Module 5: Valves

Terms and Definitions

- Manifold is a chamber with a number of inlets or outlets used to collect or distribute a fluid.
- Valve is a device for controlling, diverting, or regulating the flow of a liquid.
- Compress means to press or squeeze together.
- Pilot pressure is a pressure used to control hydraulic components.
- Poppet is a valve that rises perpendicularly from its seat.
- Accumulator is a device in which pressurized fluid is stored as a source of potential energy.

Categories of Valves

- Pressure control valves are used to adjust the maximum pressure in all or part of the system, or they may be pressure activated to provide some other control function in the system.
- Flow control valves are used to adjust the flow rate to parts of the system or the whole system.

Types of Pressure Control Valves

- Pressure relief valves.
  - Determine or limit maximum operating pressure in system.
  - Provide safety valve to prevent system overpressurization.
  - Often used to set pressure for process.
  - Note: Arrow drawn across any spring symbol indicates the device is adjustable.

- Unloading valves.
  - Remotely piloted valves.
  - Unload pump so it operates at low pressure when certain pressure conditions are met in the system.

- Sequencing valves.
  - Remotely piloted valves.
  - Used to control sequence, or order, of operation of actuators in the system.

- Parallel circuit is a closed circuit in which the current divides into two or more paths before recombining to complete the circuit.
- Downstream means to be situated closer to the outlet relative to the point of reference.
- Upstream means to be situated closer to the inlet, relative to the point of reference.
- Activating pressure is the pressure used to open a valve mechanism.

- Directional control valves determine the paths that the oil flow takes through the system.
- Integrated hydraulic systems use manifolds with cartridge valves to incorporate pressure, flow, and directional control valves into a single, compact unit.
Pressure reducing valves.
- Limit maximum pressure occurring in portion or branch of the system.
- Unlike pressure relief valve, which controls the entire system.

Counter balance valves.
- Provide back pressure.

Types and Operation of Pressure Relief Valves

- Direct acting relief valve uses the pressure that it is controlling to open the valve mechanism.
- Pressure acts directly on moving mechanism (usually ball or poppet).
- Mechanism held onto valve seat by strong spring.
- Compression (force that holds mechanism onto seat) usually adjustable by knob or screw.
- Pressure on mechanism reaches the pressure setting of valve, and the resulting force on the mechanism compresses the spring and allows the mechanism to be pushed off the seat.
- System flow directed back to tank.
  
  Note: In order for the valve to remain open, the pressure at the valve inlet must remain at the pressure setting of the valve; therefore the fluid going back to the tank does so at a high pressure drop across the relief valve, creating a great deal of heat.

Valve remains open until system pressure drops below pressure setting of valve.

Pilot operated relief valve is a two-stage valve that uses pilot pressure to operate small pilot section of valve.

Pilot section opens and relieves pressure on the back side of the main valve mechanism.

This allows the mechanism to open, so that the main system flow is directed through the valve and back to the tank.

Valve remains open until the system pressure drops below the pilot pressure required to operate the valve.

Pressure reducing valves.
- Limit maximum pressure occurring in portion or branch of the system.
- Unlike pressure relief valve, which controls the entire system.

Counter balance valves.
- Provide back pressure.

Brake valves.
- Provide back pressure.
- Speed limiter for hydraulic wheel motor operating an over running load.
- Example is a piece of earthmoving equipment going downhill.

Operation of an Unloading Valve

- How unloading valve differs from relief valve.
  - Relief valve is operated by system pressure being felt on valve mechanism.
  - Unloading valve senses pressure in a portion of the system away from valve.
- Unloading valves are commonly used in systems where accumulators are used.
- Check valve located between unloading valve and accumulator isolates portion of system containing accumulator from unloading valve.

Operation of a Sequencing Valve

- Ensures correct operating sequence.
  - Used in parallel circuits.
  - Example is a circuit containing two cylinders that must operate in a specific order.
  - Ensures correct operating sequence obtained.
- The sequencing valve is placed in the pressure line going to the cylinder that is required to be the second in the sequence to move.

