VALVES AND DRIVE METHODS OF VALVES USED IN THE HYDRAULIC INDUSTRY

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Abstract

The power of fluids is widely used in contemporary industrial applications today. Valves used in the hydraulic industry are operated as hydraulic system elements to provide the ability to do work by using the power of the hydraulic fluid. Directional control valves are used to direct the pressurized hydraulic fluid to the element that will perform the work to be done. In this study, the types of hydraulic valves and the methods used to control these hydraulic valves are examined. The advantages and disadvantages of various actuation methods of the spool inside the valve are mentioned. In addition, stepper motor actuated hydraulic directional control valve, which is one of the electro-hydraulic valve types, has been introduced. The application of electro-hydraulic valve with stepper motor is mentioned. As a result, proportional valves are given due to the necessity of using in hydraulic systems and their capabilities are mentioned.

Keywords: Electro-Hydraulic, Hydraulic Actuator, Fluid Control.

INTRODUCTION

In fluid power systems, work is done by transmitting power through fluid. The fluid can be liquid, such as oil and water, or gas, such as compressed air, nitrogen, carbon dioxide. Systems that use liquid as the transmission fluid are called hydraulic systems. [1]

Hydraulic systems are used in almost every branch of industry to generate and control force and motion in a wide variety of applications. Industrial applications such as iron and steel industry, presses, machine tools; construction and power generation applications such as bridge movements, mining machinery, nuclear reactors; in construction machines such as excavators, cranes; There are hydraulic systems and control in special application areas such as the propulsion of wing and landing gear in aircraft, military applications, entertainment industry, drilling and many other areas. [2]

The development of today's hydraulic industry has been based on some of the basic principles put forward by Archimedes and Blaise Pascal on hydrostatics. Various hydraulic presses, lifting and transport vehicles were made. Today, hydraulic energy has become an indispensable need of the industry. Hydraulic energy has a wide range of uses, from the controls of simple works in small workshops to the most advanced automation systems.

When the hydraulic system is mentioned, a system in which the fluid is pressed at a certain pressure and flow rate with a hydraulic pump driven by an electric motor and linear, circular or angular motion is produced with this hydraulic energy should come to mind. Electrical energy is given as input energy to the system. With this energy, the shaft of the hydraulic pump rotates by taking action from the electric motor to which it is connected with the clutches and absorbs the static oil in the oil chamber by vacuuming and presses the system. It is possible to express it as hydraulic energy, since the obtained pressurized fluid has the ability to do work, move and produce force.

The hydraulic energy obtained previously mentioned is the fluid at a certain pressure and flow. It is necessary to direct it to the desired location of the hydraulic circuit, to keep the pressure between certain limits and to control the speed by adjusting the amount of fluid. For this, it is necessary to ensure that the pressurized fluid performs the desired tasks, and to control the large energy that can create a dangerous environment at high pressure. Only by controlling it in this way, it is possible to do the desired work with this energy and make use of it. For this purpose, pressure control valve, directional control valve and flow control valve are used in the circuit. [2]

EXPOSITION

In the hydraulic system, directional control valves are used to ensure that the pressurized fluid can be directed to the desired parts of the hydraulic cylinders or hydraulic motors. It is necessary to control the direction of the fluid in order to provide the forward and backward movements of the pistons and to rotate the hydraulic motor shafts in both directions. Direction control valves have been developed in order to direct the hydraulic fluid to the target volumes. These directional control valves can be controlled in different ways. [2]

1.1. Directional Control Valves

Hydraulic directional control valves are circuit elements that direct hydraulic oil and move it to the desired position. They can control the connection or closure of an oil line to another oil line, as well as directing the oil transferred by the pump to the lines of the hydraulic cylinder or hydraulic motor, allowing the movements of the actuators to be controlled. [3]

1.2. Manipulating Methods of Directional Control Valves

What is typically called an exciter or actuator is the method of manipulating the slide or rotating element of a direct-acting directional valve to actuate it. We can examine the actuators (manipulator) that provide the movement of the spool in the directional control valves in five categories. It is possible to classify these manipulating methods as manual, mechanical, pneumatic, hydraulic and electrical. Various manipulating methods have been developed for the movement of the spools. Sub-categories with similar working principles can be included in these general categories. For example: levers, foot pedals are "manual" manipulating methods. A cam roller device is considered a "mechanical" method of excitation. [3]

