Pneumatic and Hydraulic Actuators and Valves

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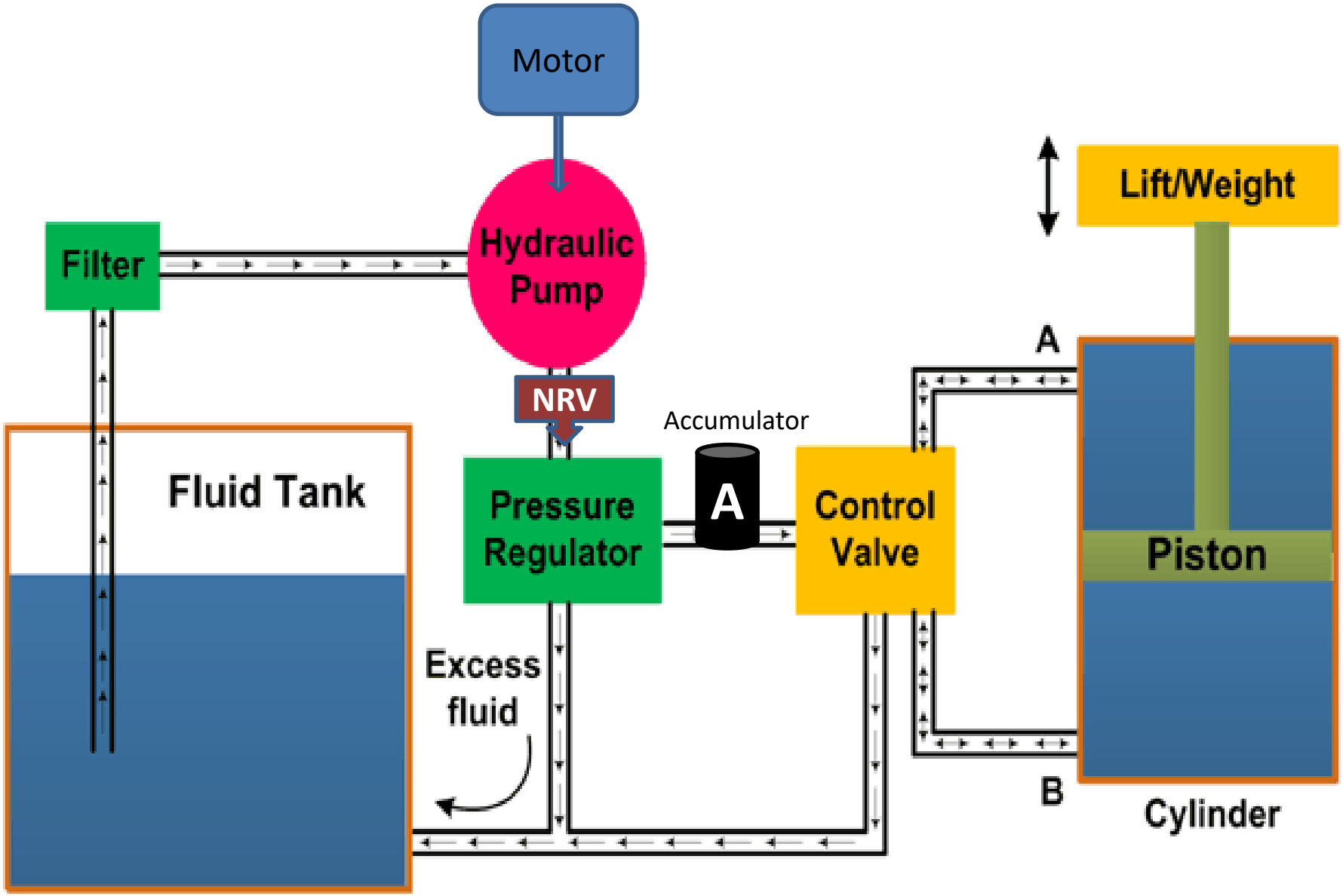
Hydraulic systems

- It is a kind of enclosed fluid-based system using pressurized incompressible liquids as transmission media. And is called as hydraulic system. The hydraulic system works on the principle of Pascal's law.
- Enclosed fluid systems can provide both linear as well as rotary motions.
- The hydraulic systems consists of following parts-

storage tank,
hydraulic pump,
accumulator,
direction control valves
piston,
filter,
non-return valve,
pressure regulator,
hydraulic cylinder,
leak-proof fluid flow pipelines.



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The storage/fluid tank is a reservoir for the liquid used as a transmission media. The liquid used is generally high-density incompressible oil. It is filtered to remove dust or any other unwanted particles and then pumped by the hydraulic pump operated by a motor. The capacity of the pump depends on the hydraulic system design.

A non-return valve is used to make sure no amount of liquid returns back to the pumping system.

The pumps generally deliver constant volume in each revolution of the pump shaft. Therefore, the fluid pressure can increase indefinitely at the dead-end of the piston until the system fails. The pressure regulator / relief valve is used to avoid such circumstances which redirect the excess fluid back to the storage tank.

In case the pump delivers non-uniform fluid supply, an accumulator needs to be used to regulate and control the amount of fluid flow. It helps in minimizing the pressure fluctuations in supply line.

The movement of the piston is controlled by changing the liquid flow from port A and port B. The cylinder movement is controlled by using a control valve which directs the fluid flow. The fluid pressure line is connected to the port B to raise the piston and it is connected to port A to lower down the piston. The valve can also stop the fluid flow in any of the ports.

The leak-proof piping is also important due to safety, environmental hazards, and economic aspects.

Applications : Machine tools, Material handling equipment, Construction field, Automobiles, Material testing laboratory, Aerospace, Railways, Medical equipment, Agricultural equipment, etc.

Advantages :

- Easy to : produce, transmit, store, regulate and control, maintain and transform.
- Possible to generate high gain in force (power amplification).
- Uniform and smooth, generate step-less motion and variable speed and force to a greater accuracy.
- Frictional resistance is much less in a hydraulic system as compared to a mechanical movement.
- Lesser noise and vibration.
- Lesser weight to power ratio.
- Better over-load safe system.
- Absolutely accurate feedback of load, position, etc. can be achieved.

Disdvantages :

- Increased manufacturing costs
- The *leakage of hydraulic oil* poses problems to hydraulic users.
- Hydraulic elements have to be specially treated to protect them against rust, corrosion, dirt, etc.
- Hydraulic oil may pose problems if it disintegrates due to aging and chemical deterioration.

