Research on the Application of Electro-hydraulic Proportional Valve in Mechanical Engineering

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Abstract: The working principle of electro-hydraulic proportional valve is that the proportional electromagnet in the valve starts to work under the drive of voltage signal, the displacement of the working valve spool and the change of the size of the valve port are implemented. On this premise, the input of voltage proportional pressure is carried out, and then the corresponding output of the flow is carried out. The displacement feedback of the spool can also be achieved in the form of electrical, mechanical or pressure. The reason why electro-hydraulic proportional valve continues to expand the application field lies in its own unique advantages, such as variety of types, convenience in setting up different electro-hydraulic systems, anti-pollution ability, ultra-high control accuracy and flexibility of setting up applications. Besides, with the advent of new products and the overall promotion of technology in mobile hydraulic machinery, new products including plug-in valve and proportional multi-way valve, are characterized with pilot control, load sensing and pressure compensation and other functions.
***Keywords*:** electro-hydraulic proportional valve, mechanical engineering, application, research

Introduction

With the development of science and technology, the development of electro-hydraulic proportional technology in China has attracted global attention and been widely used in various mechanical hydraulic systems. Although the technology started relatively late in China, it is regarded as an important member of the control field and fluid transmission family with its unique technical advantages, which tops others in hydraulic control engineering. This paper mainly discusses the application of electro-hydraulic proportional valve in machinery.

1. The working principle and performance characteristics of electro-hydraulic proportional valve

First, the proportional electromagnet receives the electrical signal sent by the system and converts it into mechanical displacement power to drive the pressure reducing spool in both directions. At this time, the pressure oil at point P flows into the oil chamber of the hydraulic valve core through the pressure reducing valve core, so as to drive the valve core, and promote connection between P1 and pressure oil at point P, P2 and T. When the system give another electromagnet, the signal transmission point P pressure oil will be connected to the P2, P1 and T connection. There is no feedback oil hole on the valve. At both ends of the reducing spool, the feedback oil will be injected through the feedback oil hole. If the liquid pressure of the reducing spool is equal to the electromagnetic pressure of the electromagnet, it will show the balanced reducing spool state. The size and direction of the electrical signal can control the size of the output flow and liquid flow direction of the valve. In the use of performance, electro-hydraulic proportional valve has a strong anti-pollution ability to greatly reduce the work failure from pollutants, which not only improve the reliability and stability of the hydraulic system, but also reduce the cost, and the structure is simple.

2. Application advantages of electro-hydraulic proportional valve in mechanical engineering

2.1 Electrification of the braking device

Based on the gradual maturity of electro-hydraulic proportional valve and related component technology, mechanical engineering electrification control can be realized, the main object of realization includes the electrification control of engi-

neering vehicle gear, steering, braking and other equipment. Electrical control is more easy to connect with the computer and the integrated control is more convenient, at the same time, flexible wiring and quick response can be achieved. Therefore, the reason why electro-hydraulic proportional valve can be widely used in modern engineering machinery hydraulic system is the result of its unique electronic control pilot technology, which not only replaced the traditional manual operation, but also become the replacement of hydraulic pilot control based multi-way valve products. The biggest advantage of applying electro-hydraulic proportional valve in mechanical engineering is that the number of operating handles is greatly reduced, which not only makes the cab simple, but also simplifies the complexity of operation, and plays an important role in improving the quality of mechanical operation and working efficiency[1].

2.2 Steering drive of engineering vehicle

At present, most thermal power plants in China adopt special engineering vehicles when the fan grinding wheel was disassembled and installed. However, there are too many obstacles such as pipelines and cement columns in the factory area, the operation space of the engineering vehicle is extremely narrow. In order to make the engineering vehicle work in the narrow site, it is necessary to realize the flexible control of the four-wheel steering control of the engineering vehicle. But because the weight of the engineering car can reach more than 40 tons after loading, and it is often uneven bearing of four wheels, resulting in the frequent broken of the wheel pull rod. In order to flexibly control the direction and speed of rotation, electro-hydraulic proportional direction control valve is used to control the wheel position drive hydraulic cylinder in the design of steering control system, and the wheel steering drive is really realized. The application of electro-hydraulic proportional directional valve in the device can ensure the stability of the start and stop of the engineering vehicle, and the speed of the four wheels can be controlled by adjusting the output current. At the same time, the output voltage is controlled to eliminate the interference caused by pressure fluctuation in the hydraulic system.