1.2.1. Manual Actuator

A manual actuator is usually a simple lever attached to some kind of link. There are also some foot operated valves, but they are generally considered unsafe in today's workplaces. While lever-operated valves are still quite common in mobile applications, repeatability, accuracy, and electronic control requirements are beginning to eliminate this type of operation outside of simple industrial machines. Figure 1 gives a picture of this type of actuator. And also the hydraulic diagram given is the diagram showing that the valve is lever controlled and spring centered, that is, it comes back to the neutral position with spring force. [4]

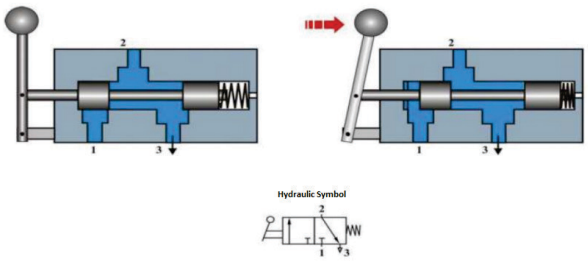

Fig. 1. *Manual Actuator*

1.2.2. Mechanical Actuator

The designs of mechanical actuators are usually made with a wheel or piston based on a wedge or cylinder that performs the movement at the slide head. As a result of the movement of the mechanical actuator (cam, cylinder, etc.), the spool based on the actuator also moves. [3] The movement state and movement feature of the spool take shape according to the cam form on which the spool is based. As given above, at the right end of the spool, a wheel in contact with the cam allows the spool to go in as the cam moves. As the spool moves, the hydraulic fluid is directed to the desired channels. After the spool is pushed in, the force on the spool is removed depending on the cam action and the spool

comes to its starting position with the spring force at the left end of the spool. The hydraulic diagram in Figure 2 shows that the valve is mechanically actuated and spring-returned, as well as a two-position 4-way valve. [4]

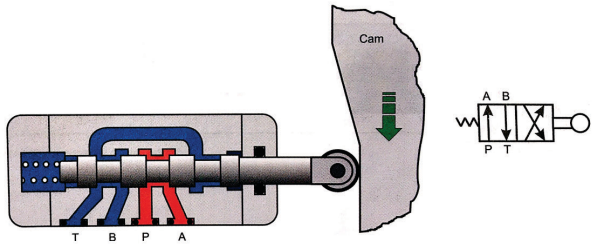

Fig. 2. *Mechanical Actuator [4]*

1.2.3. Pneumatic Actuator

A pneumatic actuator uses air pressure applied to a piston to move the valve slide. In valves using this type of actuator, the parts are usually made of aluminum or other non-corrosive material so that moisture in the air lines does not cause the parts to corrode and stick. Typically, a small hole in the actuator allows any accumulated moisture to escape. [4]

Because the air pressure can be quite low in pneumatically actuated valves, the actuator piston must be relatively large to overcome the spring and flow forces and move the spool. Sealing areas and materials should be properly selected and positioned in accordance with the design.

In Figure 3, centering springs are used on both sides of the spool. With the compressed air supplied from the left inlet, the piston is pushed and the movement of the spool based on the piston is provided. The hydraulic diagram provided shows that the valve is three position four way, spring centered and pneumatically actuated.

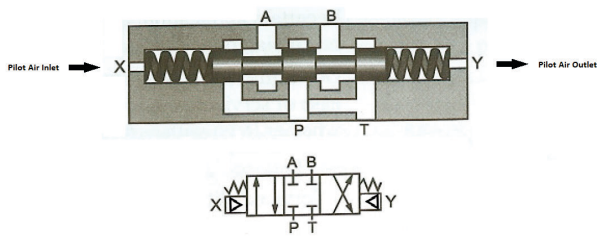

Fig. 3. *Pneumatic Actuator [5]*

1.2.4. Hydraulic Actuator

Hydraulic actuators use pilot oil flow and pressure to move the valve spool. The pilot flow and pressure controlling these actuators are usually controlled by a directly mounted directional valve (pilot valve). For this reason, these hydraulically actuated valves are often referred to as two-stage valves, consisting of a pilot stage and a hydraulically actuated main stage.

