Application and Working Principle of Hydraulic Support

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Abstract

In this paper, the main object of discussion is hydraulic support, first of all, its application field and significance are discussed in detail; secondly, the paper introduces the composition of hydraulic support in detail; finally, the working principle of hydraulic support is introduced.

Keywords

Hydraulic support; composition structure; working principle.

1. Introduction

With the continuous development of industrial technology, the increasing demand for coal in the national economy, coal mining, especially the face of production technology has undergone tremendous changes. Comprehensive mechanized coal mining is to realize mechanization in the three main production links of coal mining, transportation and support. That is, the use of drum-type or planer-type coal mining machinery such as coal dropping and loading, heavy-duty flexible face conveyor, and the corresponding slot transfer machine and retractable belt conveyor and other coal transport, self-moving hydraulic support support and management of roof. These equipments cooperate with each other to form a comprehensive mechanized equipment.

Hydraulic support is a kind of supporting and controlling roof mining face equipment, which is powered by high pressure liquid and composed of several hydraulic components and some metal structural parts. It can realize a complete set of working procedures such as supporting, landing, moving frame and pushing conveyor. Hydraulic support is advanced in technology, reasonable in economy, safe and reliable. At present, all countries in the world are constantly improving the comprehensive mechanization level of coal mining face.

Hydraulic support has the advantages of high strength, good supporting performance, fast moving speed, safety and reliability. It can make the coal face achieve high output, high recovery rate and high efficiency. It can greatly reduce labor intensity, reduce cost and tunneling rate, and realize safe production.

2. Composition of Hydraulic Support

The typical structure of hydraulic support is composed of top beam, prop, shield beam, base, push device, valve parts, pipeline system, connecting parts and various accessories. The roof beam and the base are supported between the roof and the floor through several props, forming a movable bearing member, supporting the roof and maintaining the workspace. Synthesizing the structure of various types of hydraulic support, its composition can be summed up as load-bearing structural parts, power cylinder, control and control components, auxiliary devices and working fluid five major parts.

2.1. Bearing Structure Parts

(1) Roof beam: the support component directly contacting the roof and bearing the load of roof rock is called the top beam. It provides a connecting point for supporting pillars, shielding beams, and refuse blocking devices. In addition to the whole rigid box structure, the top beam is generally composed of several sections, which can be divided into main beam, front beam and tail beam according to its role and position in roof support. The top beam is about three meters, mostly a variable cross-section of the overall top beam, from the center of the center to the front of the top beam gradually thinning and narrowing, top beam section has two symmetrical around the column socket to accept the ball head. The two earboards at the back end of the jack beam are used to articulate with the shield beam, and the support of the balance jack is arranged at the center line of the back part of the jack beam. There are three circular holes on both sides of the top beam for installing spring sleeve and side pushing jack.

(2) Shield beam: the support component that prevents the goaf from caving gangue into the working face space and bears the load of caving gangue and the horizontal thrust of roof is called shield beam. The upper part of the shield beam is directly connected with the top beam, and the lower part is directly or indirectly hinged with the base. The locus of the hinge point of the shield beam and the top beam is the double Nu line, and the four bar mechanism with double rocker is formed. The bracket adopts a double-link mechanism. The horizontal load of the roof to the top beam is transferred from the shield beam to the two connecting rods. The bracket column no longer bears the transverse force, and the column is not easy to bend and deform. The front end of the shield beam is welded with an ear plate for articulation with the top beam, the rear end is welded with an ear plate for articulation with the rear connecting rod, and the pin hole seat for articulation with the front connecting rod. A spring sleeve is arranged in the section of the shield beam to extend the movable side shield plate, one end of the spring is supported on the spring seat, and the spring seat is supported on the skeleton in the shield beam. The other end of the spring is supported on the movable side guard plate. It can also be equipped with side pushing jack, which has the function of adjusting frame and preventing slipping.

(3) Base: direct contact with the bottom plate to transfer the roof pressure to the bottom plate support components called the base. In addition to providing a connecting point for the pillar and shield beam, the base should also be equipped with moving jack and other components. The base adopts an integral rigid flat bottom seat. It has large contact area with the base plate, so the contact pressure of the bottom plate is small, and the support is not easy to sag.