Commonly used hydraulic pumps in any hydraulic system are the gear pump, vane pump and piston pump.

a. Gear Pump

b. Vane Pump

c. Piston Pumps

    a. Radial Piston Pump

    b. Axial Piston Pump


Rotary Vane Pump
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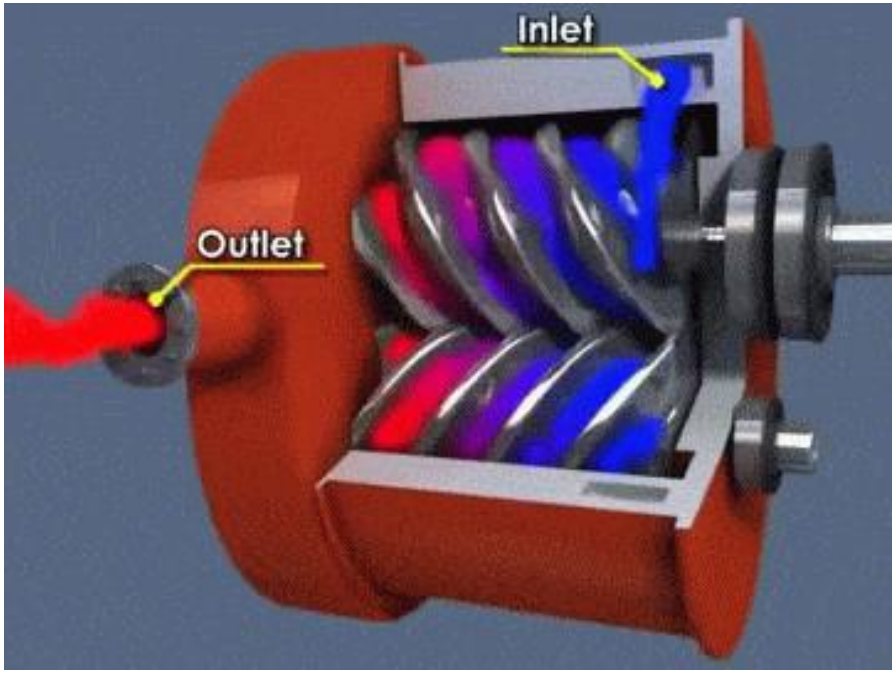
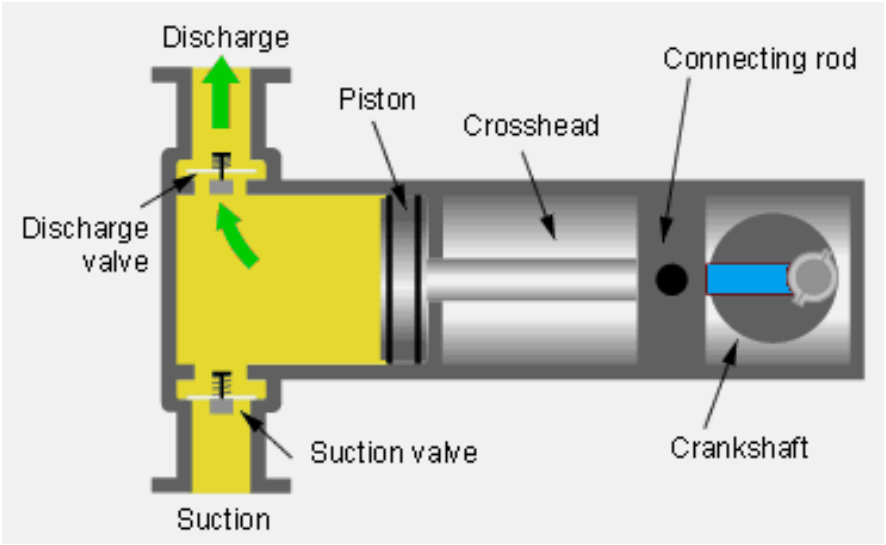
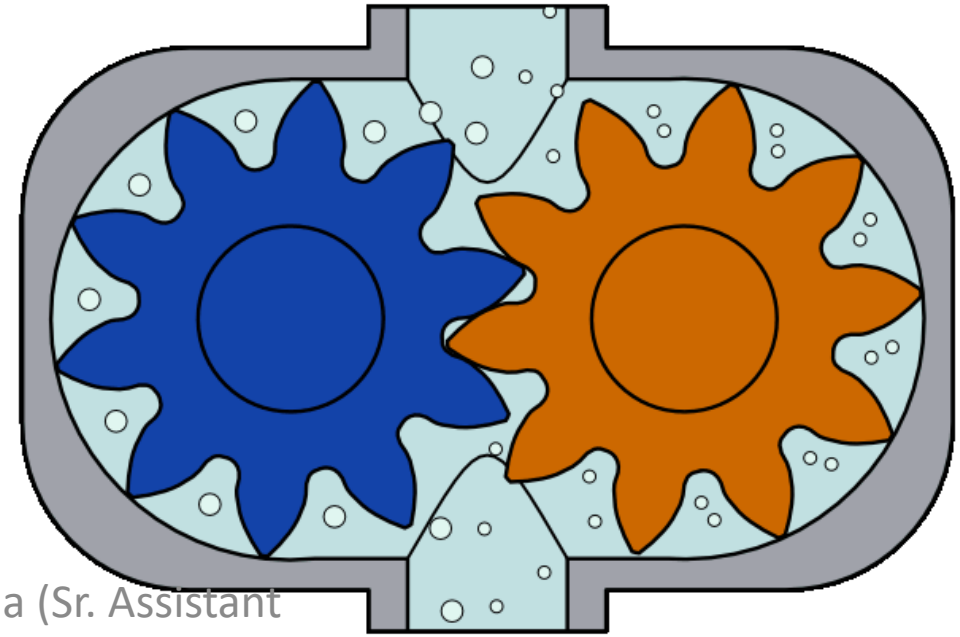

