

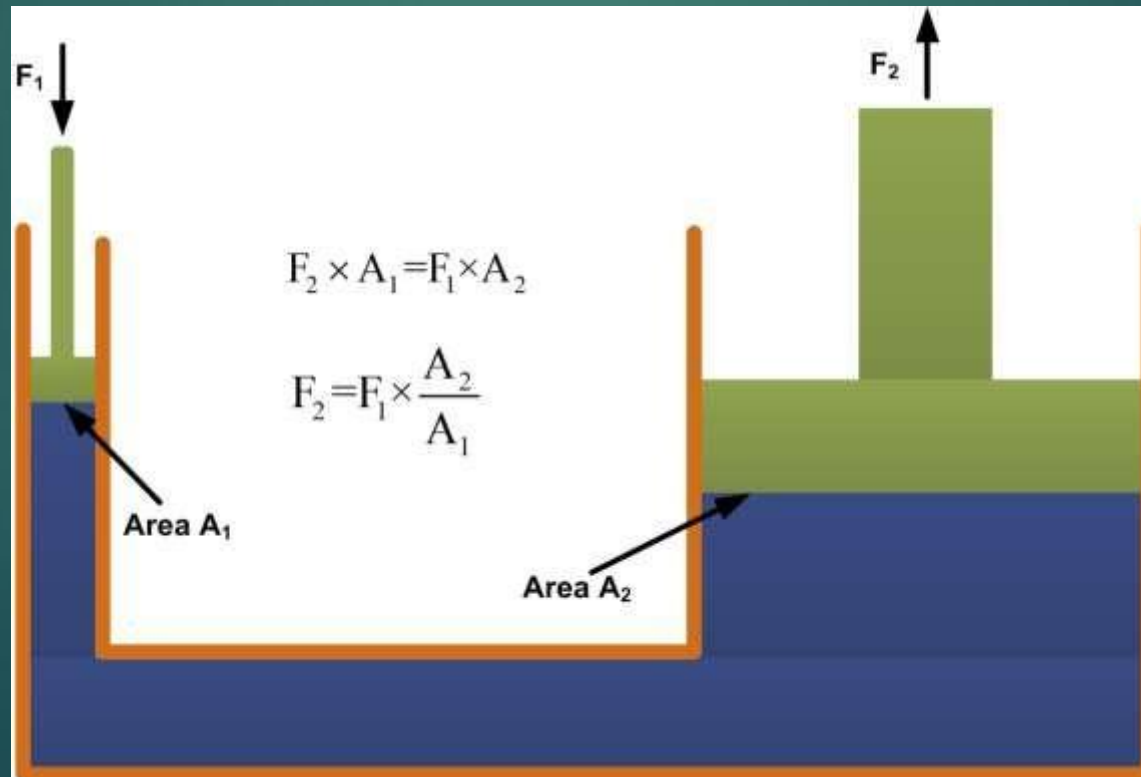
HYDRAULIC CONTROL SYSTEM

INTRODUCTION

- The controlled movement of parts or a controlled application of force is a common requirement in the industries.
- These operations are performed mainly by using electrical machines or diesel, petrol and steam engines as a prime mover.
- The enclosed fluids (liquids and gases) can also be used as prime movers to provide controlled motion and force to the objects or substances.
- The specially designed enclosed fluid systems can provide both linear as well as rotary motion.
- This kind of enclosed fluid based systems using pressurized incompressible liquids as transmission media are called as **hydraulic systems**.

PRINCIPLE OF HYDRAULIC SYSTEM

- The Hydraulic System works on the principle of **Pascal's law**.
- Pascal's law states that "The pressure in an enclosed fluid is uniform in all the directions".