Pressure on accumulator side of check valve is sensed through a remote sensing line and used to open the unloading valve.

When the unloading valve opens, it allows pump flow to return to tank at a low pressure drop and prevents the heat generation experienced with the high pressure drop through relief valves.

After the first cylinder has completed its operation, the pressure in the line to the second cylinder begins to increase.

Pressure setting reached and fluid flows.
- Pressure in line reaches pressure setting of sequencing valve.
- Allows fluid to flow to second cylinder.
Operation of a Pressure Reducing Valve

- Limits the pressure downstream of the valve in order to control the maximum pressure that portion of the system can experience.
- Senses the pressure at its outlet and uses that pressure to close the valve mechanism.
- Only pressure control valve that operates in this way, as all others sense pressure either at their inlets or remotely and use that pressure to open the valve.
- Limits the pressure available to a single actuator or to an entire branch of a system.

Operation of a Brake Valve

- Uses pressure inputs from both upstream and downstream of a hydraulic motor to adjust the position of the valve's moving mechanism to control the flow of oil through the valve.
- Action limits rotating speed of the motor and uses it as a hydraulic brake to control speed of the machine.
- Pressure downstream of motor sensed at inlet of valve (as in relief valve).
- Pressure upstream of motor sensed through remote sensing line.
- Only pressure control valve using two different pressures to adjust valve mechanism.

Operation of a Counterbalance Valve

- Valves placed at outlet of hydraulic cylinder hold vertical load in place until activating pressure of valve opens valve mechanism.
- Activating pressure sensed at either inlet of valve (outlet from cylinder) or remotely at inlet to cylinder.
- High cylinder pressures can occur in rod end of cylinder with counterbalance valves, especially if cylinder rod pointing downward.

Operation of a Check Valve

- Prevent flow in one direction.
- Allow free flow in opposite direction.

Terms and Definitions II

- Spool is a cylinder, often similar in shape to those used to wind thread or wire.
- Taper is a gradual decrease in diameter or width.
- Priority device/circuit is the most important device in the circuit or circuit in the mechanism.
- Lands are the widest part of a spool and are used to cover flow paths.
- Undercuts are the narrowest part of a spool and are used to create a flow path when the valve is open.
- Stroke is the range of motion of a cylinder.
- Feedback is the return of a portion of system output to the input.
- Plunger is a mechanical device that provides a thrusting motion, such as a piston.
- Servo is a control system that converts a small mechanical motion into one requiring much greater power and may include a negative feedback system.
- Solenoid is an electromagnetic switch.

Types and Operation of Flow Control Valves

- Needle valves.
  • Tapered device moves within valve throat.
  • Adjust size of flow opening.
  • Consequently, also adjust flow rate through valve.
  • Size of flow path (valve adjustment).
  • Pressure drop across valve (inlet pressure minus outlet pressure).
  • Pressure compensated flow control valves.
  • Use complex internal mechanism.
  • Moves spool across internal flow orifice.
- Factors affecting flow through valve.
- Valve design.
Placement of Flow Control Valves in a Circuit