Inlet
Outlet

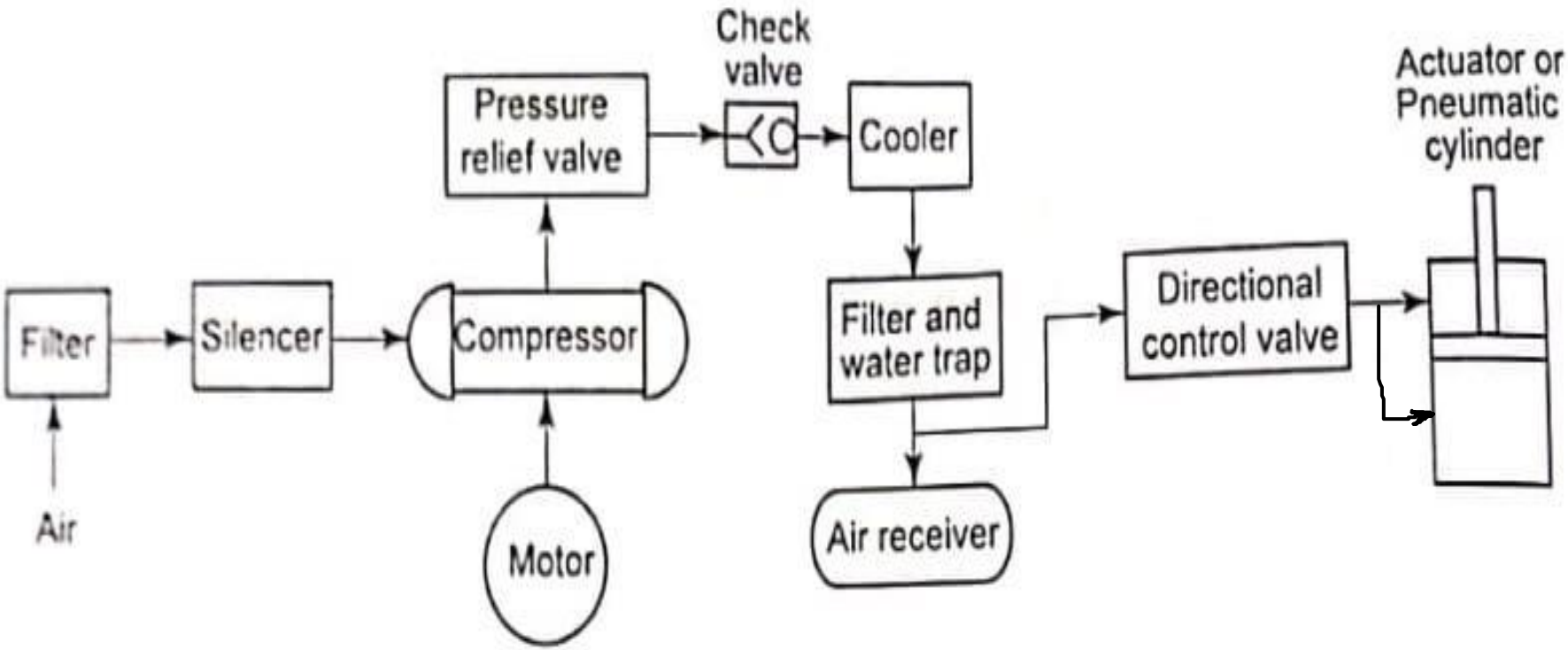

Discharge
Piston
Crosshead
Connecting rod
Discharge valve
Suction valve
Crankshaft
Suction



Pneumatic systems

- In pneumatic systems, force is produced by gas. It is mainly by air pressure acting on the surface of a piston or valve.
- Compressed air is produced in a compressor and stored in a receiver. From compressor, it is send to valves which control the direction of fluid flow. Also, flow control valves control the amount of power by the cylinder.
- A pneumatic system essentially has the following components-
  - **Compressor and Motor**
  - **Pressure relief valve and Check valve.**
  - **Cooler, filter and water trap**
  - **Air receiver**
  - **Directional control valves**
  - **Actuator or pneumatic cylinder**

Pneumatic systems



The fresh atmosphere air is not sent directly to the compressor to use in pneumatic systems. First, it is filtered atmosphere air is supplied to the compressor through silencer to reduce noise level. Then it is compressed.

Pressure relief valve is used to avoid the damage of compressor due to excess pressure raise in the system. Check valve is a one-way valve that allows pressurized air to enter the pneumatic system, but prevents backflow and loss of pressure into the compressor when it is stopped.

The cooler is used to cool the compressed air which is usually very hot. The filter is used to remove contamination in the compressed air and water trap is used to remove water particles.

The pressurized air is stored in a device called an air receiver, preventing surges in pressure and relieving the duty cycle of the compressor.

Directional control valves are used to control flow of pressurized air from the source to the selected port. These valves can be actuated either manually or electrically.

Actuator or pneumatic cylinder converts energy stored in the compressed air into mechanical motion.

