

Experiments on Hydraulic and Pneumatic circuit trainers

HYDRAULIC CIRCUITS:

Hydraulic circuits are used in high power and high load applications such as earth moving equipment. The pressure used in industrial applications is about 140 bar or 14 MPa.

For more precise control, valves actuated by electrical signals are employed, instead of manually operated valves.

Components:

Basic hydraulic power system is as shown in the Fig. H1 and consists of the components described.

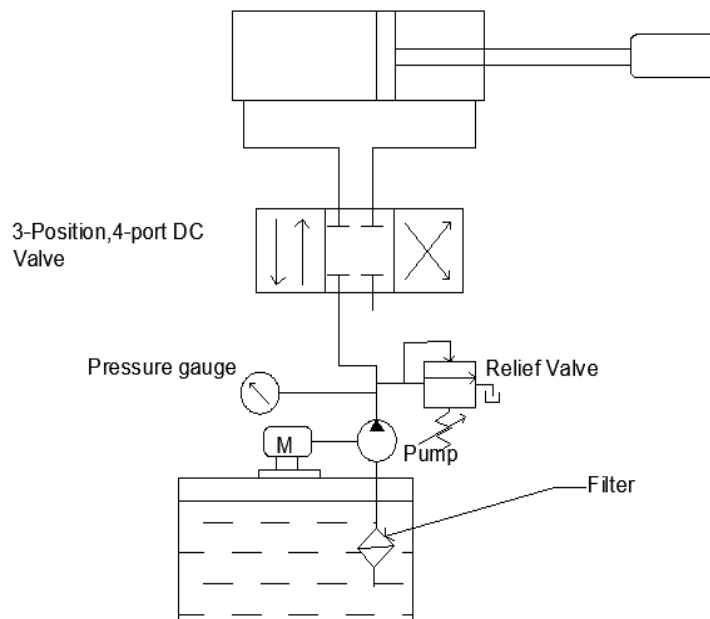


Fig. H1: Typical Hydraulic system with linear actuator

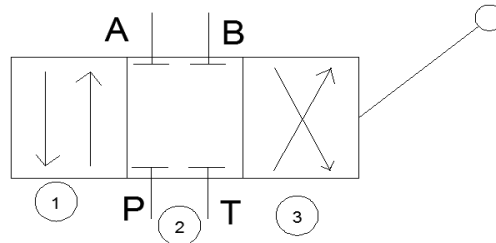
1. Oil reservoir which has suction lines to pump and other lines of system returning oil to tank
2. Electric motor - (or engine)
3. Positive displacement Pump- like vane pump, gear pump or axial piston pump
4. A relief valve to limit the maximum pressure developed to
5. Directional control valve (DC Valve) which controls direction of high pressure oil to actuator, and to tank from actuator.
6. Actuator - a hydraulic cylinder for linear motion of load (connected to piston rod), or a hydraulic motor when load actuation is rotation.
7. Filter: Oil filter is provided either in pump suction or return line.

8. Pressure gauge to indicate the pressure developed by the pump.
9. **Flow lines** - flexible hoses or rigid pipes connecting various system components.

Schematic (Symbolic) Representation of a 3-position, 4-port valve.

A 3-position 4-port Directional Control valve is schematically shown in Fig.H2.

Ports: The valve has port P connected to hydraulic pump; Port T is connected to the tank. Two ports A & B are connected to either side of the hydraulic cylinder. Thus there are 4 ports.



3-Position, 4-port DC Valve (Lever operated)

Fig.H2

Spool positions: The spool operated by a lever (for manual operation) takes 3 positions, which are shown in 3 blocks in Fig.H2.

Flow directions in the three positions are explained as per Fig.H3.

In Position 2, the neutral position, all ports are blocked.

Hence no flow from supply port to any port, and no movement of actuator piston.

Moving the spool to left end, ie Position 1, means That left block is operative, where connections P to A and B to T are established.