2.2. Power Cylinder

(1) Pillar: The main cylinder that supports between the top beam and the base directly or indirectly bearing the load of the roof is called the pillar. The prop is the main load-bearing component of the support. The support force and height of the support mainly depend on the structure and performance of the prop. The column is mainly composed of cylinder block, live column, and guide sleeve and so on. The cylinder block is made of seamless steel pipe. The lower end of the cylinder block is welded with a spherical bottom. A hole is drilled on the bottom of the cylinder and a pipe joint is welded as the liquid mouth of the lower cavity of the column. A guide sleeve is arranged at the upper end of the cylinder block to guide the reciprocating movement of the movable column. In order to prevent dirt such as coal dust from entering the cylinder block with the shrinkage of the movable column, a dust-proof ring is arranged on the guide sleeve. In order to prevent the liquid from leaking out from the upper cavity of the column, a bud-shaped sealing ring is also installed on the guide sleeve. The upper part of the cylinder block is drilled with threaded holes and welded with pipe joints, which are connected with the upper cavity and serve as the liquid mouth of the upper cavity of the column. The piston head is welded on the lower part and on the upper part. In order to divide the column into two separate cavities, a drum-shaped sealing ring with two-way sealing effect is installed on the

piston head. The guide rings on both sides of the piston head are used to guide the movement of the piston in the cylinder block. The guide ring and the guide ring are fixed by an internal card key, a foreign card key and a clamp. The upper end of the movable pole connected with the mechanical lengthening pole is hollow, and the mechanical lengthening pole with the pole head is inserted into the movable pole, and the clip ring is inserted into the annular groove of the connecting pole, and then the clip ring is sleeved outside the clip ring. Finally, the connecting pole and the hollow movable pole are fixed together by a pin through the transverse hole of the connecting pole. The groove and a number of transverse holes can be inserted into the corresponding ring groove according to specific requirements to obtain different adjusting heights, and the operation procedure is more convenient than the external long cap.

(2) Jack: all kinds of cylinders except supports are called Jack. For example, front beam, shifting, adjusting jack, balance, reset, side push and guard Jack. Complete the movements of the transport transporter, the shifting bracket, and the adjustment of the bracket. The main difference is that the diameter of the column is relatively large, the ratio of the annular area of the upper chamber to the sectional area of the lower chamber is very small, and the diameter of the piston rod of the jack is relatively small. The ratio of the annular area of the front cavity to the basal area of the lower cavity is larger.

2.3. Control Element

Including control valves, control valves and other valves and fittings. These components are the hydraulic components needed to ensure that the bracket has sufficient support force, good working characteristics, and to achieve a predetermined design action. The type and quantity of these components vary with the bracket structure and movement requirements.

(1) Hydraulic control check valve: mainly used for locking the liquid in the hydraulic cylinder to carry it.

(2) Safety valve: it is an essential component with limited pressure. It can prevent the main load-bearing structural parts of the support from overloading and ensure that the roof rock stratum is not higher than the prescribed working resistance. The valve opens when the hydraulic pressure in front of the valve orifice is balanced with the force acting on the elastic element acting on the valve core. The valve has the advantages of high sensitivity and timely overflow pressure limiting.

(3) The control valve is used for reversing the hydraulic cylinder to realize manual reversing of each movement of the bracket.

2.4. Auxiliary Device

In addition to the above three components on the support, other components can be classified into auxiliary devices, including push device, reset device, gangue device, guard device, anti-slip device, lighting device and other ancillary devices.

(1) Side shield device of shield bracket. Side shield plate is installed on both sides of shield beam and top beam. When the bracket works, one side shield plate is fixed and the other side is movable. Usually, the side guards on both sides are symmetrical, and one side can be bolted or pinned to the top and guard beams as needed in assembly. It is mainly used to eliminate the gap between the shield beam and the top beam of the adjacent support and prevent the falling gangue from entering the support space. As a guide device in the process of bracket moving, it can prevent the bracket from falling behind and tipping, and adjust the spacing of bracket.

