NPTEL: Automation & Controls
Module: 2 Hydraulic and Pneumatic Controls

Q.1. What is the working principle of fluid power transmission?

Ans: Fluid power transmission works under the principle statement of Pascal's law which states that- "Pressure applied to a confined fluid is transmitted undiminished in all directions and acts with equal force on equal areas and at right angles to a container's walls."

Q.2. How many types of valves are used in hydraulic/pneumatic systems? What are their symbols?

Ans: Following are the types and symbols of valves used in Hydraulic/Pneumatic systems

1. Directional Control Valves

Directional control valve (2 ports / 2 positions)

-Normally closed directional control valve with 2 ports and 2 finite positions.

-Normally open directional control valve with 2 ports and 2 finite positions.

Directional control valve (3 ports / 2 positions)

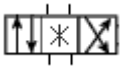
-Normally closed directional control valve with 3 ports and 2 finite positions.

-Normally open directional control valve with 3 ports and 2 finite positions.

Directional control valve (4 ports / 2 positions)

-directional control valve with 4 ports and 2 finite positions

Directional control valve (4 ports / 3 positions)



-directional control valve with 4 ports and 3 finite positions *-(center position can have various flow paths)

Directional control valve (5 ports / 2 positions) Normally a pneumatic valve

-directional control valve with 5 ports and 2 finite positions

Directional control valve (5 ports / 3 positions) Normally a pneumatic valve

 -directional control valve with 5 ports and 3 finite positions

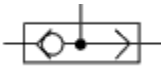
2. Check valves, Shuttle valves, Rapid Exhaust valves

 -check valve -free flow one direction, blocked flow in other direction

 -pilot operated check valve, pilot to close

 -pilot operated check valve, pilot to open

Shuttle valve

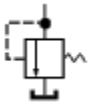
 -to isolate one part of a system from an alternate part of circuit.

Rapid exhaust valve/Pneumatic

 -installed close to an actuator for rapid movement of the actuator.

3. Pressure Control Valves

Pressure Relief Valve(safety valve) normally closed

 - Line pressure is limited to the setting of the valve, secondary part is directed to tank.

Proportional Pressure Relief

 - Line pressure is limited to and proportional to an electronic signal

Sequence Valve

 - When the line pressure reaches the setting of the valve, valve opens permitting flow to the secondary port. The pilot must be externally drained to tank.

Pressure Reducing valve

 - pressure downstream of valve is limited to the setting of the valve

4. Flow Control Valves

Throttle valve

 -adjustable output flow

Flow Control valve

 -with fixed output (variations in inlet pressure do not affect rate of flow)

 -with fixed output and relief port to reservoir with relief for excess flow (variations in inlet pressure do not affect rate of flow)

 -with variable output

 -fixed orifice

 -metered flow toward right free flow to left

 -pressure compensated flow control fixed output flow regardless of load

 -pressure and temperature compensated

 -with variable output and relief port to reservoir

Flow dividing valve

 -flow is divided equally to two outputs.

Shut-Off Valve

 -Simplified symbol

Q.3. What is the function of hydraulic actuators in the automated system? How many types of actuators are used?

Ans: A hydraulic actuator receives pressure energy and converts it to mechanical force and motion. An actuator can be linear or rotary. A linear actuator gives force and motion outputs in a straight line. It is more commonly called a cylinder but is also referred to as a ram, reciprocating motor, or linear motor. A rotary actuator produces torque and rotating motion. It is more commonly called a hydraulic motor or motor.

Normally two types of hydraulic actuators are used which are:
Reciprocating actuators: Single acting cylinders, Double acting cylinders.
Rotary actuators: Hydraulic motors.

Q.4. What oils are normally used for hydraulic operations? What are the desired properties of such oils?

Ans: Most hydraulic systems will operate satisfactorily using a variety of fluids. These include multi-grade engine oil, automatic transmission fluid and more conventional anti-wear hydraulic oil. But it is not possible to make one definitive recommendation about the type of fluid which is best for a particular application and may cover all types of hydraulic equipment in all applications. A satisfactory liquid for a hydraulic system must be thick enough to give a good seal at pumps, motors, valves.

Q.5. What are the differences between positive displacement pump and non-positive displacement pump?