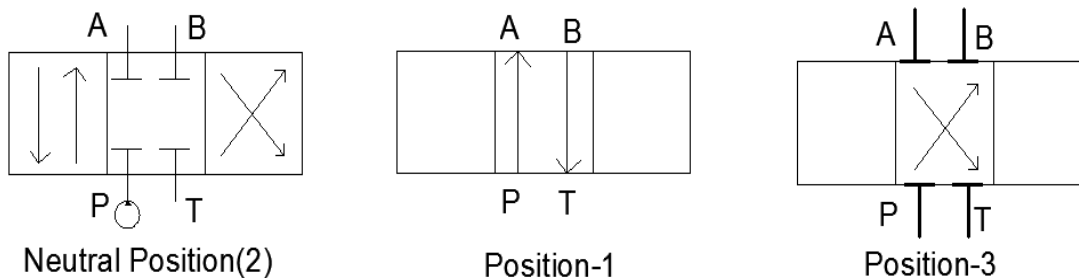


Fig. H3

Similarly Position 3 of spool means, P - B and A -T are connected.

Thus there are 4 ports and 3 valve positions. Hence the valve is called 3-position, 4- port Directional Control Valve.

(In the experiment, there are 2 tank ports, and it is a 3-position, 5 port DC valve).

Experiment 1: Control of a Double Acting Cylinder:

A double acting cylinder is one in which the piston rod can be moved forward or backwards by supplying high pressure fluid to piston or rod side chamber of the actuator. The fluid flow to the required side is controlled by movement of the spool of the DC valve (or a lever actuating the spool)

Operation:

The circuit connection is as shown in Fig.H4.

In Position 2, the supply oil is blocked in the valve, as the two ports A&B connected to the actuator are blocked.

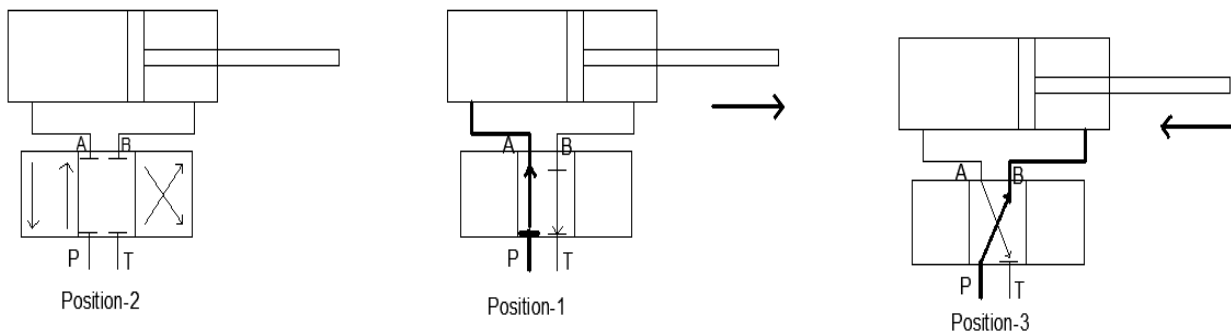


Fig.H4

In Position 1, P is connected to A port connected to the piston side of actuator. Hence the piston is pushed to right. The oil trapped in the rod-side chamber is connected to the Tank (or reservoir) and is free to flow to tank.

In position 3, Pressure line P is connected to port - B which is connected to rod side and pushes the piston to left. The oil in the piston-side chamber is connected to tank port of the valve and flows to tank.

Note: The pump develops as much pressure as is required to move the load.

Procedure:

1. Set relief valve pressure setting to zero.
2. Connect various hoses from supply and tank to the valve. Connect A & B ports to either side of actuator
3. Turn motor on.
4. Keep the valve in neutral position (Position2)
5. Increase relief valve pressure setting to 5 bar, observing the pressure gauge.

Now the valve spool is moved to left or right to observe the movement of the piston rod in forward or reverse directions.

Experiment 2 : Control of a Single Acting Cylinder :

In single acting cylinder, actuator has only one port on the piston side. When high pressure oil is supplied, piston moves against the force of the spring which is on the rod side. For backward stroke, the port is connected to tank by the DC valve, and piston retracts due to spring force. .