COMPONENTS OF HYDRAULIC SYSTEM

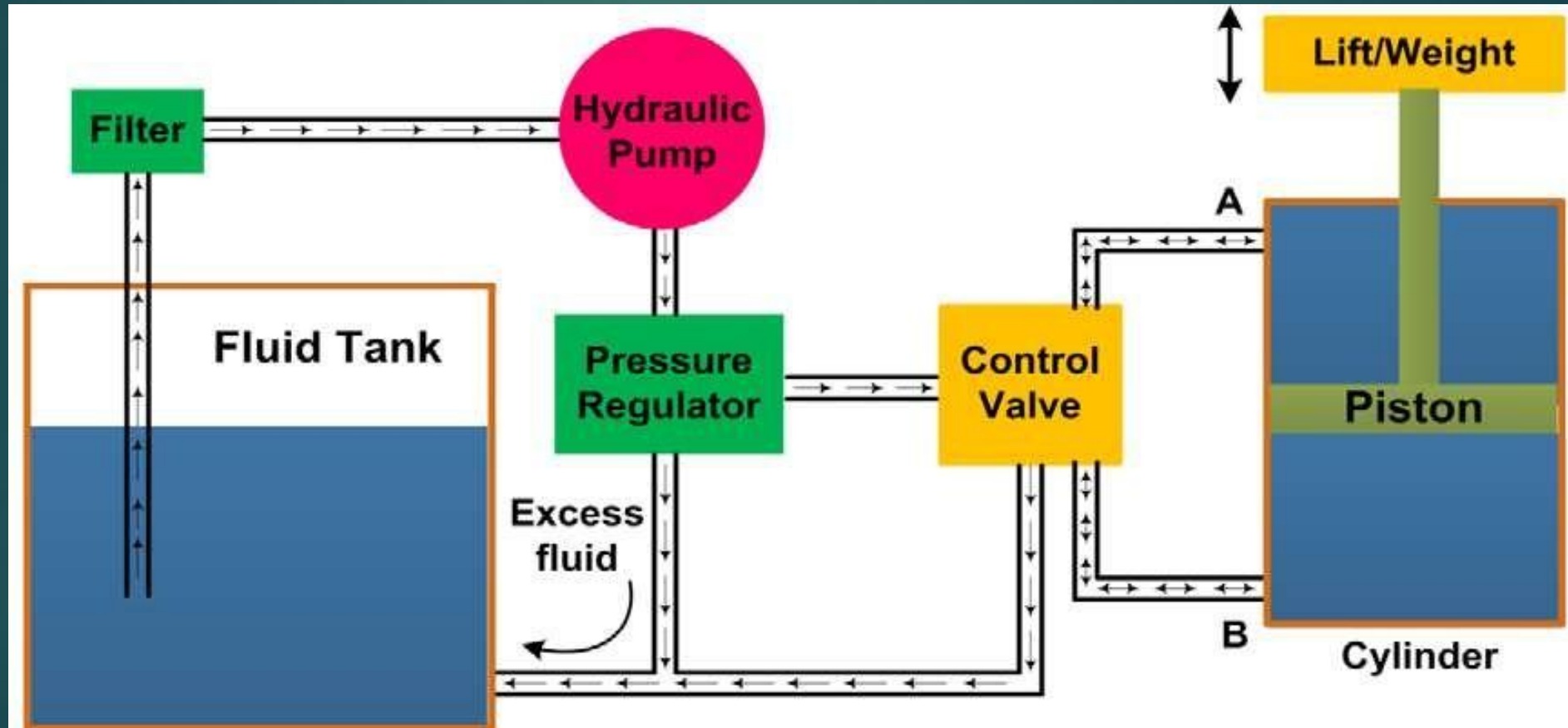
- **The major components of a hydraulic system are:**
 1. Prime Mover
 2. Pump
 3. Control Valves
 4. Actuators(Hydraulic motors, pistons)
 5. Piping System
 6. Fluid

COMPONENTS OF HYDRAULIC SYSTEM

- **The supporting components include:**

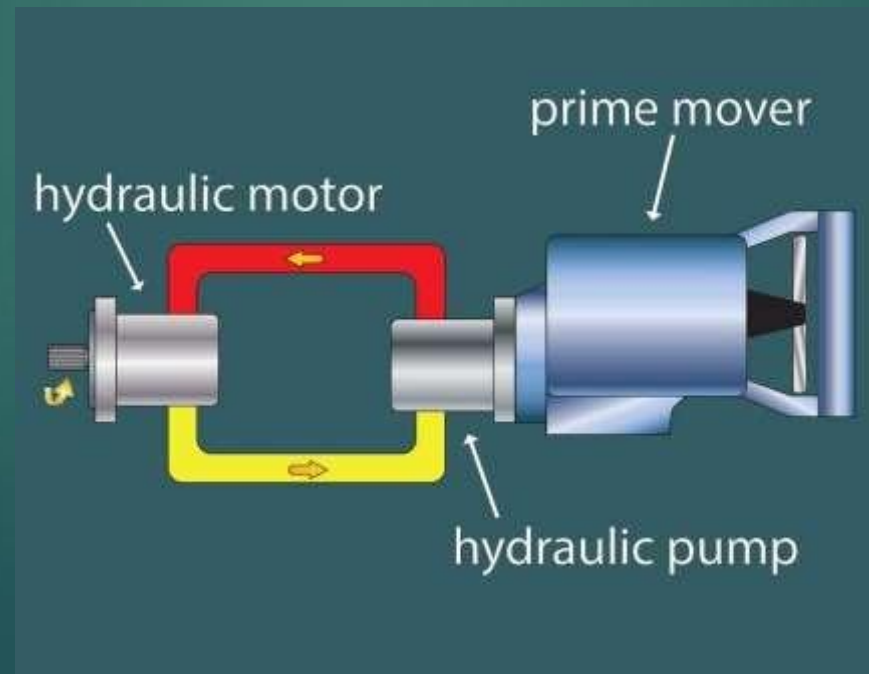
1. Filters
2. Strainers
3. Storage Tanks
4. Heat Exchanger
5. Pressure Gauges
6. Sensors
7. Protective Devices
8. Control Devices
9. Accumulators

SCHEMATIC DIAGRAM OF HYDRAULIC SYSTEM



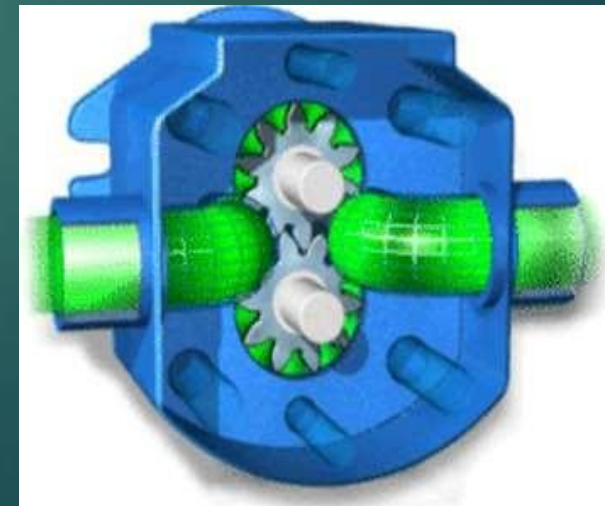
I. PRIME MOVERS

- Prime mover is a device which develops the mechanical power.
- This power in a hydraulic system is basically used to drive the pump.
- Prime mover includes IC Engine, Turbines, etc



II. HYDRAULIC PUMPS

- Pump is a device which converts mechanical energy to fluid energy.
- The hydraulic pump takes hydraulic fluid (mostly some oil) from the storage tank and delivers it to the rest of the hydraulic circuit.
- The hydraulic pumps are characterized by its flow rate capacity, power consumption, drive speed, pressure delivered at the outlet and efficiency of the pump.



