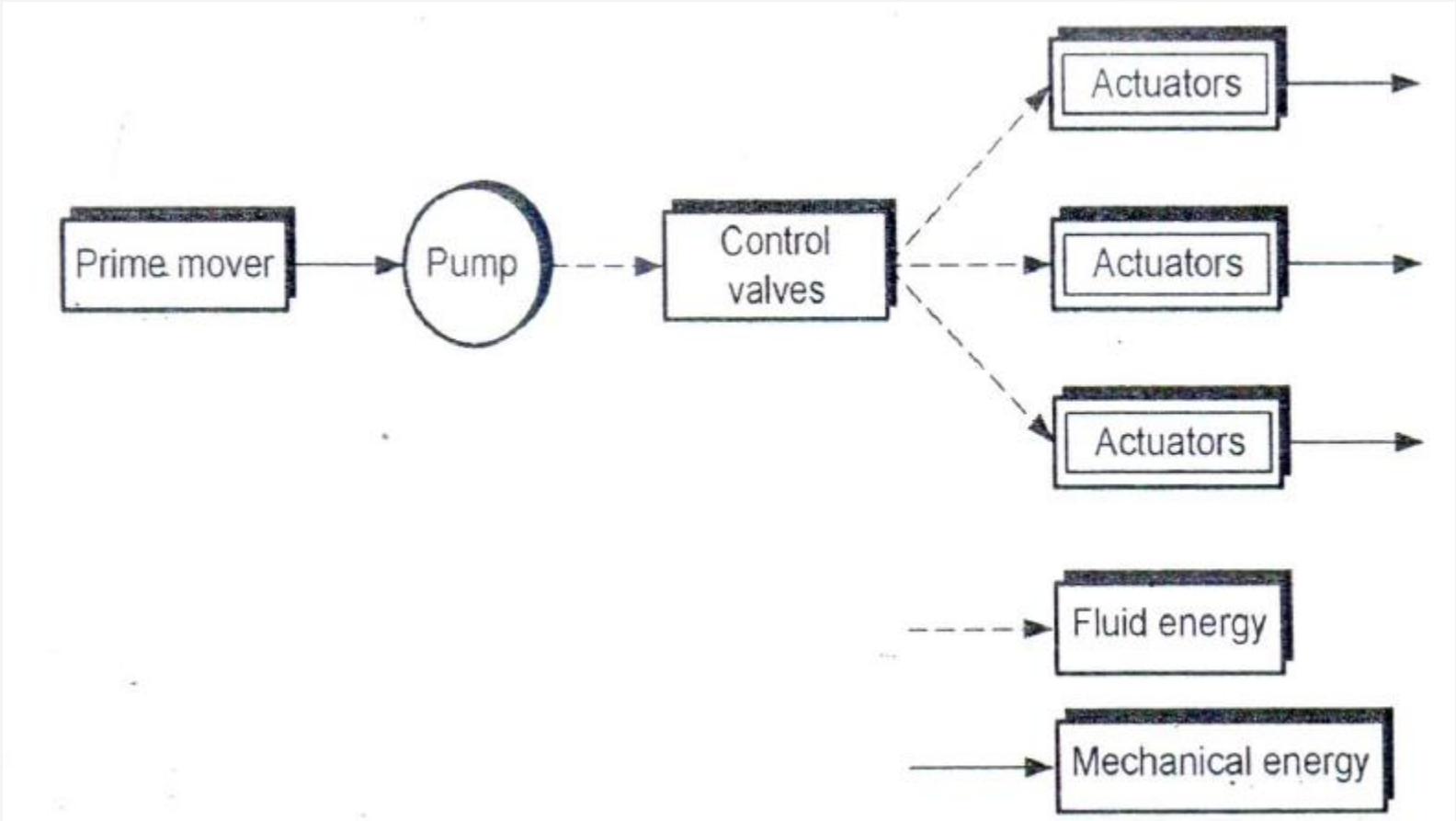
Hydraulic Systems

What is Meaning of Hydraulic system?

- A Hydraulic system is a power transmission system in which the transmission of power takes place through a fluid medium.
- Such a system avoids the mechanical linkages such as gears, belts, ropes, chains etc. to a great extent of a conventional power transmission system.
- The transmission of power by Hydraulic system is most convenient and highly efficient.
- Due to this, the present conventional power transmission systems are being replaced and changed over to Hydraulic based systems.