DC Valve: A 2 -position 3-port valve as shown in Fig.H5 is used for this purpose. Circuit connection is as shown

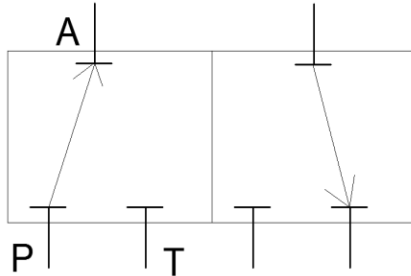


Fig. H5: 2/3 valve positions

In Position 1 of spool, supply is connected to the piston side chamber. Due to pressurized oil, piston moves against the spring force.

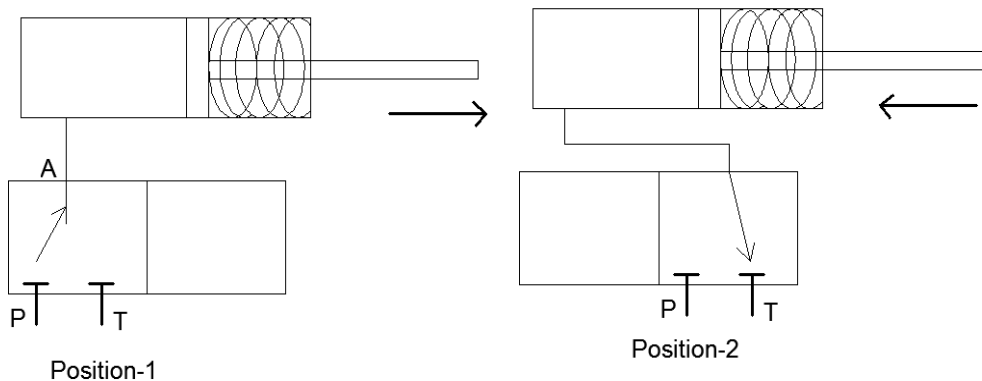


Fig. H6

In Position 2, oil supply port is blocked, while the piston side oil is connected to tank. The spring acts to retract the piston rod and pushes the oil on piston side to tank.

Procedure:

1. Connect hoses from supply manifold to P port of valve, and T port to tank, and A port to cylinder.
2. Set relief valve pressure to zero.
3. Start the motor.
4. Set relief valve to about 5 bar.
5. Move valve spool (or lever) to position 1 and 2 to actuate the piston rod to forward or backward strokes.

PNEUMATIC CIRCUITS

Pneumatic circuits are used in relatively low load applications. These are usually employed in industrial automation where pneumatic cylinder operations follow as per a predetermined logical sequence.

The fluid used is high pressure air from air compressor, usually upto 10 bar pressure (10 Kgf/Cm² or 1 MPa).

Following experiments are conducted.

Experiment 1: Control of Single Acting Cylinder

A 2-position, 3-port valve as shown in Fig. P1 is used. The two positions are effected by push button or lever.

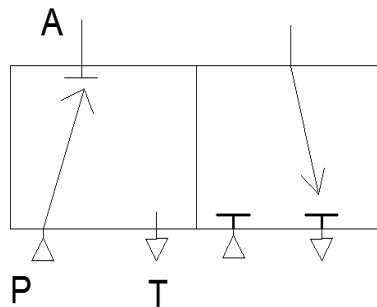


Fig. P1

Circuit connections as per valve position are shown in Fig. P2.

In Position 1, pressure port is connected to piston side of cylinder, and causes the piston rod to move to right. In Position 2 of the valve, actuator piston side port is connected to exhaust port T, while P port is blocked. The rod now retracts back due to spring force.