TYPES OF HYDRAULIC PUMPS

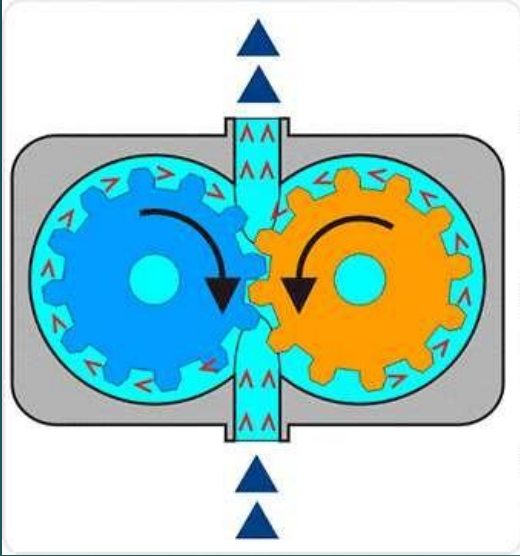
- **Non-positive displacement pumps:**

- ✓ Known as hydro-dynamic pumps
- ✓ Fluid is pressurized by the rotation of the propeller and the fluid pressure is proportional to the rotor speed
- ✓ Used for low-pressure and high-volume flow applications
- ✓ Eg: Centrifugal Pumps

- **Positive displacement pumps:**

- ✓ These pumps deliver a constant volume of fluid in a cycle
- ✓ Used in most of the industrial fluid power applications
- ✓ The output fluid flow is constant and is independent of the system pressure
- ✓ Eg: Vane pump, Piston Pump, Gear Pump

HYDRAULIC GEAR PUMPS



External Gear Pumps



Internal Gear Pumps



Gerotor Pump

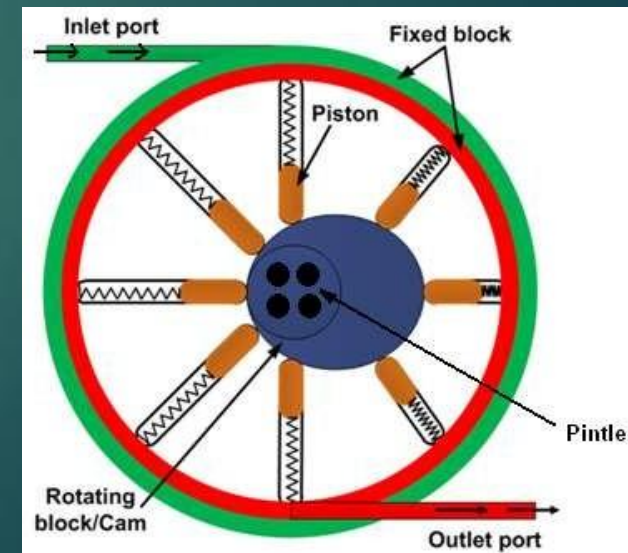
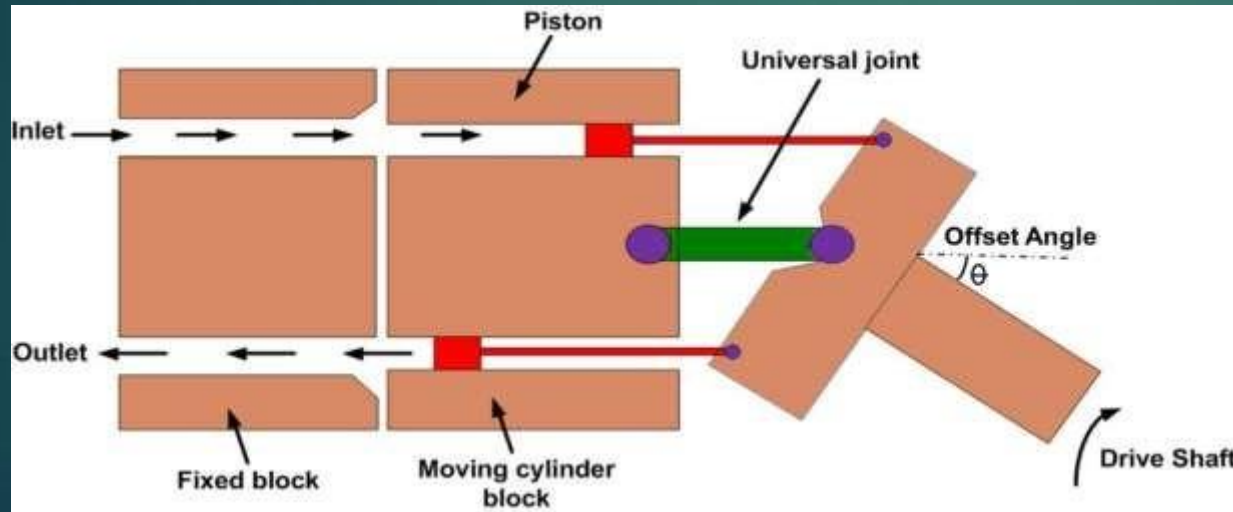