Basic Principles of a Hydraulic System

1. Systematic layout of a hydraulic system



- In this, a prime mover supplies the mechanical energy to pump which is used to pressurize a fluid. Therefore, the mechanical energy supplied by the prime mover is converted into the pressure energy by the pump and it’s stored in a fluid.
- The pressurized fluid is now transmitted to different parts of the system through special piping or tubing. The various parameters such as pressure and flow rate of the fluid can be controlled by using various control valves.

- At the desired places of use, the fluid energy is converted back into mechanical energy by the devices called actuators consisting of hydraulic cylinders, hydraulic motors etc.
- Thus, the energy supplied by the prime mover has been transmitted conveniently through fluid medium to various locations and *at these locations, the mechanical energy has been recovered back in a more convenient form.*
- **Since the power is transmitted through a hydraulic fluid as a medium, such a system is called Hydraulic System.**

Components

(a) Prime mover

(c) Control valves

(e) Piping system

(b) Pump

(d) Actuators (Hydraulic Motors, Pistons)

(f) Fluid

- In. addition to the above major components, there are few other supporting components for its proper functioning. These includes

(a) Filters *(b) Strainers*

(c) Storage tank (d) Heat exchangers

(e) Pressure gauges (f) Sensors

(g) Protective devices (h) Control devices

(i) Accumulators

a) Prime Mover

- It is a device which develops the mechanical power.
- It could be any type of power producing device.
- It may be an IC engine, an electric motor or a turbine.
- This power developed by the prime mover will be transmitted and utilized.
- The type of prime mover will depend on the application of the system.
- After passing through the entire fluid power system, this power is again available to us as mechanical power, minus the losses, but in a much more convenient form.

b) Pump

- Pump is driven by the prime mover, the function of the pump is to pressurize the fluid there by converting the mechanical energy to fluid energy. The pressurized fluid contains the fluid energy.
- In case of gas, a compressor is used in place of a pump. But in both 'cases, the action s the same i.e. it pressurizes the fluid. Generally, in hydraulic systems, the pressure raised will be very high, of the order of several hundred bars. This difference is basically due to their difference in compressibility between liquids and gases.

C) Control Valves

- The pressurised fluid supplied by the pump is required to be diverted to various parts of the system.
- Also, it may be necessary to control various parameters of the flowing fluid.
- The control valves can be broadly classified into three types:
  (a) Pressure control valves
  (b) Flow control valves
  (c) Direction control valves.

Pressure control

- Pressure control valves control the level of energy. In other words, they are used to maintain desired pressures in various parts of the hydraulic circuit.
- - Pressure Control Valves may be classified in to the following types.
- These are:

1. Normally Closed Type
2. Normally Open Type

- **(a) Normally Closed Type:**
- These types of valves remain closed in the normal position. When actuated by an actuating signal it opens either fully or partially. Examples of this type of valves are Pressure relief valves, Unloading valves, Counter balance valves, Sequence valves etc.
- These valves normally remain open unless actuated by an actuating force. Pressure reducing valves belong to this type. They remain open under normal working conditions. When actuated by the actuating force, it restricts the flow by slowly closing and finally blocks the flow. Thus they can reduce the pressure up to a certain value but not above the inlet pressure.

