ST.ANNE'S COLLEGE OF ENGINEERING AND TECHNOLOGY

(Approved by AICTE, New Delhi. Affiliated to Anna University, Chennai)
(An ISO 9001: 2015 Certified Institution)
ANGUCHETTYPALAYAM, PANRUTI – 607 106.

DEPARTMENT OF MECHANICAL ENGINEERING

ME 8694 HYDRAULICS AND PNEUMATICS

THIRD YEAR – SIXTH SEMESTER

PREPARED BY

K.SARAVANAN. ASP/MECHANICAL

ME8694 HYDRAULICS AND PNEUMATICS **L T P C**
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OBJECTIVES:

- To provide student with knowledge on the application of fluid power in process, construction and manufacturing Industries.
- To provide students with an understanding of the fluids and components utilized in modern industrial fluid power system.
- To develop a measurable degree of competence in the design, construction and operation of fluid power circuits.

UNIT I FLUID POWER PRINICIPLES AND HYDRAULIC PUMPS 9

Introduction to Fluid power – Advantages and Applications – Fluid power systems – Types of fluids - Properties of fluids and selection – Basics of Hydraulics – Pascal's Law – Principles of flow - Friction loss – Work, Power and Torque Problems, Sources of Hydraulic power : Pumping Theory – Pump Classification – Construction, Working, Design, Advantages, Disadvantages, Performance, Selection criteria of Linear and Rotary – Fixed and Variable displacement pumps – Problems.

UNIT II HYDRAULIC ACTUATORS AND CONTROL COMPONENTS 9

Hydraulic Actuators: Cylinders – Types and construction, Application, Hydraulic cushioning – Hydraulic motors - Control Components : Direction Control, Flow control and pressure control valves – Types, Construction and Operation – Servo and Proportional valves – Applications – Accessories : Reservoirs, Pressure Switches – Applications – Fluid Power ANSI Symbols – Problems.

UNIT III HYDRAULIC CIRCUITS AND SYSTEMS 9

Accumulators, Intensifiers, Industrial hydraulic circuits – Regenerative, Pump Unloading, Double- Pump, Pressure Intensifier, Air-over oil, Sequence, Reciprocation, Synchronization, Fail-Safe, Speed Control, Hydrostatic transmission, Electro hydraulic circuits, Mechanical hydraulic servo systems.

UNIT IV PNEUMATIC AND ELECTRO PNEUMATIC SYSTEMS 9

Properties of air – Perfect Gas Laws – Compressor – Filters, Regulator, Lubricator, Muffler, Air control Valves, Quick Exhaust Valves, Pneumatic actuators, Design of Pneumatic circuit – Cascade method – Electro Pneumatic System – Elements – Ladder diagram – Problems, Introduction to fluidics and pneumatic logic circuits.

UNIT V TROUBLE SHOOTING AND APPLICATIONS 9

Installation, Selection, Maintenance, Trouble Shooting and Remedies in Hydraulic and Pneumatic systems, Design of hydraulic circuits for Drilling, Planning, Shaping, Surface grinding, Press and Forklift applications. Design of Pneumatic circuits for Pick and Place applications and tool handling in CNC Machine tools – Low cost Automation – Hydraulic and Pneumatic power packs.

TOTAL:45 PERIODS

OUTCOMES:

Upon the completion of this course the students will be able to

CO1 Explain the Fluid power and operation of different types of pumps.
CO2 Summarize the features and functions of Hydraulic motors, actuators and Flow control valves
CO3 Explain the different types of Hydraulic circuits and systems
CO4 Explain the working of different pneumatic circuits and systems
CO5 Summarize the various trouble shooting methods and applications of hydraulic and pneumatic systems.

TEXT BOOKS:

1. Anthony Esposito, "Fluid Power with Applications", Pearson Education 2005.
2. Majumdar S.R., "Oil Hydraulics Systems- Principles and Maintenance", Tata McGraw-Hill, 2001.

REFERENCES:

1. Anthony Lal, "Oil hydraulics in the service of industry", Allied publishers, 1982.
2. Dudelyt, A. Pease and John T. Pippenger, "Basic Fluid Power", Prentice Hall, 1987.
3. Majumdar S.R., "Pneumatic systems – Principles and maintenance", Tata McGraw Hill, 1995
4. Michael J, Prinches and Ashby J. G, "Power Hydraulics", Prentice Hall, 1989.
5. Shanmugasundaram.K, "Hydraulic and Pneumatic controls", Chand & Co, 2006.