Lobe Pump

HYDRAULIC VANE PUMPS



HYDRAULIC PISTON PUMPS



III. CONTROL VALVES

- The control of the mechanical outputs (motion and force) is one of the most important functions in a hydraulic system.
- The proper selection of control selection ensures the desired output and safe function of the system.
- In order to control the hydraulic outputs, different types of control valves are required.
- There are basically three types of valves employed in hydraulic systems:
 1. Directional control valves
 2. Flow control valves
 3. Pressure control valves

DIRECTIONAL CONTROL VALVES

- Directional control valves provide the direction to the fluid and allow the flow in a particular direction.
- These valves are used to control the start, stop and change in direction of the fluid flow.
- They can be classified in the following manner:

➤ **Type of construction:**

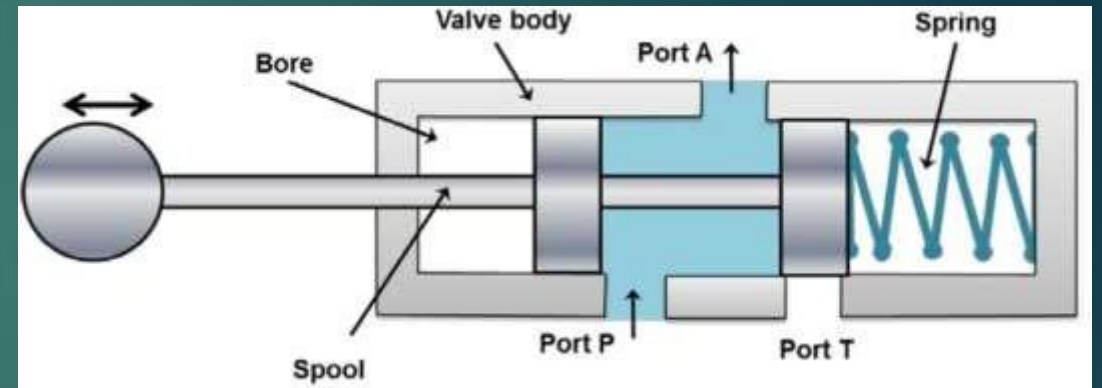
1. Poppet valves
2. Spool valves

➤ **Number of ports and switching positions:**

1. Three way two position
2. Four way three position
3. Four way two position

➤ **Method of change over from one position to next:**

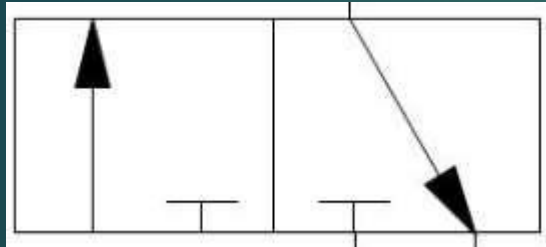
1. Non throttling type
2. Throttling type



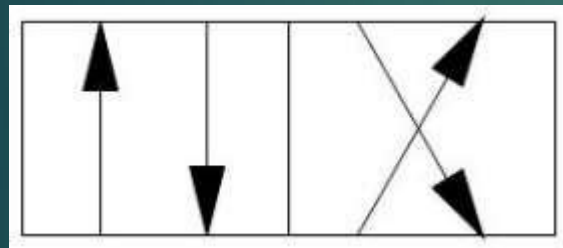
THREE WAY VALVE

- Directional control valves are generally specified using the number of ports and the number of switching positions. It can be represented in general form as n_p/n_s , where n_p is the number of ports connected to the direction control valve and n_s the number of switching positions.

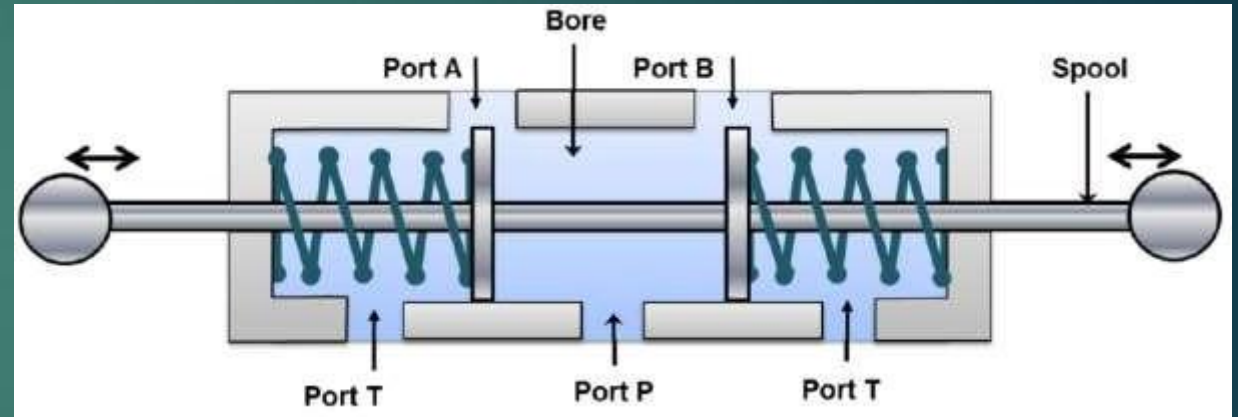
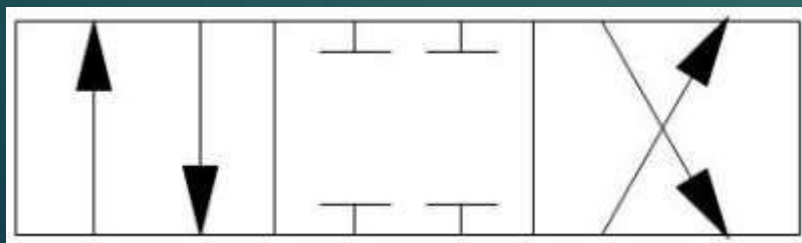
❖ THREE WAY TWO POSITION DCV