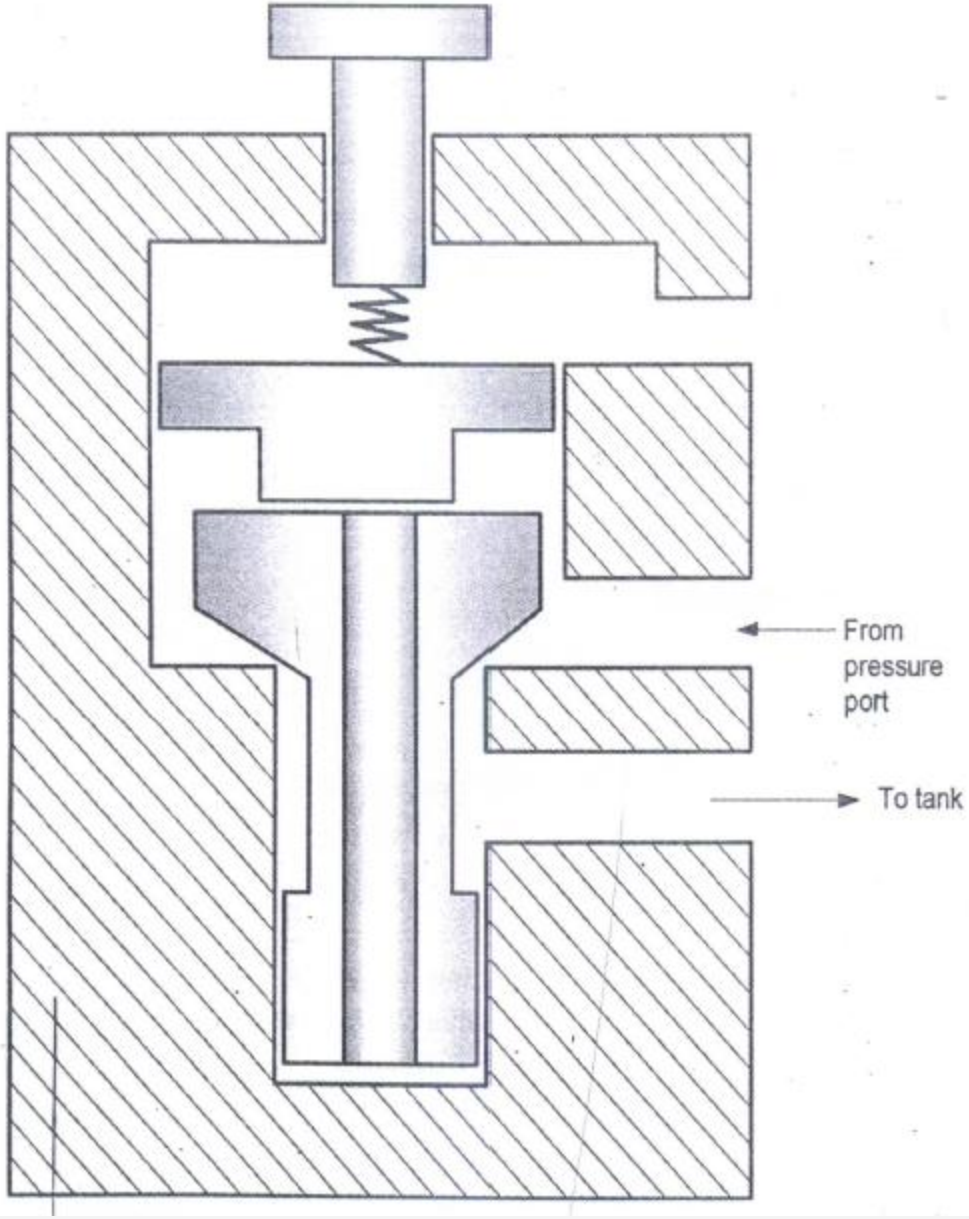
- Thus pressure control valves may be further classified into the following categories:
- Pressure Relief Valves
- Unloading Valves
- Counterbalance valve (Back pressure valve)
- Sequence Valve ,
- Pressure Regulating Valve (Pressure Reducing Valve Pressure Regulator)

Pressure Relief Valves

- Function:-

  The *pressure relief valves are the most essential component of a hydraulic system. These valves* are used to limit the maximum pressure at any point or a region in a system.

  This is achieved by providing an alternate path to the oil as shown in Fig. Relief valves differ from safety valves since a relief valve is a functional part of the system and not a safety device.



- The valve consists of a body with two ports. One of the ports is connected to the pressure point which is to be protected. The other port is connected to the tank. The ports can be opened or closed by the movement of a spool. The spool is kept in position by a bias spring. The pressure acting on the plunger can push the bias spring thereby moving the spool upwards. The actuating pressure can be set by the adjusting screw provided with the bias spring.

Working

- Under normal working conditions when the pressure at the pressure point is below the set pressure. the pressure port remains closed by the spool. The pressure acting on the plunger is not sufficient to push the spool upwards.
- When the pressure at the pressure port comes equal to the set pressure the plunger is lifted against the bias spring. The pressure port now gets connected to the tank port and oil flows freely to the tank thereby relieving the pressure.
- As the pressure comes down the spring force pushes down the spool downwards and closes the outlet port from the pressure line.