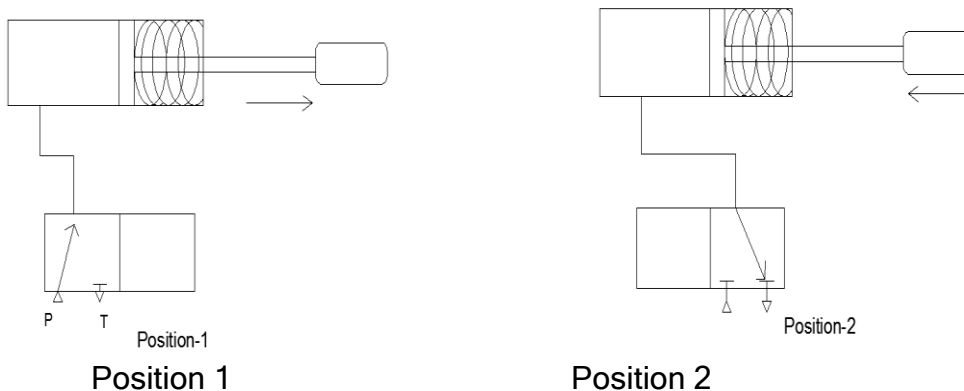


Fig.P2: Operation of Single acting cylinder

Experiment 2: Control of double acting cylinder - manual

A 2-position, 4-port valve shown in Fig.P3 is used in the circuit.

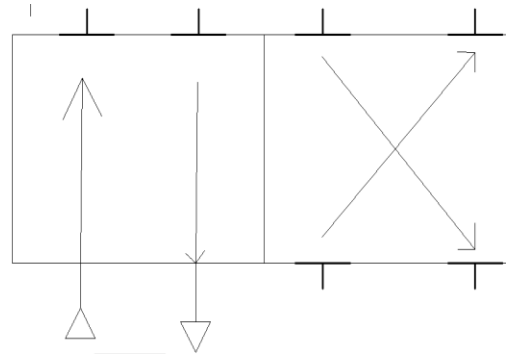


Fig.P3: Valve positions

Actuation of the piston is shown in Fig.P4.

In Position 1, left block is effective, when high pressure air supply is connected to the piston side. Air in the rod side chamber is connected to tank port. The rod moves to right.

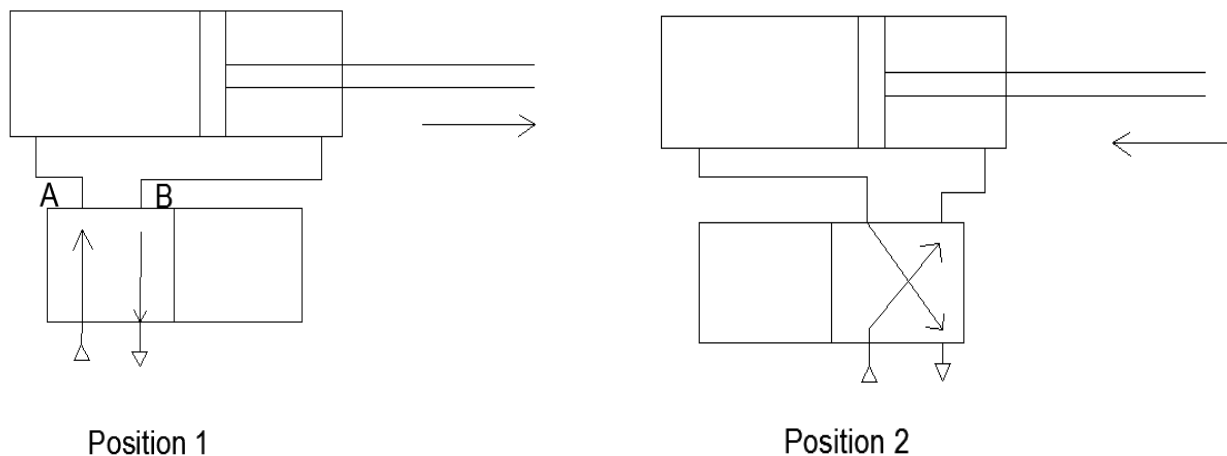


Fig. P4. Operation of double acting cylinder with 2/4 valve

In Position 2, right block of the valve is effective, when pressure acts on rod side of piston and piston side is connected to tank port. The rod thereby moves to left.

Experiment 3:**Control of double acting cylinder with limit switches using Pilot operated valve**

In this experiment, circuit connection is made for automatic toggling of an actuator, between two set positions on stroke.

In a pilot-operated valve (main valve), the spool moves due to fluid pressure (control pressure) acting on one end of the spool thereby causing the spool to move to the other position. The control pressure is effected by another valve, called control valve, which is operated by a limit switch, which in turn is actuated by a cam on the cylinder rod. or another type of logical sequence signal.