❖ FOUR WAY TWO POSITION DCV



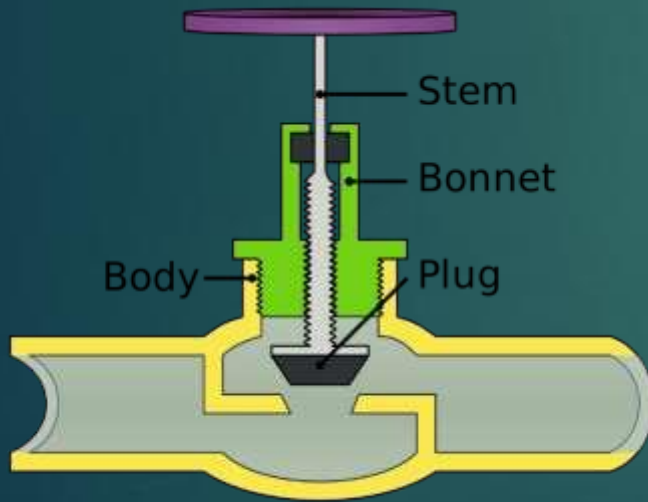
❖ FOUR WAY THREE POSITION DCV



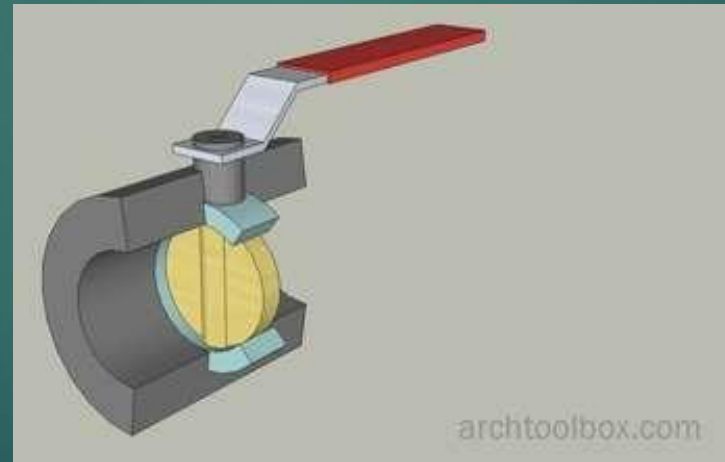
FOUR WAY THREE POSITION DCV

FLOW CONTROL VALVES

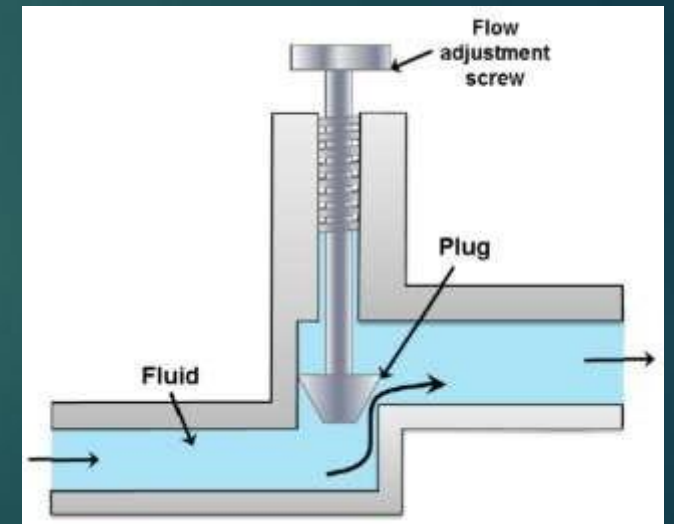
- A flow control valve can regulate the flow or pressure of the fluid.
- The fluid flow is controlled by varying area of the valve opening through which fluid passes.