ME 8694 HYDRAULICS AND PNEUMATICS

UNIT I FLUID POWER PRINICIPLES AND HYDRAULIC PUMPS

Introduction to Fluid power – Advantages and Applications – Fluid power systems – Types of fluids - Properties of fluids and selection – Basics of Hydraulics – Pascal's Law – Principles of flow - Friction loss – Work, Power and Torque Problems, Sources of Hydraulic power : Pumping Theory– Pump Classification – Construction, Working, Design, Advantages, Disadvantages, Performance, Selection criteria of Linear and Rotary – Fixed and Variable displacement pumps – Problems.

1. Define fluid power.

Fluid power is the technology that deals with generation, control and transmission of power using pressurized fluids.

2. What are the primary functions of hydraulic fluid?

(i) Transfer fluid power efficiently.
(ii) Lubricate the moving parts.
(iii) Absorb, carry and transfer the heat generated within the system.

3. Name few properties of a hydraulic fluid.

(iv) Viscosity (ii) Viscosity Index (iii) Oxidation stability(iv) Demulsibility (v) Lubricity (vi) Rust prevention (vii) Flash point and fire point (viii) Neutralization Number.

4. Under what situations, Electrical, Mechanical and fluid power transmissions are suitable?

Electrical power transmissions are suitable for power transmission over long distances Mechanical power transmissions are suitable for power transmission of motion and force over relatively short distance

Fluid power transmissions are suitable for power transmission over intermediate distance.

5. Define demulsibility

The ability to be demulsified being sometimes expressed as the rate at which a liquid (such as an oil) Separates from an emulsion.

6. What is Darcy Equation?

It says that the discharge rate q is proportional to the gradient in hydraulic head and the hydraulic conductivity
(q = Q/A = -K*dh/dl).

7. What is the fundamental difference between hydraulics and Pneumatics?
Distinguish between hydraulic and pneumatic power sources with respect to payload, accuracy,speed control and maintenance (AU Nov/Dec2021)

	Hydraulic power sources	Pneumatic power sources
Pay load	Hydraulic systems are used for high force and where stiffness in position is necessary. Industrial applications of hydraulics use 1000 to 5000 psi or more than 10000 psi for specialized application.	Pneumatic systems are used for relatively lower forces, where stiffness isn't required. Most industrial pneumatic applications use pressures of about 80 to 100 pounds per square inch (550 to 690 kPa)
Accuracy	Precision up to ± µm can be achieved depending on expenditure.	Without load change, precision of 1/10mm is possible
Speed control	They move relatively slowly but can handle higher loads. V=0.5 m/s	faster motion, They have a very controlled force, regardless of stroke or load resistance. V=1.5 m/s
Maintenance	Maintenance cost is high.	Maintenance cost is Less.

8. List any four advantages and disadvantages of using the fluid power.

Advantages

i. Ease and accuracy of control ii. Multiplication of force iii. Constant force ortorque iv. Simplicity, safety and economy

Disadvantages

lack of understanding of the equipment and poor circuit design, which can result in overheating and leaks.

Overheating occurs when the machine uses less energy than the power unit provides.

9. What are the basic components of hydraulic system?

Reservoir or tank, Pump, Prime mover, Valves, Actuator and fluid transfer piping.

12. Differentiate between a liquid and a gas.

Liquid	gas
Posses a definite volume for a given mass, but conforms to the shape of the container	It has definite mass, but does not posses a definite volume and conforms to the shape of the container
Incompressible fluid	Compressible fluid

13. What is meant by viscosity of a fluid? Also state Newton's law of viscosity.

Viscosity is the measure of the ability of a fluid to flow. It is the measure of the fluids internal resistance to shear

Newton's law of viscosity states that the shear stress is directly proportional to the rate of shear strain.

14. State the effect of temperature and pressure on viscosity of liquids.

The viscosity of the liquids decreases with increase in temperatures whereas the viscosity increases with increasing pressure.

15. State the effect of temperature and pressure on viscosity of gases.

The viscosity of gases increases with increase in temperature and decreases with decrease in temperature.

16. What is Viscosity Index and Give is its significance?

The rate of change of viscosity with temperature is indicated on an arbitrary scale called Viscosity Index rate of change in viscosity with changes in temperature is relatively less with high V.I oils than the low V.I. oils

17. Define Bulk modulus and give the relationship between compressibility and bulk modulus.

Bulk modulus is the reciprocal of compressibility Mathematically Bulk modulus

$$K = 1/\mathit{Compressibility}$$

$$= \frac{-\mathbf{dp}}{\frac{\boldsymbol{dv}}{\boldsymbol{v}}}$$

18. What is demulsibility? Write its significance.

The ability of a hydraulic fluid to separate rapidly from moisture and resist emulsification is known as demulsibility.