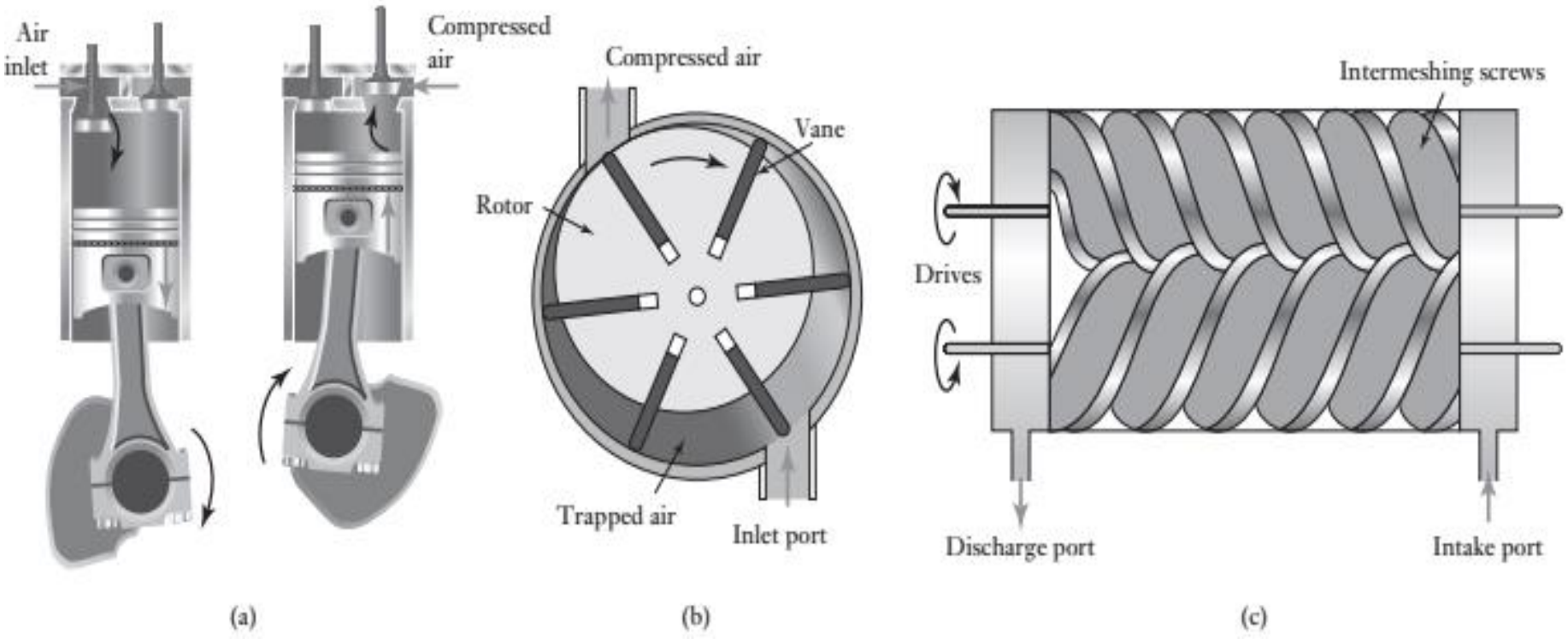
Commonly used air compressors are

(a) Single acting reciprocating compressor

(b) Rotary Vane Compressor

(c) Screw Compressor

(d) Gear pump



Valves

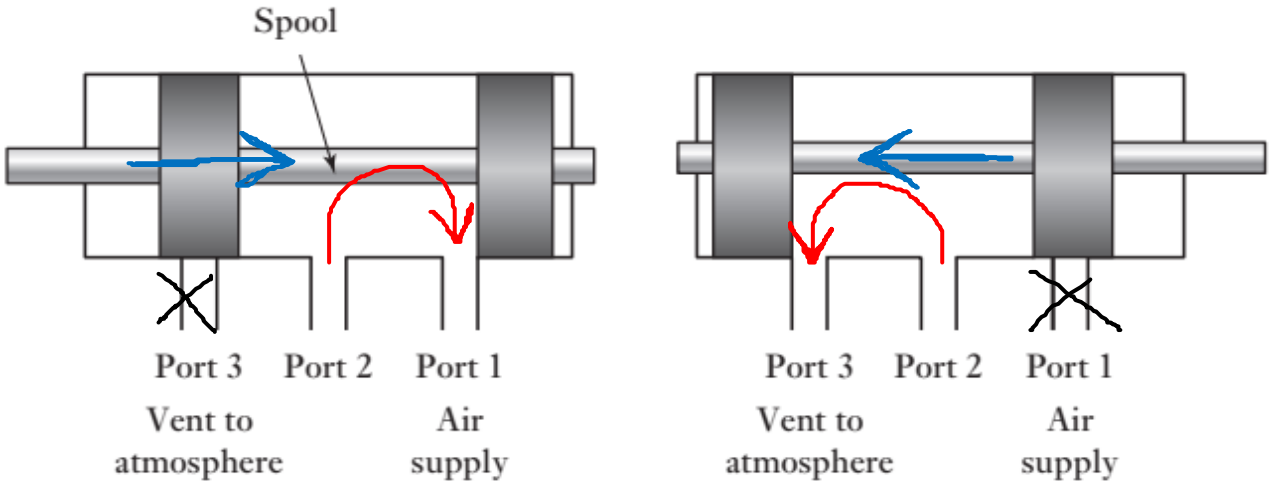
- Valves are used with hydraulic and pneumatic systems to direct and regulate the fluid flow.
- There are basically just two forms of valve, **the finite position** and the **infinite position valves**.
- The **finite position valves** are ones where the action is just to allow or block fluid flow and so can be used to switch actuators **on or off**. They can be used for directional control to switch the flow from one path to another and so from one actuator to another.
- The **infinite position valves** are able **to control flow anywhere between fully on and fully off** and so are used to control varying actuator forces or the rate of fluid flow for a process control situation.

Directional Control Valves

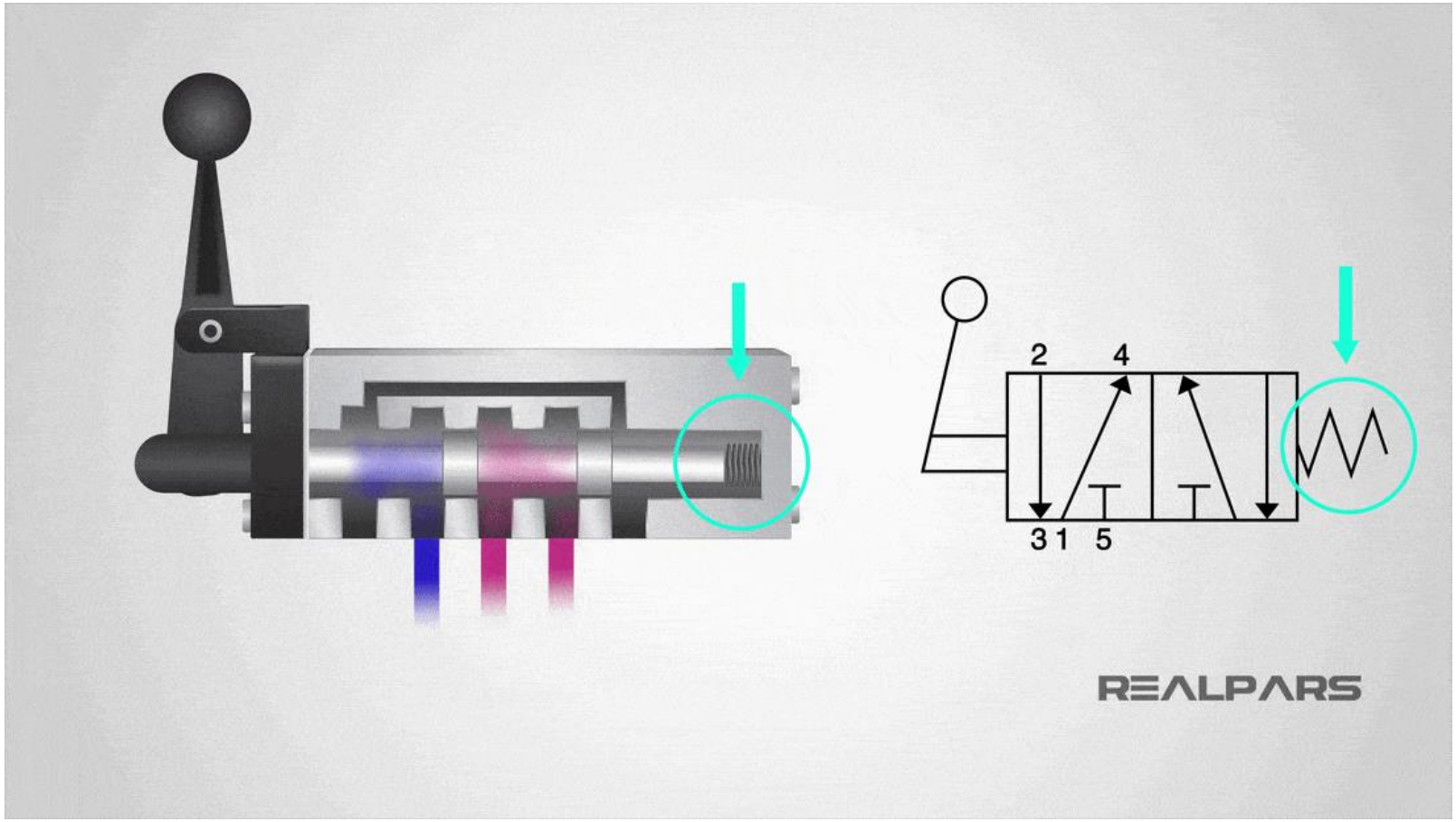
- They are not intended to vary the rate of flow of fluid but are either completely open or completely closed, i.e. on/off devices.
- They might be activated to switch the fluid flow direction by means of mechanical, electrical or fluid pressure signals.