(2) Pushing device: The moving force of shield support should not only overcome the friction of the floor, but also overcome the friction of the adjacent supports on both sides, and the friction of the roof to the support caused by the residual load of the column when the shield support is moved, so the moving force it needs is very large. In order to obtain a larger moving frame force, a frame device is often added to the pushing device, so as to use the pushing force of the jack to move the frame and push it away by pulling force.

(3) Band protection device: in order to prevent the coal wall or shield the role of the baffle, to avoid injuring staff or damage equipment. Brackets should be installed. The main components of the retaining device are the retaining plate and the retaining Jack.

3. Working Principle of Hydraulic Support

3.1. Principle of Automatic Shift of Hydraulic Support

Hydraulic support is powered by high-pressure liquid, through the expansion of various power cylinders, so that the hydraulic support to complete the lifting, landing, walking, pushing conveyor and other actions. So that the support can be repeatedly supported, moved forward and adjusted along with the working face.

(1) Drop column: When the rotary control valve turns to the position of the drop column and opens the feed valve, the high-pressure liquid enters the piston rod cavity of the prop by the main hydraulic pipe through the control valve and the oil pipe, and also enters the control pipeline of the hydraulic control one-way valve, opens the hydraulic control one-way valve, and the oil in the piston cavity of the prop passes through the oil pipe, the hydraulic control one-way valve and the control valve. Flow back to the main return pipe, and the column unloading will drop.

(2) Moving frame: After unloading the hydraulic support, the control valve is transferred to the position of moving frame, and the feeding valve is opened. The high-pressure liquid enters the piston rod cavity of the pushing jack through the control valve and the oil pipe through the main hydraulic pipe. At the same time, it enters the hydraulic control oil circuit, opens the hydraulic control one-way valve, and the oil in the piston cavity flows back to the main return pipe through the oil pipe, the hydraulic control one-way valve and the control valve, pushes the jack to shrink, takes the conveyor as the fulcrum, and moves forward the puller. The transport aircraft is fixed by the jack of the adjacent support, and the jack is locked by the hydraulic check valve.

(3) Lifting Pillar: After the hydraulic support is moved to a new position, the lifting pillar shall be promptly lifted to support the newly exposed roof, the control valve shall be shifted to the position of the lifting pillar, the liquid supply valve shall be opened, the high-pressure liquid shall be entered by the inlet hydraulic pipe, through the control valve to the liquid-controlled one-way valve, the valve ball shall be pushed through the tubing into the piston cavity of the prop, and the oil in the piston rod cavity of the prop. The main pipe is returned to the liquid pipe through the oil pipe and the control valve, and the movable column and the top beam are raised to support the roof.

(4) Pushing conveyor: when the hydraulic support is moved forward and re-supported, the control valve is shifted to the push-slip position, and the supply valve is opened. The high-pressure liquid enters the piston rod cavity of the jack of the pushing device through the control valve and the hydraulic control one-way valve from the inlet pipe, and the oil in the piston cavity flows back to the main return pipe through the oil pipe and the control valve, thus pushing the jack to move. The plug rod is extended and the hydraulic support is used as a fulcrum to transfer the transporter to the new working position.

3.2. Support Bearing Principle of Hydraulic Support

The supporting load principle of the support refers to the mechanical working principle of the interaction between the hydraulic support and the roof, which includes three working stages, i.e. initial support resistance increasing, and load resistance increasing and constant resistance.

Initial bracing stage: in the process of lifting column, from the top beam contact with the roof, until the hydraulic pressure of the piston chamber of the prop reaches the pump station working pressure, loosen the handle, stop the liquid supply, the hydraulic control one-way

valve immediately closed. The valve ball seals the oil in the piston chamber, which is the initial stage of the support increasing resistance. At this point, the supporting force on the roof of the prop or bracket is known as the "setting force".

Bracing force of braces: $fz = \frac{\pi D^2 P_b}{4 \times 1000}$

Setting force of the scaffold: $Fc = n \bullet fc \bullet \eta$

Type: Pb--- pump station working pressure;

D--- Inner diameter of support cylinder block;

N--- The number of props for each scaffold;

η -- Supporting efficiency;

The magnitude of the support force depends on the working pressure of the pump station, the number of supports, the inner diameter of the cylinder block and the type of the support. In fact, the hydraulic pressure in the piston chamber is often lower than the working pressure of the pump station due to the loss of resistance, operation and valve sensitivity after the initial support.