Ans: Following points illustrates the differences between positive displacement pumps and non-positive displacement pumps:

- Non-positive displacement pumps provide a smooth, continuous flow; positive displacement pumps have a pulse with each stroke or each time a pumping chamber opens to an outlet port.
- Pressure can reduce in a non-positive pump's delivery. High outlet pressure can stop any output; the liquid simply re-circulates inside the pump. In a positive displacement pump, pressure affects the output only to the extent that it increases internal leakage.
- Non-positive displacement pumps, with the inlets and outlets connected hydraulically cannot create a vacuum sufficient for self-priming; they must be started with the inlet line full of liquid and free of air. Positive-displacement pumps often are self-priming when started properly.

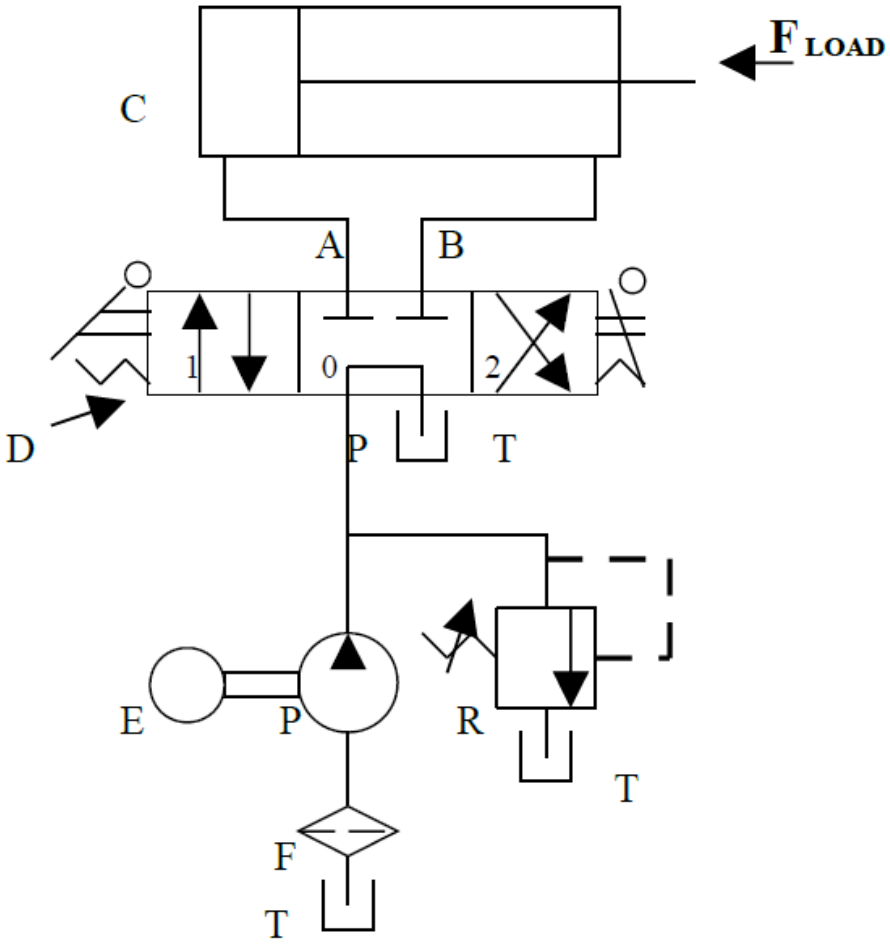
Q.6. What is the criterion for pump selection?

Ans: Following are the pump selection guidelines:

- Select the actuator (Hydraulic cylinder or motor) based on load.
- Determine flow rate requirements.
- Determine pump speed and select the prime mover.
- Select pump type based on application.
- Select System pressure.
- Select reservoir and other components.
- Calculate overall cost of the system.
- Consider factors as noise level, horsepower loss, need of heat exchanger, schedule maintenance.

Q.7. What is pressure head? How losses in pressure head occur and how are they measured?

Ans:



Q.8. Draw a hydraulic circuit to display the controlling of a double acting cylinder.

Ans: Control of Double acting hydraulic cylinder.