GLOBE VALVE



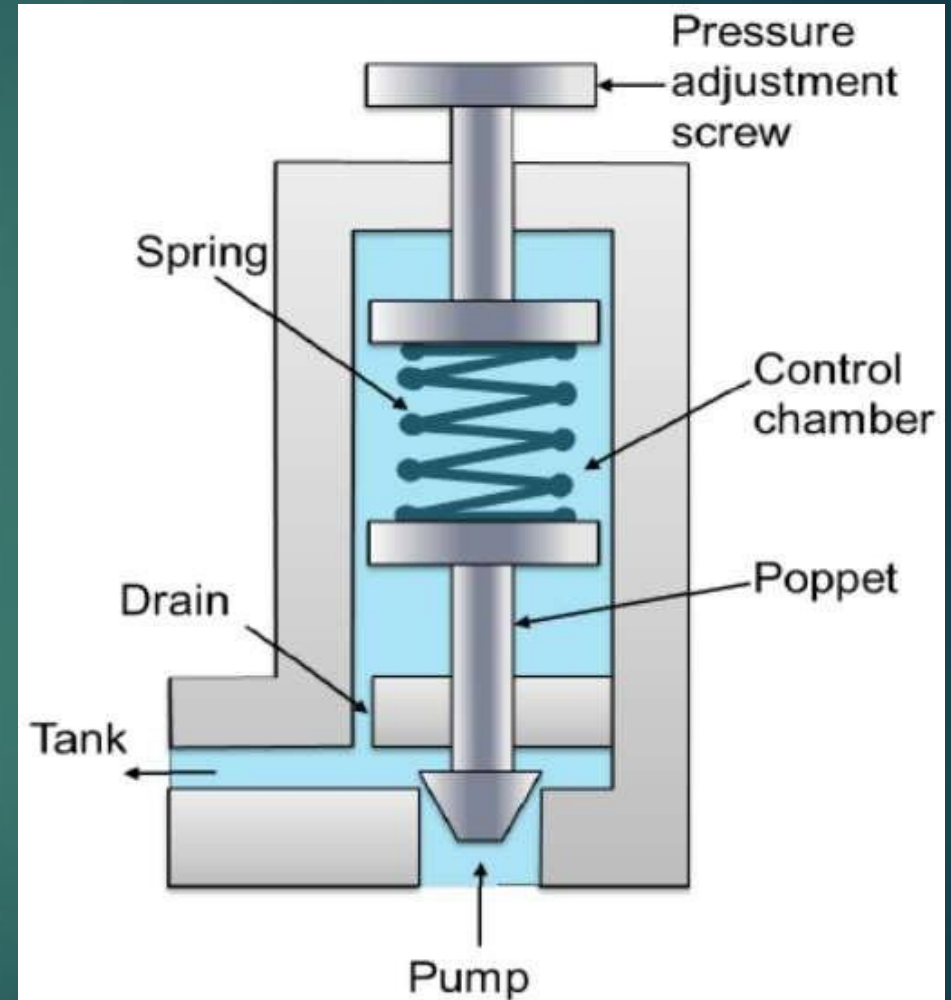
BUTTERFLY VALVE



PLUG VALVE

PRESSURE CONTROL VALVE

- The pressure control valves are used to protect the hydraulic components from excessive pressure.
- It is normally a closed type and it opens when the pressure exceeds a specified maximum value by diverting pump flow back to the tank.
- Pressure control valves are the functional part of the system.



IV. HYDRAULIC ACTUATORS

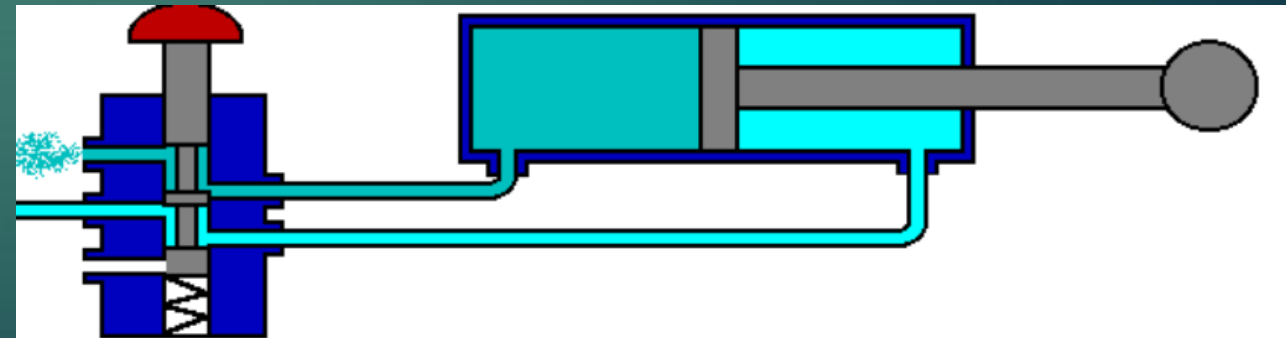
- Hydraulic Actuators employ hydraulic pressure to drive an output member.
- These are used where high speed and large forces are required.
- The fluid used in hydraulic actuator is highly incompressible.
- They convert fluid power into mechanical power.
- Depending on motion they can be classified as:
 1. **Linear actuators:** linear motion as output(cylinder and piston)
 2. **Rotary actuator:** rotary motion as output(motor)

HYDRAULIC CYLINDERS

- Cylinders are linear actuators, that is, they produce straight-line motion and/or force.
- Cylinders are classified as:
 1. Single-acting Cylinder
 2. Double-acting Cylinder
- Single Acting Cylinder has only one fluid chamber and exerts force in only one direction.
- The double-acting cylinder is operated by hydraulic fluid in both directions and is capable of a power stroke either way.



