reduce the impact of these factors, sometimes taking compensation measures to eliminate the cumulative error.

3.2 Comparison of various synchronous circuits

For the idea of this article, the initial idea is simply to connect the eight columns in parallel and lock them through a set of hydraulic locks. Compared with the later optimization, it is found that the parallel mode error is too large, and the synchronization performance is not enough. By consulting the data and analyzing and sorting out, a suitable synchronization loop is selected. The following describes several synchronous loops [3].

Figure 2 is a synchronous circuit in which two parallel hydraulic cylinders are controlled by a speed regulating valve. The two speed regulating valves respectively adjust the moving speed of the two-cylinder pistons. When the effective areas of the two cylinders are equal, the flow rate is also adjusted to be the same; if the two cylinders are not equal in area, the flow rate of the speed regulating valve can also be changed to achieve synchronous motion. The circuit structure is simple and can be adjusted; however, the adjustment is cumbersome, and the synchronization accuracy is low due to the oil temperature change and the difference in the performance of the speed control valve, generally 5%-7%.

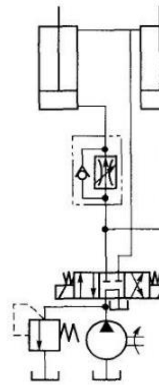
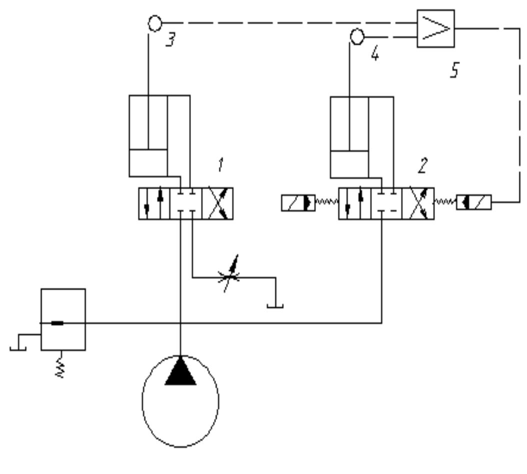


Figure 2 Synchronous loop with speed control valve

The synchronizing circuit shown in Fig. 3(a) receives the feedback signals of the displacement sensors 3 and 4 by the electro-hydraulic servo valve 2 to keep the output flow rate the same as that of the reversing valve 1, thereby realizing the synchronous movement of the two cylinders. In Figure 3(b), the servo valve directly controls the synchronous action of the two cylinders. The loop of the servo valve is highly accurate and expensive. It is also possible to use a proportional valve instead of a servo valve to lower the price, but the synchronization accuracy is also reduced accordingly. Both of these circuits involve displacement sensors. Control is more complicated than pure hydraulic control, but the relative accuracy is high and the overall design price is relatively high.



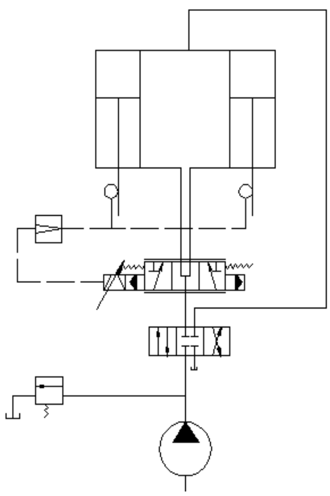


Figure 3(a) Figure 3(b)

Figure 3 Synchronous circuit with electro-hydraulic servo valve

In the finishing process, it was found that there is a relatively simple hydraulic valve, which is a split flow collecting valve [4] [5]. The diverter valve is also called the speed synchronizing valve. It is the general term for the diverter valve, the collector valve, the one-way diverter valve, the one-way collector valve and the proportional diverter valve in the hydraulic valve. Synchronous valves are mainly used in two-cylinder and multi-cylinder synchronous control hydraulic systems. There are many ways to achieve synchronous motion, but the synchronous control hydraulic system using the split manifold-synchronous valve has the advantages of simple structure, low cost, easy manufacture, and high reliability. Therefore, the synchronous valve has been widely used in the hydraulic system. The synchronizing of the diverter manifold is speed synchronization. When the two cylinders or the cylinders are subjected to different loads, the diverter manifold can still ensure the synchronous movement.

The circuit shown in Figure 4 uses a split manifold (synchronous valve) instead of a speed control valve to control the flow of the two hydraulic cylinders into or out of the flow, so that the two hydraulic cylinders can still achieve speed synchronization when subjected to different loads. The one-way throttle valve 2 in the circuit is used to control the descending speed of the piston, and the pilot operated check valve 4 is used to prevent the two cylinders from escaping through the inner orifice of the diverter valve due to different loads when the piston is stopped. Because the synchronous action is automatically adjusted by the diverter valve, it is convenient to use, but the efficiency is low and the pressure loss is large, which is not suitable for the low-pressure system.

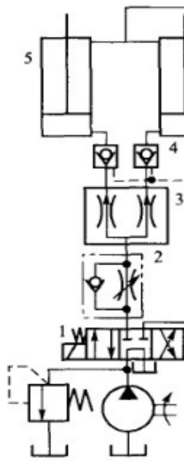
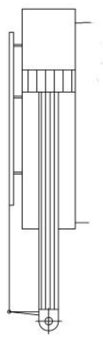


Figure 4 Synchronous loop with split manifold

4. Electro-hydraulic control design of column synchronous circuit

A displacement sensor measuring point is installed at a plurality of positions of the hydraulic cylinder to detect the speed of each position point, and then the signal given by the position sensor controls the proportional correction system in the lifting oil path to ensure the column synchronization [6].



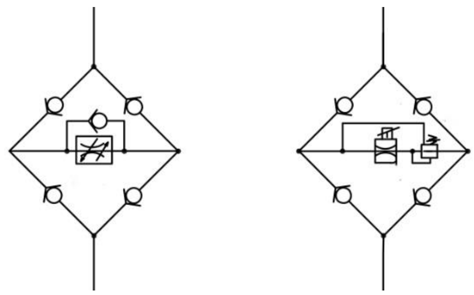


Figure 5 Hydraulic cylinder with displacement sensor

Figure 6 Proportional flow valve monitoring system

The proportional flow valve is used to monitor the signal given by the displacement sensor. After the sensor gives the cylinder speed signal, the proportional controller of the proportional flow valve determines the opening degree according to the speed information of the other oil path, thereby ensuring the two-oil road speed is same [7] [8].The above-mentioned displacement sensor, proportional flow valve and PLC control system constitute the proportional correction system of the lifting oil passage, and the self-adjusting ability of the system is also enhanced to a greater extent while ensuring the synchronous lifting of the column. In the case of fluctuations in load fluctuations, high synchronism can also be guaranteed [9].

5. Conclusion

This paper designs, analyzes and optimizes the synchronous lifting system of mine rapid moving equipment designed and produced by enterprises. It mainly completes from simple to complex, from theory to practice, and the system synchronization is getting higher and higher. For mine rapid moving equipment, it is an important equipment to speed up the mining speed of fully mechanized mining face, and it is also a key problem to be solved in the fully mechanized mining face of major coal mines at this stage. It is directly related to the economic benefits of coal mines. Advances in rapid moving equipment also mark the level of coal mining technology in a country. As mine production increases, the amount of equipment disintegration and assembly work on the work surface will increase. Research and development of special disassembly and transportation equipment for underground working face will greatly improve the mining efficiency of fully mechanized mining face. It reduces the labor intensity of workers, saves a lot of manpower and time, has good economic benefits and huge social benefits, and has broad application prospects.

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