A common type of directional control valve is the **SPOOL VALVE.**

A spool moves horizontally within the valve body to control the flow. In (a) the air supply is connected to port 1 and port 3 is closed. Thus the device connected to port 2 can be pressurised. When the spool is moved to the left the air supply is cut off and port 2 is connected to port 3. Port 3 is a vent to the atmosphere and so the air pressure in the system attached to port 2 is vented. Thus the movement of the spool has allowed the air firstly to flow into the system and then be reversed and flow out of the system.



Spool Valve (Direction Control Valve)



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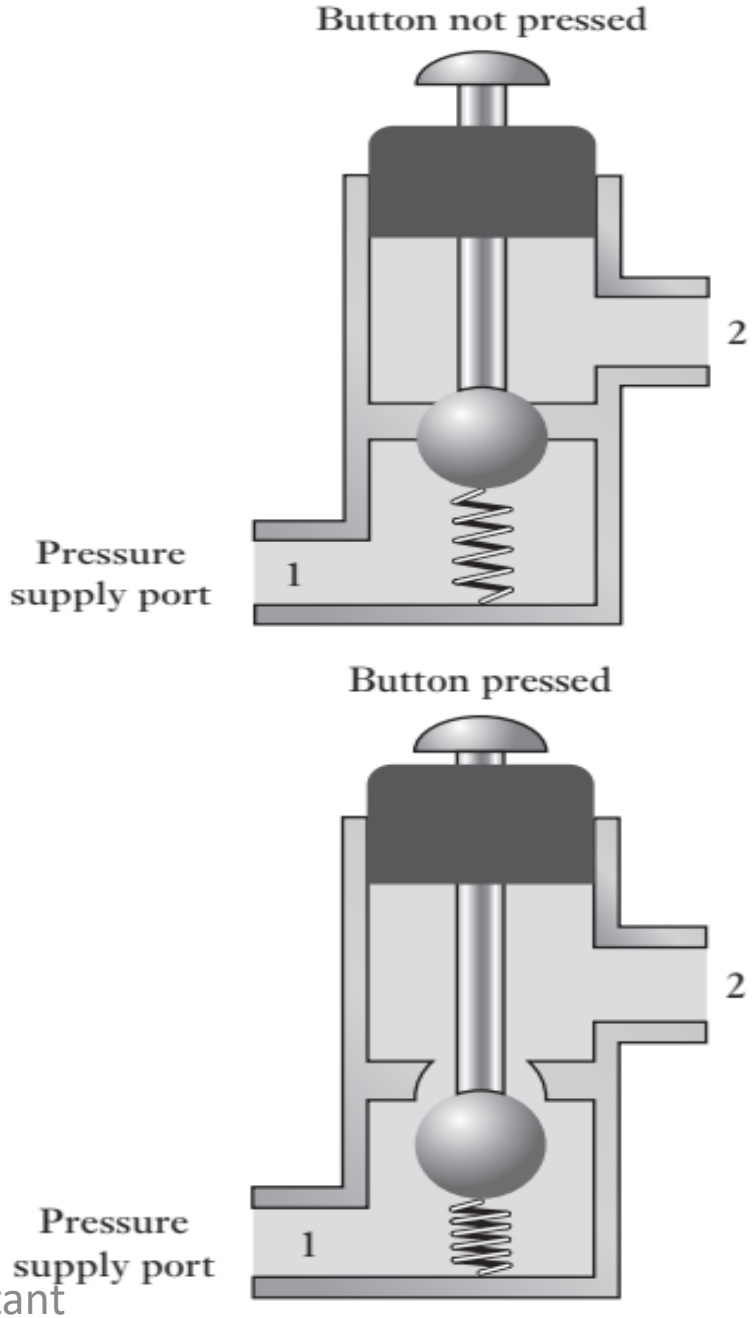
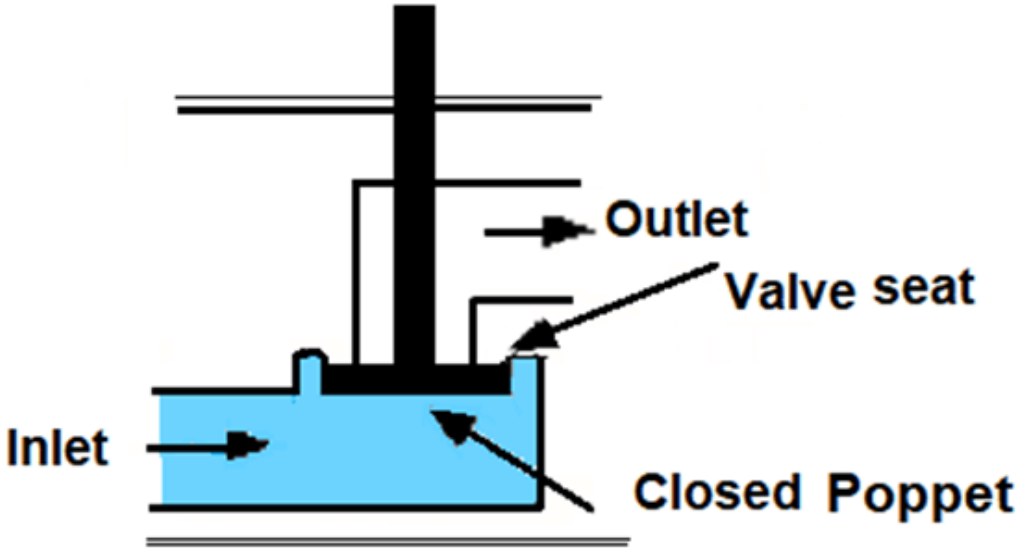
Poppet Valve