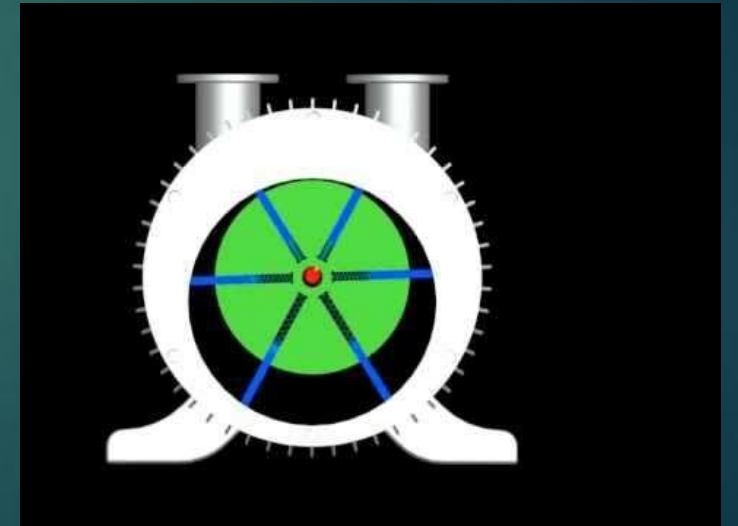
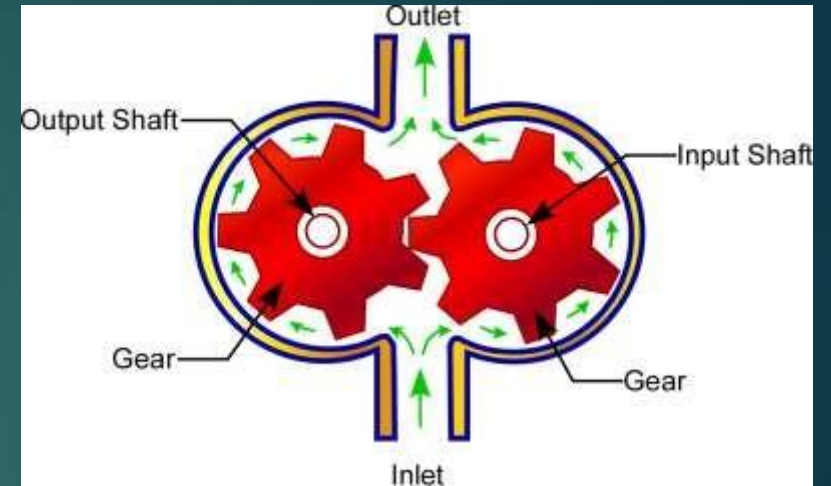
SINGLE ACTING CYLINDER



DOUBLE ACTING CYLINDER

HYDRAULIC MOTORS

- Motors work exactly on the reverse principle of pumps.
- In motors fluid is forced into the motor from pump outlets at high pressure and is converted to mechanical energy.
- This fluid pressure creates the motion of the motor shaft.
- Though any pump can be used as motor, the commonly used hydraulic motors are:
 1. Vane Motors
 2. Gear Motors
 3. Piston Motors



V. HYDRAULIC FLUID

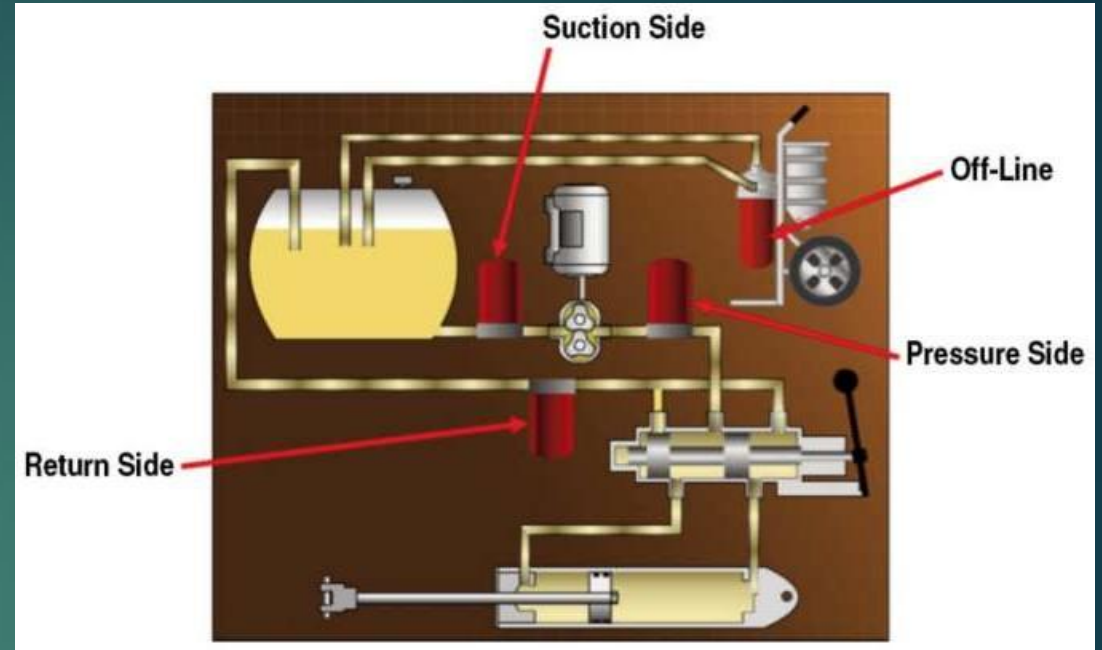
- Hydraulic fluid must be essentially non-compressible to be able to transmit power instantaneously from one part of the system to another.
- At the same time, it should lubricate the moving parts to reduce friction loss and cool the components so that the heat generated does not lead to fire hazards.
- The most common liquid used in hydraulic systems is petroleum oil because it is only very slightly compressible.
- **Properties of hydraulic fluids:**
 1. Non compressible
 2. Low volatility
 3. Corrosion control
 4. Fire resistance
 5. Low toxicity
 6. Good lubricator