Main Function

- Pressure relief valve is a normally closed type valve. In a hydraulic system the pump would be working continuously and delivering the oil to the system. But the actuators and other components which consume the oil would receive the oil as and when required, based on the work cycle.
- So, when the actuator stops taking the oil and the pump continues to pump, pressure builds up. Since the pumps are positive displacement type, if not controlled, the pressure can build up indefinitely.
- In order to stop the pressure build up indefinitely, at a preset valve of the pressure, the pressure relief valve diverts the oil to the tank and limits the pressure. Thus relief valve continuously performs its function as long as the system is working.

Flow control valves

- Flow control valves are used to control the flow rate of the working fluid. Since the fluid energy is contained in the fluid in the form of pressure energy, the flow control valves also controls the rate of energy transfer in a fluid power system. The rate of flow of fluid controls the rate of movement of machine elements. Thus it is possible to control the speed of actuators like cylinder or motor by flow control.
- 1. Regulate the fluid flow rate to actuators.
- 2. Speed control of actuators.
- 3. Control of energy output of actuators.
- 4. Distribution of flow rates of fluid from pump to various hydraulic circuits.

Basic Principle of Flow Control

- A flow control valve controls the rate of flow of oil through it. It is achieved by varying the area of flow, therefore a flow control valve is basically a variable area orifice. However, when the orifice area is varied, it is subjected to change in the differential pressure . This change in the differential pressure also causes the flow to change. We conclude that for a given orifice area, the flow rate is not fixed. Since it depends on the differential pressure also.

- A flow control valve is being an orifice of variable area of cross section, the orifice acts as an obstruction across which pressure drop takes place.
- The flow rate can be related to the pressure drop and the area of cross section according to the basic equation of flow control valve as follows:

$$Q \propto A\sqrt{\Delta p}$$

- From the above Equation we find that the flow rate can be varied by varying either the area of flow or the pressure drop.
- Since area of flow can be varied easily. the flow control valves are usually designed based on changing the area of flow of the obstruction.
- It should be noted that the variation of flow with area is not linear. The complete equation for discharge with respect to Ap could be written as given below,

- Where,

Δp – is the pressure differential across the obstruction

S_g – is the specific gravity of the fluid

C_v – is the capacity coefficient.

$$Q = C_V \sqrt{\Delta p / S_g}$$

- Depending on the variation of flow rates, Q with change in differential pressure, f1p, the control
- valves can be classified into two categories as follows:
- (a) Fixed throttle valve: In this the area of the orifice is fixed.
- (b) Variable throttle valve: In this the area of the orifice can be varied.

Needle Valve

- It takes the name after the controlling element i.e. the needle which controls the area of the orifice. The needle is moved up or down by the valve stem. This causes the change in flow rate through the valve.

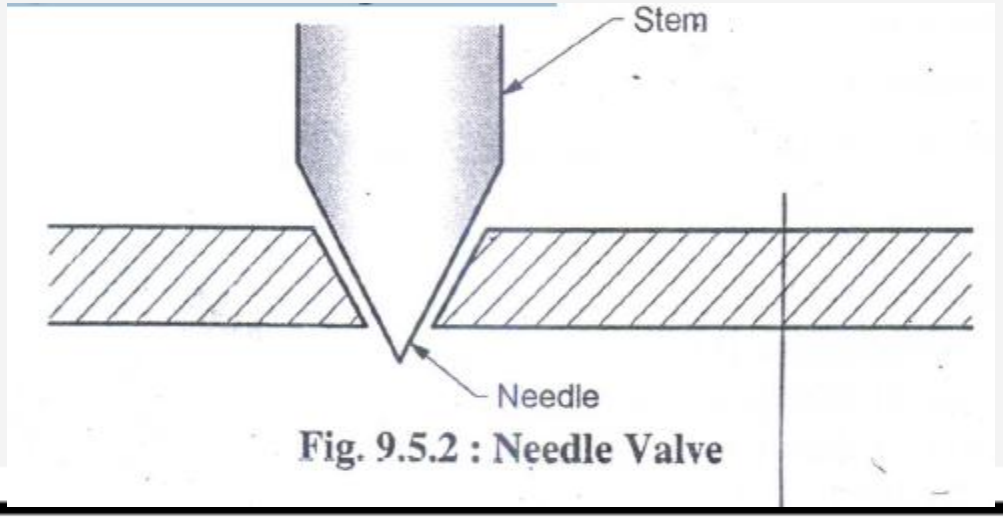


Fig. 9.5.2 : Needle Valve

globe valve

- In this case the controlling element for variation of area of flow is a globe or disc.
- The movement of the valve stem causes the disc to move up or down thereby changing the flow area of the orifice.
- Globe valves have greater capacity control compared to a needle valve.