The pilot valve used in the experiment has a supply port P, A&B ports connected to either side of actuator, and two control ports. It has 2 positions and the effective position of spool is determined by which control pressure is effective.

The control pressures are supplied by two control valves which are operated by cam-type limit switches (integral to control valves) that are used for limiting the stroke of the piston rod. The piston rod load end is shaped as double taper to smoothly operate the cams.

The complete circuit is shown in Fig.P5.

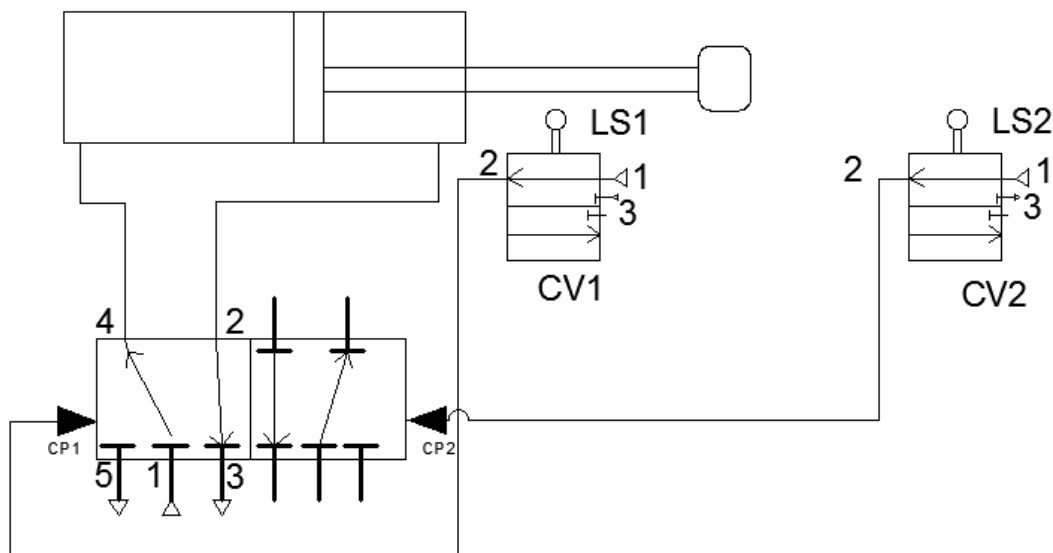


Fig.P5: Circuit for automatic to and fro motion of actuator.

Operation:

When supply is connected, suppose the left side of main valve is effective. Then supply port (1) is connected to A port (4), which is connected to piston side and pushes the piston to right. The air on the rod-side is now connected to tank (3) and is freely discharged.

- a. As piston moves to right, the rod end hits the cam of LS2 (on CV2),
- b. Position 1 of CV2 becomes effective, thereby the air pressure is connected to Control port 2 (CP2) of Main valve.
- c. This causes Position 2 of the main valve to be effective, ie., supply (1) is connected to port 2 (B port), pushing the piston to left. Even after the rod moves back and releases the cam on limit switch 2, the main spool position continues in the same position.
- d. As the rod travels to left and cam hits LS1, limit switch1, position 2 of CV1 becomes operative.
- e. This causes control pressure to flow to CP1 of the main valve. .
- f. It makes Position 1 of the Main valve effective so that main supply is connected to piston side of actuator, pushing piston to right.
- g. The process continues as from step (a).

Thus the actuator toggles between the two positions of the limit switches. The stroke can be suitably changed by positioning the limit switches.

Speed Control:

Actuator velocity can be modified by introducing a uni-directional flow control valve (Fig. P6), in the line from A or B to actuator. The flow rate is adjusted suitably by rotation of the screw provided on the flow control valve.

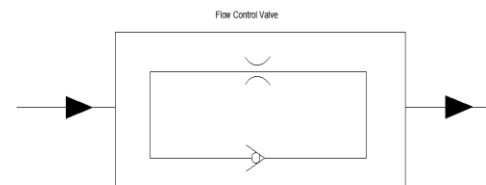


Fig. P6.

For example, introducing the valve in the line connecting A port to the piston side, forward (or right-side) speed of the actuator is controlled. It is called meter-in control.