2.3 Remote control of the signal

In recent years, with the rapid development of digital wireless communication technology, wireless remote control system arises at the historic moment, which is especially suitable for the application of construction machinery. Remote receiving equipment is mounted on mobile machinery due to its stable and reliable operation capability. The obtained radio signals can be converted into other two signals, including the switch signal of the control electro-hydraulic switch valve and the proportional signal of the control electro-hydraulic proportional valve. At the same time, other signals can be effectively controlled, which really realizes the goal of remote operation instead of manual operation.

3. The category and form of electro-hydraulic proportional valve

Electro-hydraulic proportional valve is composed of three seed valves, namely proportional pressure valve, proportional directional valve and proportional flow valve. However, the working procedures and characteristics of the comprehensive engineering machinery hydraulic system are divided based on the structural level, and there are generally three types: slide valve proportional valve, proportional multi-way valve, spiral proportional valve.

3.1 Spiral cartridge proportional valve

The electromagnetic proportional plug-in is fixed on the original oil circuit integrated block by thread, which is the concept of the so-called spiral cartridge proportional valve. The device is widely used in construction machinery with many advantages of saving pipeline, flexible application and low cost. Spiral cartridge proportional valve is mainly composed of two, three, four and multi-pass form. Two-way valves have the effect of proportional throttle valves, and other devices to form a composite valve for reasonable control of pressure and flow. Three-way valve has the function of proportional pres-sure reducing valve, which has become the main body of proportional valve in mechanical hydraulic system. The key role is to carry out the reasonable operation of hydraulic multi-way valve pilot oil road. The three-way proportional pressure reduc-ing valve has ultra-high accuracy and flexible control ability, completely replacing the traditional manual pressure reducing pilot valve. Proportional servo control manual multi-way valve is made using the principle of three-way valves. As shown in Figure 1, according to different transmission signals, the output piston pressure and flow will also be different, which can effectively control the displacement of the multi-way spool. The four-way spiral cartridge proportional valve can completely implement separate control of the working device.

3.2 Slide valve type proportional valve

Slide valve type proportional valve is applied in mobile mechanical hydraulic system with the importance of core components. It has the function of distribution valve, and plays the role of compound valve in the adjustment of direction

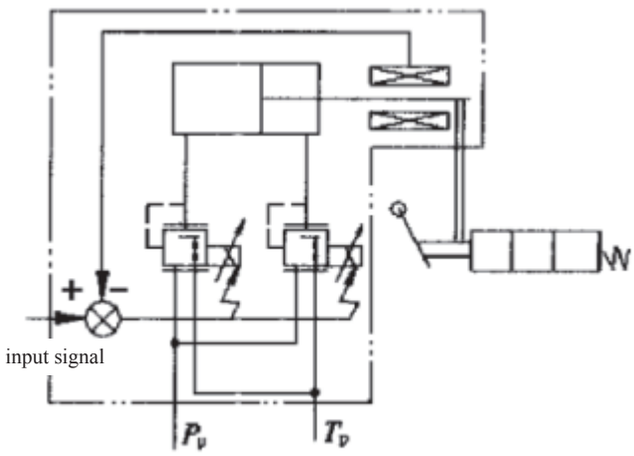

Figure 1. Principle of proportional servo control manual multi-way valve

and flow. In mechanical engineering equipment components, electro-hydraulic proportional multi-way valve occupies very important position, and the main function is to control the electro-hydraulic conversion. It can not only retain the role of the traditional manual multi-way valve, but also add super control ability, the biggest advantage is that you can operate proportional servo, the object is the position feedback and load sensing is the most advanced products of mechanical engineering.