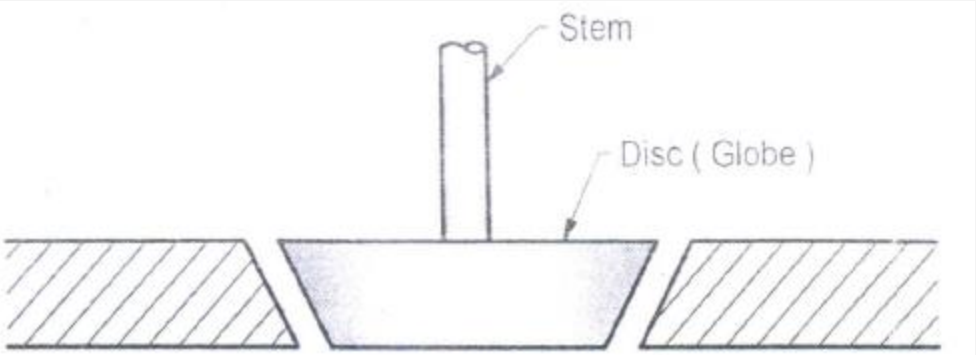


Fig. 9.5.3 : Globe valve

Gate Valve

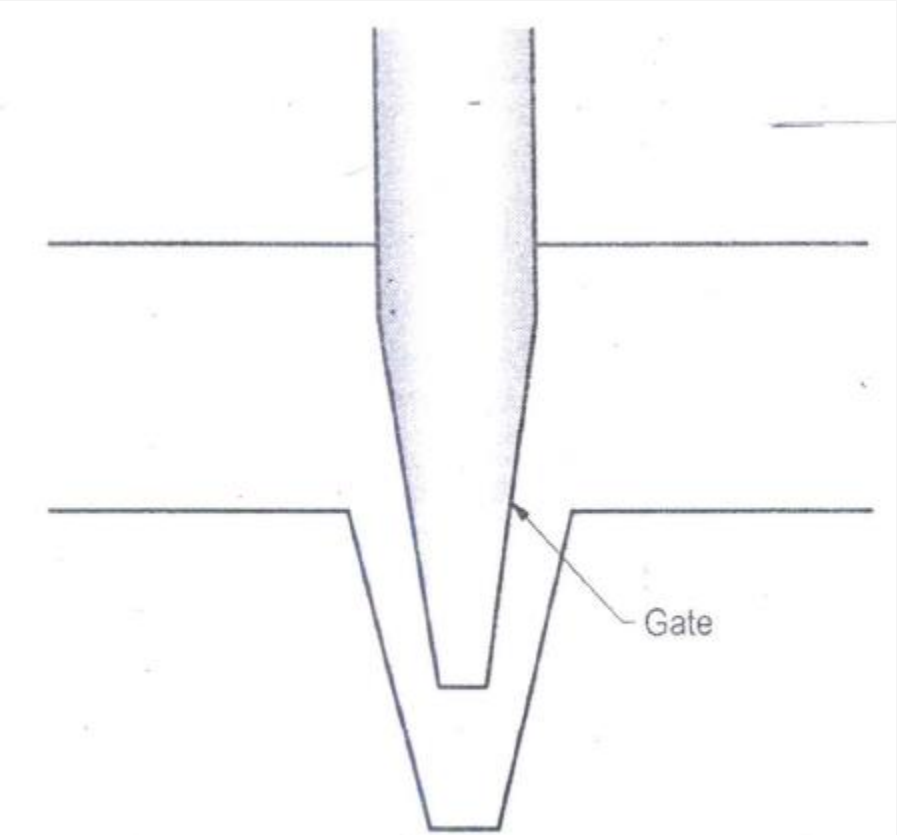


Fig. 9.5.4 : Gate Valve

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