C = Double acting cylinder
P = Pump
E = Electric Motor
T = Tank
F = Filter
R = Relief Valve
D =3-position, 4 way, manually operated and Spring Centered DCV

Q.9. A double acting cylinder is hooked up to reciprocate. The relief valve setting is 70 bars. The piston area is 0.016 m^2 and the rod area is 0.0045 m^2. If the pump flow is 0.0013m^3/s, find the cylinder speed and load- carrying capacity for the following:

a. Extending stroke

b. Retracting stroke.

Ans: Solution:

Relief valve pressure setting, p = 70 bars = 70 * 10^5 N /m^2

Piston area, A_p = 0.016 m^2

Rod area, A_r = 0.0045 m^2

Pump flow, Q_p = 0.0013 m^3/s

a. Extending Stroke:

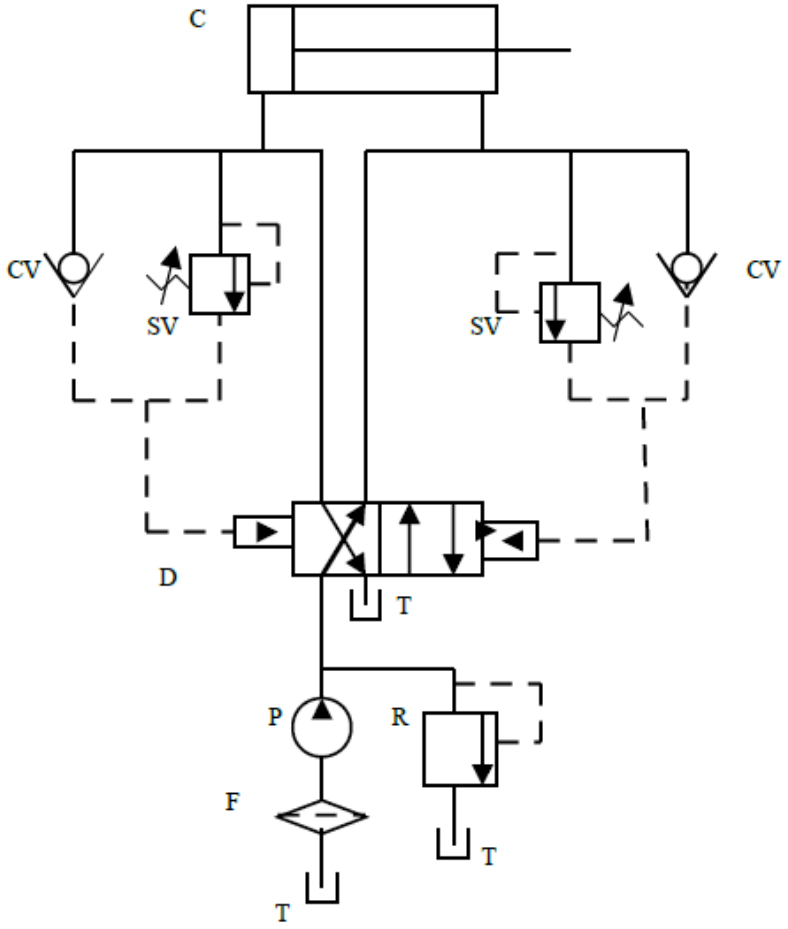
- Cylinder speed, $V_{p\ ext}$ = Q_p / AP
  = 0.0013 / 0.016
  = 0.0813 m / s
- Load carrying capacity, F_{load} = p * AP
  = 70 * 105 * 0.016
  = 112000 N **= 112kN**

b. Retracting Stroke:

- Cylinder Speed, $V_{p\ ret}$ = Q_p / (A_P – A_r)
  = 0.0013 / (0.016 - 0.0045)
  = 0.113 m / s
- Load carrying capacity, F_{load} = p * (A_P – A_r)
  = 70 * 105 * (0.016 - 0.0045
  = 80500 N **= 80.5kN**

Q.10. Draw a hydraulic circuit for automatic cylinder reciprocating system using DCVs.

Ans:



Automatic Cylinder Reciprocating System using Sequence valves

C = Double acting cylinder

P = Pump

SV = Sequence Valve

CV = Check Valve; R = Relief Valve

T = Tank; F = Filter

D = 2-position, 4 way, pilot operated DCV