VI. FILTERS

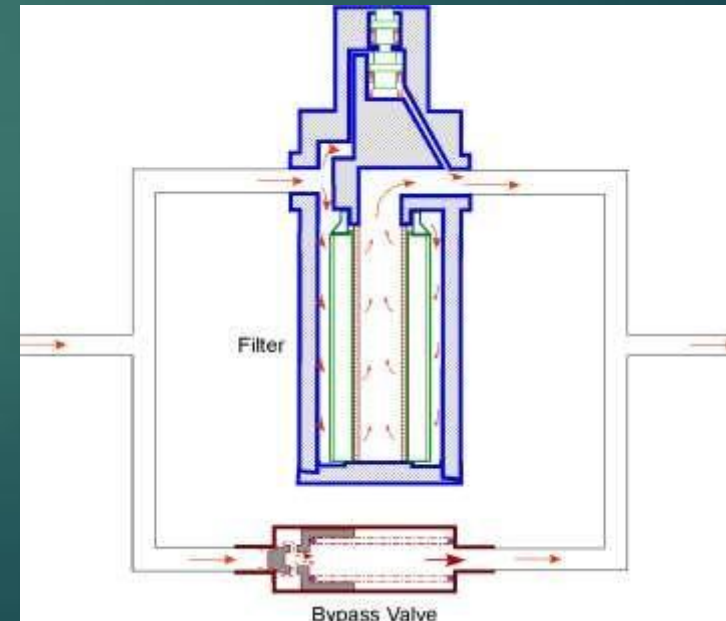


- The hydraulic fluid is kept clean in the system with the help of filters and strainers.
- It removes minute particles from the fluid, which can cause blocking of the orifices of servo-valves or cause jamming of spools.
- **Types of hydraulic filters:**
 1. **Suction Filters:** The suction filter provides protection to the hydraulic pump from particles larger than 10 microns.
 2. **Pressure Side Filters:** Located downstream from the hydraulic pump, these filters are designed to clean the fluid as it exits the pump to protect more sensitive system components such as control valves and actuators from contaminants generated from the pump.

3. Return Side Filter: Located between the control valve and the fluid reservoir, these filters are designed to capture wear debris from the hydraulic systems working components before returning the fluid back to the reservoir

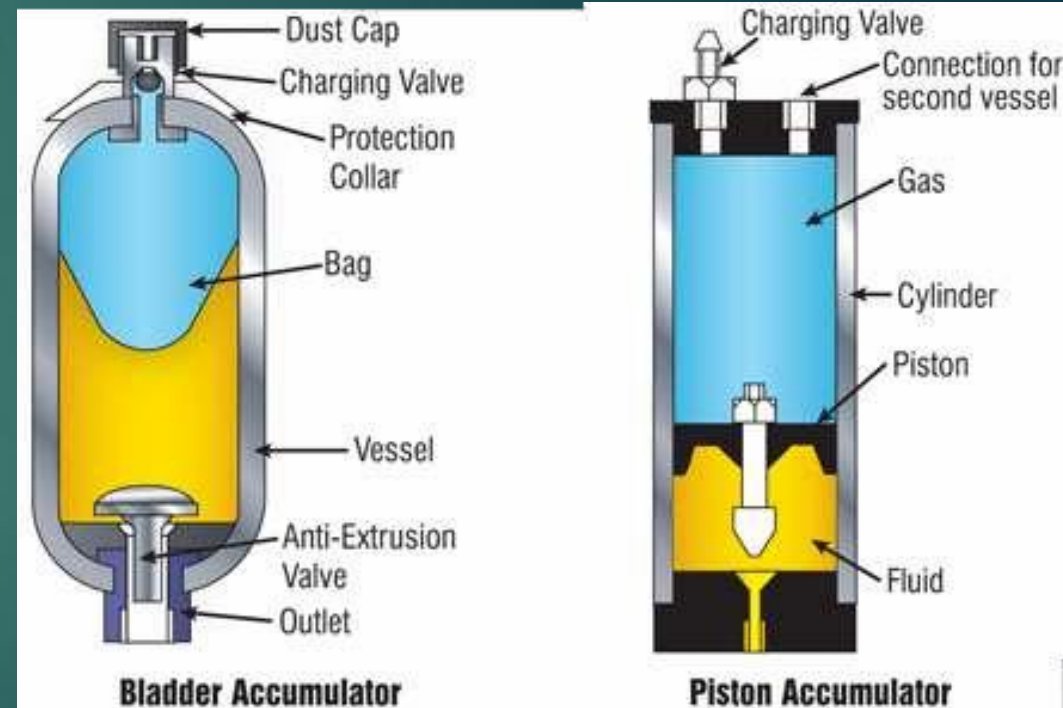


4. Offline Filter: These filters are used, independent from the hydraulic system, to clean hydraulic fluid before it enters the hydraulic system itself.



VII. ACCUMULATORS

- Unlike gases the fluids used in hydraulic systems cannot be compressed and stored to cater to sudden demands of high flow rates that cannot be supplied by the pump.
- An accumulator in a hydraulic system provides a means of storing these incompressible fluids under pressure created either by a spring, compressed a gas.
- Any tendency for pressure to drop at the inlet causes the spring or the gas to force the fluid back out, supplying the demand for flow rate.



APPLICATIONS OF HYDRAULIC SYSTEMS

- **Industrial:** Plastic processing machineries, steel making and primary metal extraction applications, automated production lines, machine tool industries, paper industries, loaders, crushes, textile machineries, R & D equipment and robotic systems etc.
- **Mobile hydraulics:** Tractors, irrigation system, earthmoving equipment, material handling equipment, commercial vehicles, tunnel boring equipment, rail equipment, building and construction machineries and drilling rigs etc.
- **Automobiles:** It is used in the systems like breaks, shock absorbers, steering system, wind shield, lift and cleaning etc.
- **Marine applications:** It mostly covers ocean going vessels, fishing boats and navel equipment.
- **Aerospace equipment:** There are equipment and systems used for rudder control, landing gear, breaks, flight control and transmission etc. which are used in airplanes, rockets and spaceships.