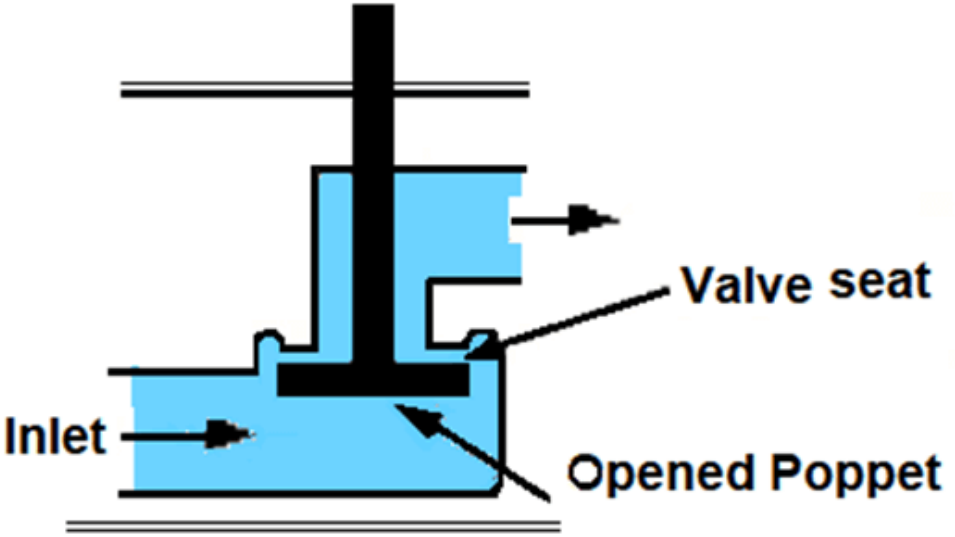
- Another common form of directional control valve is the poppet valve.
- This valve is normally in the closed condition, there being no connection between port 1 to which the pressure supply is connected and port 2 to which the system is connected.
- In poppet valves, balls, discs or cones are used in conjunction with valve seats to control the flow.
- In the figure a ball is shown. When the push-button is depressed, the ball is pushed out of its seat and flow occurs as a result of port 1 being connected to port 2.
- When the button is released, the spring forces the ball back up against its seat and so closes off the flow.