3.3 Proportional multi-way valve

Considering the relatively low cost in manufacturing and low requirements in mechanical control accuracy, in general, proportional multiway valves are equipped with displacement sensors, and electronic detection and error correction functions are not required. Therefore, the pressure fluctuation caused by load changes will affect the displacement of the spool, visual inspection can be applied to ensure the completion of the process in the actual operation process. In the process of electric control or remote control, attention must be paid to external interference factors. In recent years, in the field of electronic technology with rapid development, an increasing number of people begin to use the built-in differential transformer and other sensors to effectively detect the position of the moving spool and implement reasonable control of the spool displacement. This highly integrated proportional valve correction function is very strong, which can make up for the lack of ordinary proportional valve, significantly improve the control accuracy, and the main components include electromagnetic proportional valve, related electronic circuit, position feedback sensor and drive amplifier.

4. Analysis on load sensing and pressure compensation technology

In the application of electro-hydraulic proportional valve in mechanical engineering, pressure compensation technology and load sensing technology are applied to mechanical engineering based on energy saving, promoting oil temperature drop and strengthening precision control, as a result, to ensure that many components will not interfere with each other when running synchronously. The concepts of pressure compensation and load sensing show great similarity. In order to meet the various requirements of the system, both of them adjust the flow of the valve. The means of adjustment is usually realized by pressure changes caused by load changes. For the quantitative pump, the load sensing oil circuit is usually used, and load sensing directs load pressure to remotely regulated relief valves. If the load is very small, the pressure of the relief valve will also be adjusted. With the increase of load, the pressure setting will increase correspondingly, but there is always a corresponding overflow loss. For variable pump system, the realization of its function is also a variable process, whose main performance for the program will be introduced to the load sensing hydraulic pump, the output of the pump pressure rise with the increase of load pressure, fixed minimum differential pressure. The output flow of the pump is consistent with the actual flow on the whole, and the overflow does not show any loss, so as to achieve the goal of energy saving. Pressure compensation as an assurance measure is designed to enhance the capacity of the control valve The load pressure behind the valve port is introduced into the compensation valve. In order to ensure the rationality of the pressure value before and after the valve port, the pressure compensation valve should be effectively adjusted against the pressure in front of the valve port. Therefore, the flow through the valve port depends on the opening of the valve port, and the load pressure will not affect it[2].

5. Pilot control and remote control analysis of electro-hydraulic proportional valve in construction machinery

As described above, electro-hydraulic proportional valve and related component technology is gradually mature, mechanical engineering electrification control can be realized. The most typical signs are the engineering vehicle gear braking steering and the control of the working device. The electrified electrical control can respond quickly and carry out flexible wiring, which is more convenient to connect with the computer and implement integration

Wireless remote control transmitting and receiving system is widely used in many engineering machinery transformation. From the perspective of application security, each transmitted digital data instruction corresponds to a set of system address codes of special significance, and all of them are disposable address codes of manufacturers. Each receiver can respond only after the same address code of the transmitted signal is confirmed. Other wireless signals, even if they are of the same frequency, will not affect the function of the receiving device. In addition, additional security measures are taken to fully ensure the security and reliability of the system. The technology has achieved good results in remote control transformation of a variety of mobile machinery, including the transformation of loader, bridge repair truck, rock drill, aerial work truck and so on. There is no doubt that the electro-hydraulic proportional valve and the relevant industrial remote control device complement each other, that is to say, the electro-hydraulic proportional valve provides a safe interface for the remote control of construction machinery, and in turn the remote control equipment promotes the maximum role of the electro-hydraulic proportional valve.

6. Application examples of electro-hydraulic proportional valve in construction machinery

Figure 2 is a schematic diagram of the hydraulic system of a mechanical engineering truck crane. Only the content of the associated electro-hydraulic proportional valve is shown in the diagram. The crane adopts TECNORD TDV-4/3 LM-LS/PC model of three-piece proportional multi-way valve, the maximum pressure in the workload can be selected from the three shuttle valves in the load sensing oil circuit, and then transmitted to the remote control port of the remote pressure regulating