While the pilot valve can use any type of actuation, a solenoid operated valve is often preferred. This allows hydraulic circuits to be installed that can achieve loads greater than those that single-stage solenoid-driven hydraulic valves can handle. In addition to achieving high loads with this design, the advantages of electrical control are also allowed. [4]

In the hydraulic diagram given in Figure 4, it is seen that centering springs are used on both sides of the spool. In addition, the spool of the valve is moved with the pilot oil supplied from the left inlet. The hydraulic diagram provided shows that the valve is three position four way, spring centered and hydraulic actuated.

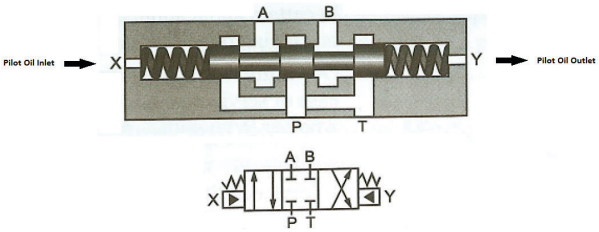

Fig. 4. *Hydraulic Actuator [5]*

1.2.5. Electric Actuator

The electrical control type is the most commonly preferred control type in terms of industrial automation. In addition, electrical impulses can take many different forms. [3] Electrically actuated valves are preferred in transmission valves of tractors, controls of front loaders, backhoe and loader controls of construction machines, and industrial applications that require sensitive and fast response. Common examples of electric actuators are solenoids. Generally used solenoids are "on-off" solenoids. When an

electrical signal is received in on-off solenoids, the slide or pin of the solenoid suddenly switches to the fully open or closed position. Besides on-off solenoids, the structures of proportional solenoids are substantially different from those of on-off solenoids. And it needs an electronic circuit board to be driven. They perform work by providing a smoother transition than on-off solenoids.

A solenoid consists of two basic parts. These parts are a coil that provides an electromagnetic field and an armature with parts in which the mechanical function takes place. Applying electricity to the coil creates a magnetic field on the armature. The magnetic field formed around the armature pushes the spool or a small bar called a pin inside the armature. This causes the valve spool to apply counterforce to a spring at the other end of the valve. As soon as the force applied by the solenoid overcomes the spring force, the spool is directed and the hydraulic oil flow flows in the desired direction. In the linear solenoid, the force generated in response to the electric current applied to the winding is balanced with the force of the centering spring, and the valve slider is tried to be positioned proportionally to the current input. In some applications a position sensor (LVDT) can be added to the end of the slider by removing the centering springs to improve positioning accuracy. Position accuracy is ensured by receiving feedback with LVDT. [6]

2.1. Stepper Motor Actuated Hydraulic Valve Design

Stepper motor exciter can be given as an example of the electric actuators mentioned earlier.

In the hydraulic system, directional control valves are used to ensure that the pressurized fluid can be directed to the desired parts of the hydraulic cylinders or hydraulic motors. It is necessary to control the direction of the fluid in order to provide the forward and backward movements of the pistons and to rotate the hydraulic motor shafts in both directions. In order to direct the fluid to different sections, directional control valves that can be controlled in different ways have been developed.

Hydraulic systems are used in order to fulfill the desired function of vehicles such as tractors, front loaders of tractors, work machines. Valves are used as hydraulic elements in directing the fluid oil used in hydraulic systems. Equipment controlled by the valves include front loaders, backhoes, etc. is located. The valves used for the control of these equipment fulfill their function by directing the passage of oil. For the safety of the attachment, the operator and the environment, it is essential that the oil diversion be controlled. Valve designs are designed considering such situations. Non-proportional on/off valves are usually used when the equipment has two states, such as on/off. However, if it is desired to control the equipment in intermediate positions, this means that the spool in the valve can be positioned in every position and therefore the manipulating system needs to be proportional.