- Flow control valves can be used in three different locations relative to the actuator to control the actuator speed.
- Meter in valve can be placed so that it controls the flow rate going into the actuator.
- Meter in valves can be placed on either the cap end or the rod end of a cylinder to control the extension or retraction speed of the cylinder, or they can be placed on both ends to control the speeds in both directions.
- Meter in valves can also be placed on either or both sides of a hydraulic motor to control the speed in either or both directions of rotation.
- Meter out valve can be placed so it controls the flow rate leaving the actuator.
- Placement on cylinders on either cap end or rod end of cylinder controls the extension or retraction speed of the cylinder, or they can be placed on both ends to control the speeds in both directions.
- If the cylinder is used to lower a vertical load, meter out flow control is required.
- If the rod of the vertical cylinder is pointed downward, very high pressures may be experienced in the rod end of the cylinder, which is called pressure intensification in the rod end, and can result in blown rod pressure seals or even a bowed or split cylinder.
- Meter out valves can be placed on either or both sides of a hydraulic motor to control the speed in either or both directions of rotation.
- Check valves used with meter in and meter out flow controls and the direction of installation determines whether the valve is meter in or meter out.
- Using either meter in or meter out flow control, the flow not used to operate the actuator is dumped back to the tank through the relief valve at relief valve pressure, which results in high heat generation and high horsepower loss.
- Bleed off system allows the fluid flow not needed to drive the actuator to be bled off and dumped directly back to tank at low pressure.
- Meter in or meter out can be placed on either or both sides of actuator in the same system, but the bleed off system can be used on only one side, either the cap end or rod end of cylinder or one side of a hydraulic motor.

Factors affecting flow through valve.
- Valve design.
- Flow path (valve adjustment).
- Independent of pressure drop across valve.

Valves adjustment.
- Adjusted with knob (as with needle valve).
- Once set, flow rate remains constant, even if inlet or outlet pressures change.

Operation of a Priority Flow Divider

- Flow requirements of critical system first.
  - Parallel hydraulic system has section with more critical operation than the other.
  - Priority flow divider provided to satisfy flow requirements of critical system first.

- Fixed orifice size.
  - Determines flow to priority device.
  - Secondary outlet gets remainder of flow.

- Priority circuit supplied first.
  - Device always ensures that the priority circuit is supplied if not sufficient flow for both circuits.

Operation of a Proportional Flow Divider

- Equalizes flow to two actuators.
- Ensures operation at same speed.
- There are two common types of proportional flow dividers.
  - Pressure compensated spool-type has a sliding spool that is automatically positioned by pressure imbalances occurring at outlet ports to actuators due to load or other factors.

- The rotary or gear-type flow divider device uses two hydraulic gear motors that are mechanically linked so that they must turn at the same speed and are driven by the flow from the system pump that enters the divider through single inlet port.
  - Two motors act as metering devices, provide equal flows to the two outlet ports, and are contained in a single housing and are purchased as an assembly.
Directional Control Valve Mechanisms

- Spools (most common for hydraulic applications).
- Sliding plates.
- Rotating plates.
- Cartridges.

Operation of a Spool-Type Directional Control Valve

- Has a sliding spool that moves within a bore in the valve to cover and uncover flow paths in the valve.
- Spool has large diameters, called lands, that block internal flow paths.
- Spool also has small diameters, called undercuts, that provide the flow paths between the valve ports.
- Depending on the spool design, a valve may have two or three functional positions.

Operation of a Two-Position Valve

- Two-position valve has two functional positions.
- Controls direction of operation of an actuator.
- Directs a cylinder to extend or retract.
- Directs a hydraulic motor to move forward or reverse.
- Note: With a two-position valve, the actuator cannot be stopped and held except at the ends of its stroke.

Operation of a Three-Position Valve

- Incorporates third functional position that allows for additional functional operations when the spool is placed in its center position.
- Spring on each end of the spool returns it to center position when the valve is not actuated, and there are four common center positions.
- In the closed center position, all four ports are blocked.
- In the open center position, all four ports are connected.
- In the tandem center position, the two actuator ports are blocked with the pressure and tank ports connected.
- In the float (or motor) center position, the pressure port is blocked, and the rest are connected together.

Directional Control Valve Actuators

- Numerous methods for moving spools in directional control valves.
- The manual directional control valve typically uses a hand-operated lever.
- With a solenoid directional control valve, the plunger in an electrical solenoid is used to push the valve spool into position.
- The plunger in an electronically positioned solenoid is used to push the spool to a position determined by the current to the solenoid.
- With a servo type of directional control, the valve spool is positioned electronically through a very sophisticated servo system using external feedback circuits.
- Note: Servo valves are extremely sensitive to contaminated fluid.