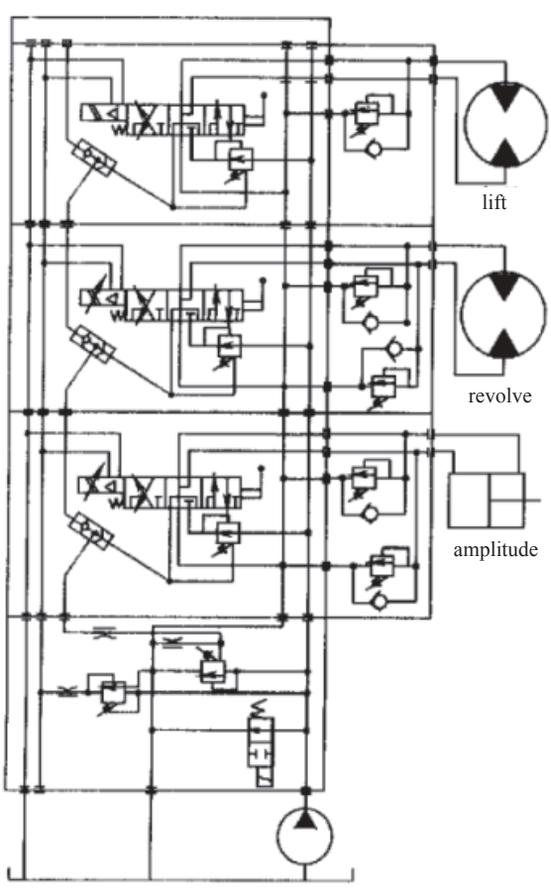

Figure 2. Control principle diagram of hydraulic system of a certain truck crane

relief valve, and the relief valve relief pressure can be reasonably adjusted to ensure that the load pressure of the system is consistent with the output pressure of the hydraulic pump and to maximize energy saving. The flow of each pressure compensation valve depends on the opening of the valve, which is not directly related to the load, but not directly related to the load of other valve pieces, so as to ensure that the speed of the load can be effectively controlled at any time and anywhere.

Figure 3 is an example of manual and electro-hydraulic proportional pilot control of a bulldozer shovel. If the two-position-three-way solenoid valve in the figure can not achieve electrification, then the manual decompression pilot valve is connected to the pilot pressure. In the case of shuttle valves, the pressure of the manual pilot valve is used to control the hydraulic directional control valve, and the pilot controls the pressure oil to the three-way proportional relief pilot valve, which controls the hydraulic directional control valve through the shuttle valve.

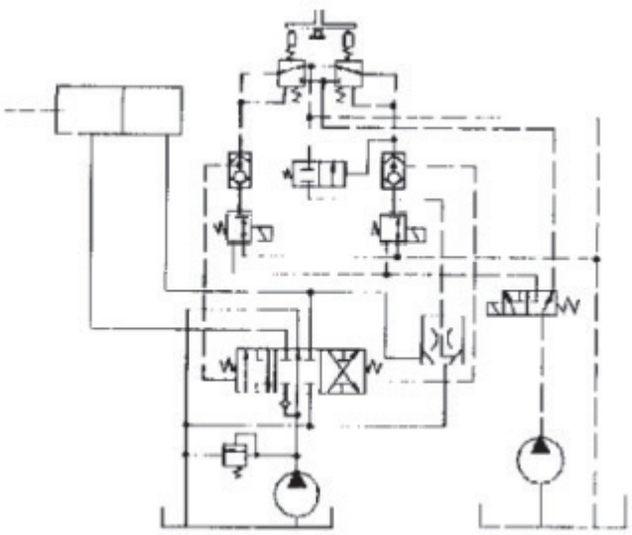

Figure 3. Manual and electro-hydraulic proportional pilot control principle of a bulldozer shovel

Conclusion

In conclusion, the application of electro-hydraulic proportional valve in modern mechanical engineering can greatly simplify the operation procedure of construction machinery, significantly improve the work efficiency and operation accuracy and the intelligent operation technology is truly realized. The continuous improvement of performance and the gradual expansion of the scope of application are the prerequisite to promote the significant improvement of the relevant technical level. In this paper, the difference of electro-hydraulic proportional valve applied in mechanical engineering field is described, especially the application of pilot control and remote control. Effective analysis is made based on engineering examples in order to lay a data foundation for future product updates and applications in broader fields[3].

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