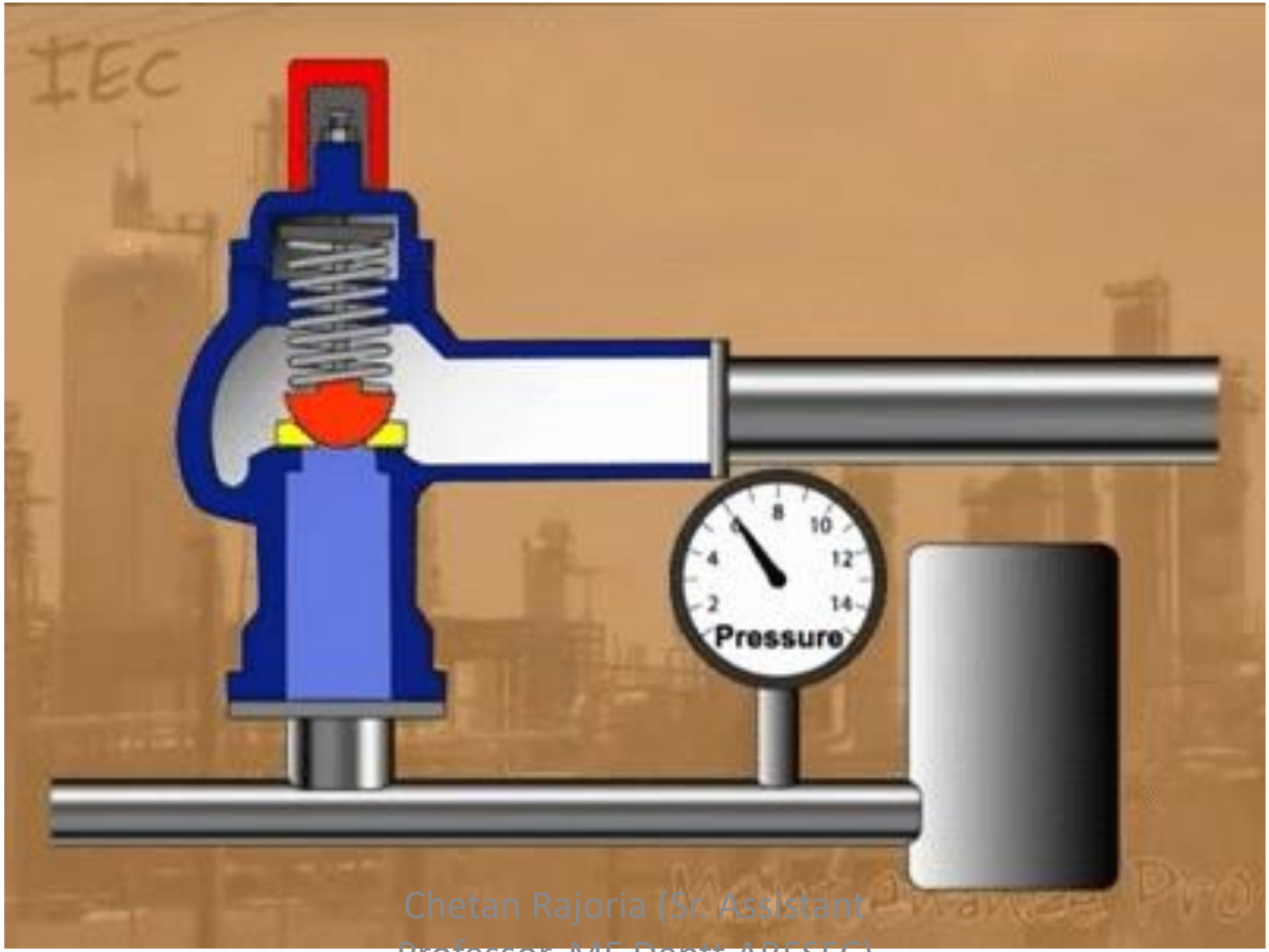
Poppet Valve
Close-Position



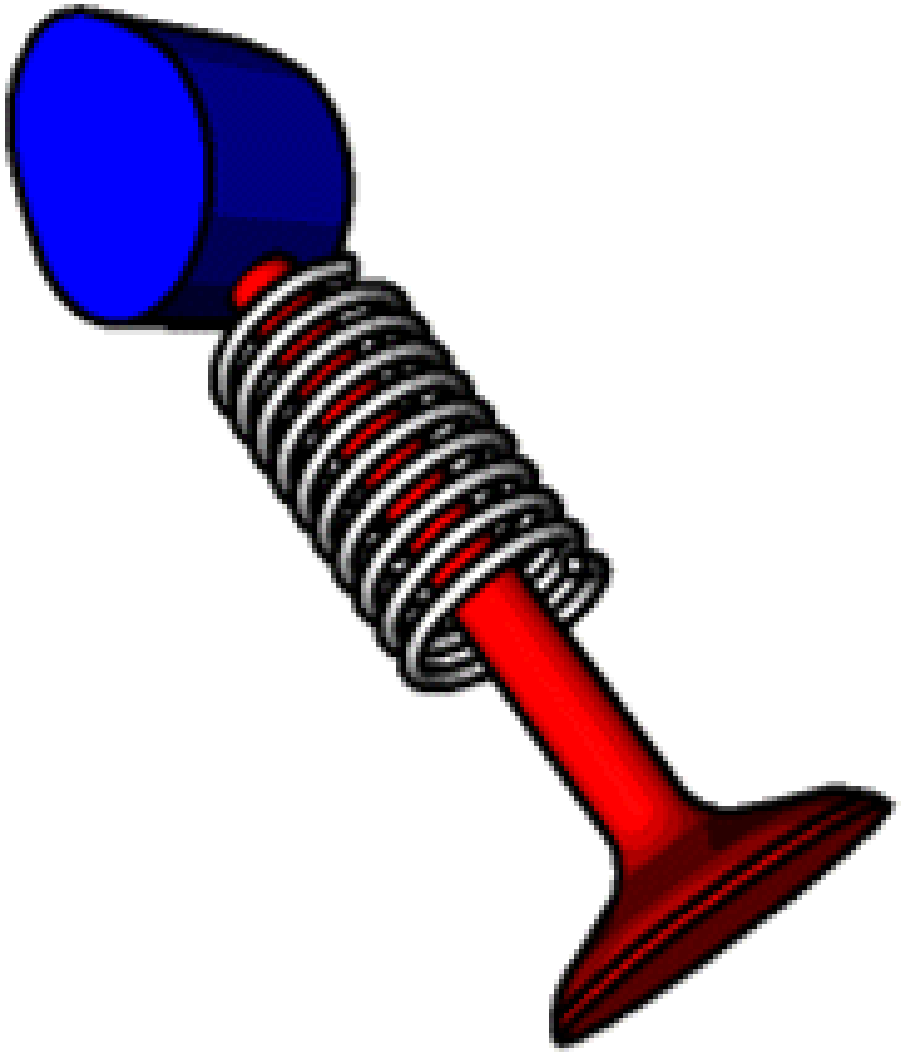
Poppet Valve
Open-Position



Poppet valve



Engine Valves are also examples of Poppet valve



Flow Control Valves

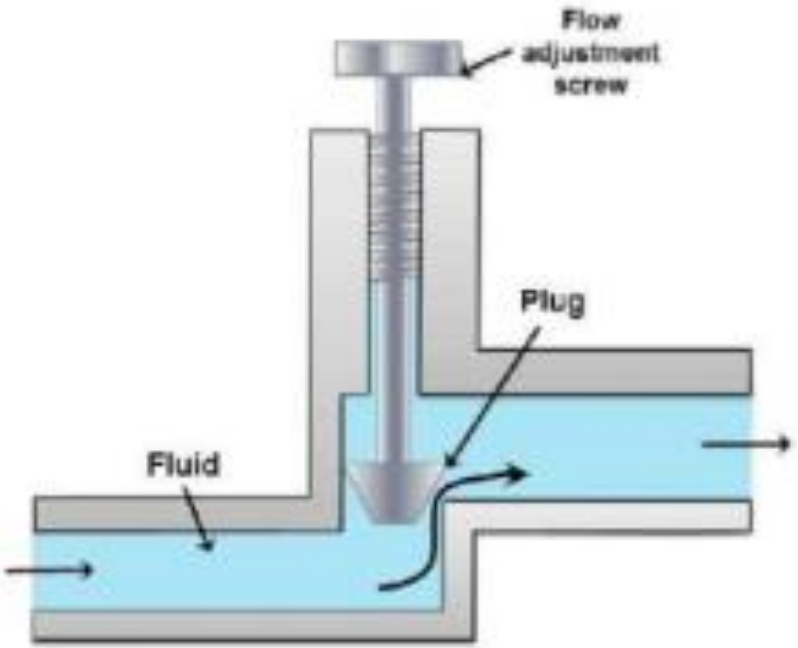
Flow control valves in hydraulics are used for controlling the volume of fluid which is supplied to different parts of the hydraulic system.

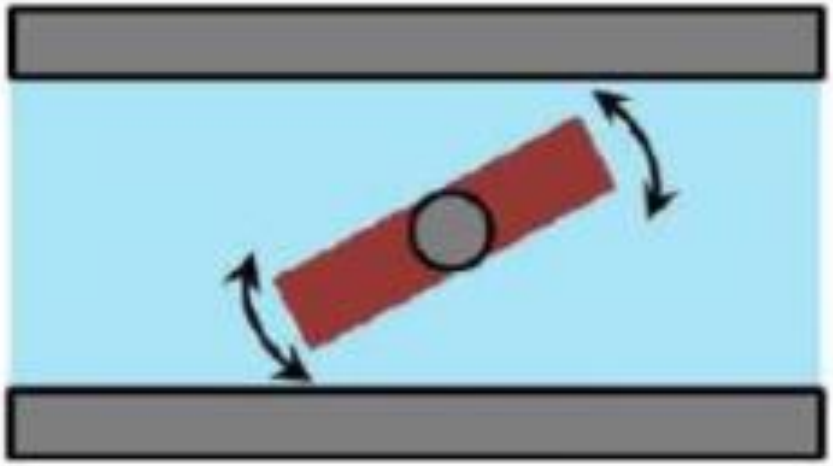
The speed of the actuators which is being used in the hydraulic circuits can be controlled by regulating the fluid flow.