In tractor front loaders or work machines, a smoother transition of the hydraulic valve slide may be desired, or it may be desired that the spool can work in intermediate positions in addition to its inside and outside positions. In such cases, front loader manufacturers require proportional valves from their suppliers with the ability to perform proportional control of the hydraulic system.

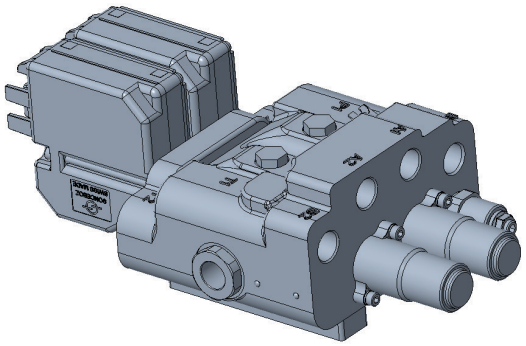

Fig. 5. *Stepper Motor Actuated Hydraulic Valve*

In the stepper motor-controlled sliding directional control valve, the stepper motor, which is the hydraulic valve actuator, performs the steering of the spool (Figure 5.). In the event that an operation is not desired, the stepper motors are not signaled, so the rack gear in the stepper motor does not move. In cases where the rack gear does not move, the spool of the valve also maintains its neutral

position. If the spool is in the neutral position, the oil coming from the pump and entering the valve is discharged into the tank line in the easiest way.

If a signal is given to the stepper motor by the operator, the gear of the motor and thus the spool of the valve moves. According to the amount of directing, the desired amount of oil flow can be provided to the port. By delivering the desired flow to the work port, it also has the ability to do sensitive work.

The purpose of using the stepper motor manipulating in the directional control valve is to measure the weight of the load taken on the tractor front loader or the work machine loaders by keeping it in intermediate positions on the loader. The weight of the load taken to the front loader is realized by the load cell mounted on the loader. With this application, the necessity of going to the weighbridge for weight measurement and repeating the operations of getting on and off the scale is eliminated.

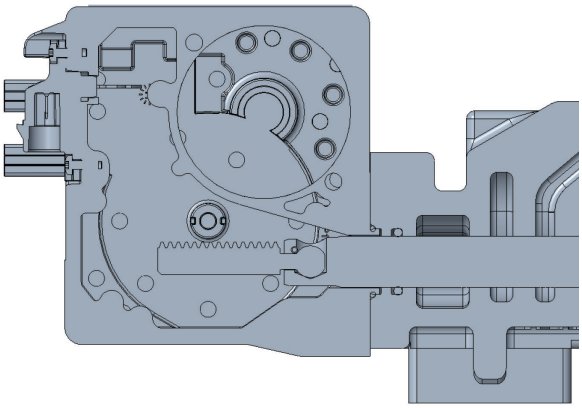

Fig. 6. *Stepper Motor Integration for manipulating the hydraulic valve spool*

In Figure 6, the integration of the rack gear of the stepper motor actuator into the valve with the special processing on the slide of the valve is provided. The spool performs its movement with every movement coming from the actuator. There is no need to add an LVDT position sensor as an add-on to the valve spool to check whether the valve spool is in the desired position. Because there is an encoder integrated that measures the position of the gear movement of the stepper motor.

CONCLUSION

In this study, the valves used in the hydraulic industry and the manipulating methods of these valves are emphasized. The advantages and disadvantages of these manipulating methods are stated. While designing the hydraulic control valve, it is essential to design according to the characteristics of the system to be used. Proportional control should be provided in systems where precise control is required. Proportional control allows the work to be done with the targeted precision.

Proportional solenoids can be used to achieve proportional control. However, in slide valves, the proportional solenoid does not have the capacity to keep the valve spool fixed in every desired position in millimeters and do the work. The idea of a stepper motor actuated directional control valve is presented as a solution to the desired situations for precise spool movements in hydraulic system control.

Electro-hydraulic valve application with step motor stimulated provides the desired proportionality. This application has the ability to move the spool very precisely in slide valves. This allows precise control of the operator controlling the system.

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