Load-increasing stage: after the initial support, with the subsidence of the roof, the closed oil of the piston chamber of the prop is compressed, and the hydraulic pressure continues to increase, showing load-increasing resistance state. At this time, because of the cylinder diameter of the prop increased, the oil was compressed and the volume reduced, even if the emulsion did not have any leakage, the relief valve did not operate unloading, and the total length of the prop will be shortened. The reduced value of the column caused by the elastic shrinkage of the column is called the elastic shrinkage of the column. It can be calculated by pressing.

$$\Delta_1 = \Delta_p [\beta \bullet l + \frac{2}{E}(\frac{D^2 + d^2}{D^2 - d^2} + \mu)]$$

Type: the elastic shrinkage of the l-- column.

The liquid pressure increment of the lower column of the p-- column.

The volume compressibility of beta liquid.

The height of the liquid column in the lower part of the l--- column.

E--- Young's modulus of cylinder material;

Uh - Poisson's ratio of cylinder material.

D --- Cylinder bore diameter;

D--- External diameter of cylinder block.

This reduction is elastic. If the load acting on the prop, in turn, decreases from the working resistance to the initial support force, the prop will return to its original length. Therefore, the reduction in the length of the prop is called the elastic contractibility of the prop. This elastic shrinkage will cause the roof to sink before the pillar work reaches the working resistance, which may cause the rock to be separated from the stratum and is unfavorable to the roof management. Reducing the elastic expansion of the prop plays an important role in improving the management of the roof. The concrete measures are to use high-pressure emulsion to improve the quality of the one-way valve by increasing the initial support force of the prop. To be able to close the liquid circuit in time, pay attention to the mode of operation, so that the lower chamber of the prop as far as possible to reach the working pressure of the pump station.

Constant resistance stage: if the support fully supports the roof, does not allow the roof to sink, it needs a strong support. In actual production, because the roof pressure is sometimes very large, it is very difficult to design a support that can withstand the huge roof pressure without any pressure. Therefore, when the support can sink with the roof, there is a certain amount of shrinkage, but also maintain a certain supporting force, so as not to make the roof arbitrarily

sink and cause damage to fall. The support is required to have both a certain initial support force and a contractibility, which is controlled by the pillar's safety valve. When the pressure of the roof increases, the oil pressure of the pillar piston chamber will be increased rapidly. When the pressure is worth exceeding the action pressure of the relief valve, the high-pressure liquid in the piston chamber of the prop leaks out through the relief valve, the prop shrinks, and the liquid pressure in the piston chamber of the prop decreases, which is the pressure-yielding characteristic of the support. When the pressure is less than the action pressure of the relief valve, the relief valve closes, stops discharging, the liquid in the piston cavity of the prop is closed again, and the bracket returns to normal work. Because of the restriction of the action pressure of the relief valve, the prop presents the characteristic of constant resistance. The maximum load on the prop or support is called working resistance.

It can be seen from the above that the supporting force changes with time when the prop or support is working. The support rises, the top beam begins to contact the roof to the initial bracing stage when the hydraulic control one-way valve closes, the initial bracing stage to the loading stage before the relief valve unloads and the constant resistance stage when the relief valve repeatedly unloads. It reflects the relationship between the supporting force and time of the support (Fig. 2-1). The dotted line in the diagram indicates that some of the supports have moved forward before reaching the rated working resistance. The scaffold is moved forward and is supported by the original process.

4. Conclusion

The above-mentioned working process shows that the hydraulic support can increase the resistance when working below the rated working resistance value, so as to ensure the effective support of the support to the roof. When the support force of the bracket exceeds the rated resistance value, the bracket can shrink down as the roof sinks. Keep the bracket constant working resistance, that is, shrinkage and constant resistance. The resistance of the support itself depends on the sealing performance of the hydraulic check valve and the prop. Contractility and constant resistance are determined by the relief performance of the relief valve, therefore, the hydraulic control one-way valve, relief valve, prop these three components, and is to ensure the performance of the key components of the support.

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