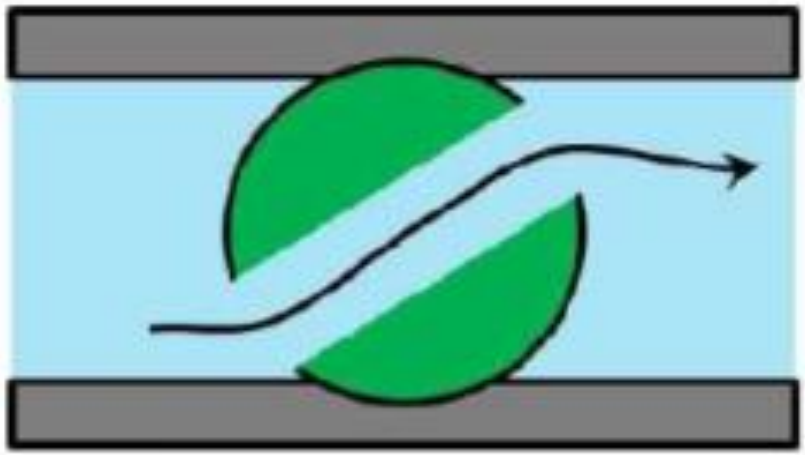
Types of flow control valves-

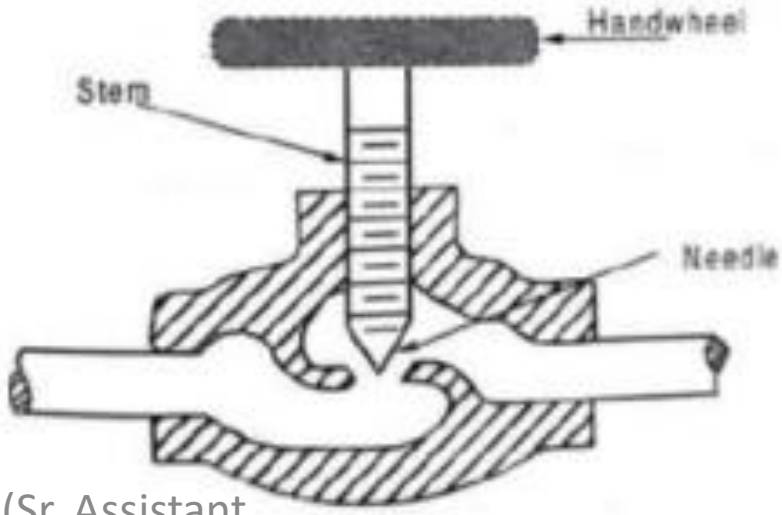
- **Plug or glove valve**
- **Butterfly valve**
- **Ball valve**
- **Pin or needle valve**

Flow Control Valves









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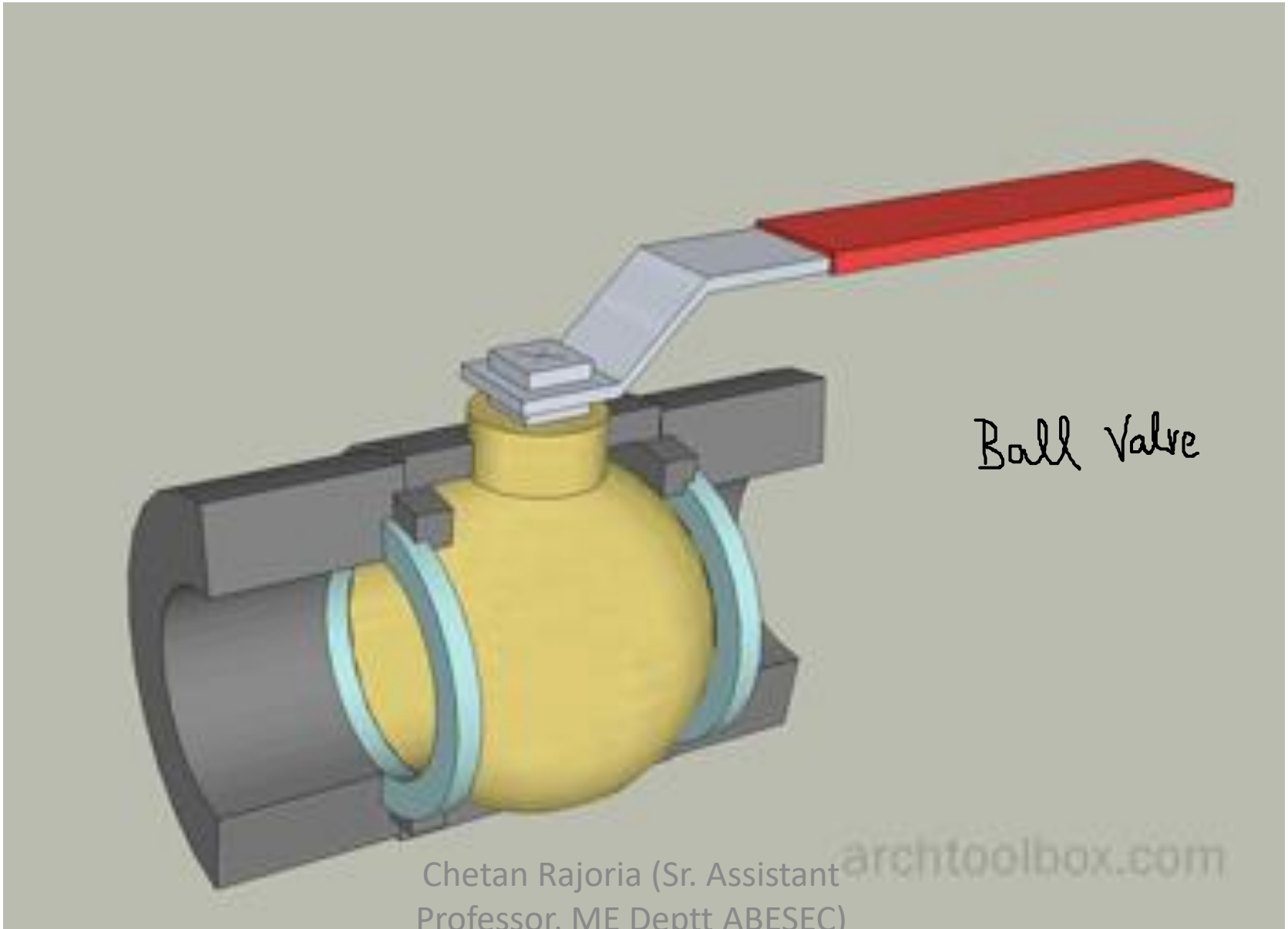

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