Significance: This property is significant because the operations of many hydraulic systems are conducive to the forming of moisture.

19. What is neutralization number of hydraulic fluid and give its significance?

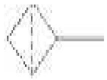
Neutralization number is a measure of acidity or alkalinity of a hydraulic fluid. High acidity causes the oxidation rate in an oil to increase rapidly.

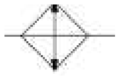
20. List few required properties of a good hydraulic fluid.

Good lubricity, compatibility with system materials, stable physical and chemical properties, good heat dissipation capability and high bulk modulus.

21. Draw the ANSI symbols for the following hydraulic components

Reservoir 

Filter 

Coolers 

Accumulator 

22. State Pascal's law? Any two applications of Pascal's law.

Pascal's law states that the pressure generated at any point in fluid acts equally in all direction.
i. Bramah's hydraulic press and ii. Air- to- hydraulic pressure booster.

23. Define Reynolds's number and give its significance.

It is the ratio of inertia force to viscous force Reynold's number is the basis for determining the laminar and turbulent flow. If Re< 2000then the flow is laminar and if Re >4000 then the flow is turbulent.

24. What is balanced vane pump

Balanced vane pumps are fixed displacement pumps consisting of a two-lobe cam ring with two pressure and suction quadrants opposite each other.

25. State the continuity equation.

It is based on law of conservation of mass which states that mass entering the system is equal to mass leaving the system

26. Write the classifications of Hydraulic Motors. AU June2007

i.) Gear type hydraulic motors
(ii) Vane type hydraulic motors
(iii) Piston type hydraulic motors

27. What is the function of a Hydraulic Pump? AU Dec2011

In a hydraulic system, a pump converts mechanical energy into hydraulic energy.
Mechanical energy is given to the pump via a prime mover such as an electric motor.

28. What is positive displacement Pump? AU Dec2007

The positive displacement pump discharges a fixed quantity of fluid unto the hydraulic system per revolution of pump shaft rotation. Since the flow of fluid is guaranteed on every revolution of the shaft, this type of pump is named as 'positive' displacement pump

29. Discuss the factors to be considered in selection of a linear actuator for an industrial application. (AU Nov/Dec 2021)

The primary factors to be considered for selecting linear actuator components are**:**

- Accuracy.
- Speed.
- Load.
- Cost.
- Maintainability.
- Safety.

30. List different types of Pumps used in Hydraulics. AU June2007

(i) Gear pumps (Fixed displacement only)
 a) External gear pump, b) Internal gear pump, c) Lobe pump, d) Screw pump, e) Gear rotor pump.
(ii) Vane pumps (Fixed or Variable displacement)
 a) Balanced vane pump, b) Unbalanced vane pump.
(iii) Piston pumps (Fixed or Variable displacement)
 a) Axial design, b) Radial design

31. What are the advantages of positive displacement pumps? AU June2007

i) Positive displacement pumps can operate at very high pressure.
ii) They are small and compact in size.
iii) They have very high power-to-weight ratio.
iv) They achieve high volumetric efficiency.

32. List the factors to be considered in the pump selection. AU May2005

1. Actuator type based on load carrying capacity.
2. Flow rate requirements.
3. Type of application.
4. Pressure rating

33. When is Lobe pump preferred? AU Dec2009

Lobe pump is preferred for high volumetric displacement places.

34. What do you mean by non-positive displacement pumps? State its applications. (AU Dec 2006)

In non-positive displacement pumps, the fluid flow is achieved using the inertia of the fluid in motion. Since these pumps cannot withstand high pressures, they are used only for transporting from one place to another. For the same reason, they are not preferred in the fluid power industries.

35. Differentiate pressure compensated and non-pressure compensated pumps. AU Dec2006

In pressure compensated pump, the pump flow can be made to zero. Such a pump has its own protection against excessive pressure build up. Also there is no power waste and reduced fluid heading. Whereas non-pressure compensated pumps are hydraulically unbalanced and cause undesirable side load on the bearings of the pump.

36. What is Pump Cavitation's? How can you avoid it? AU May2008

The formation, growth, and collapse of vapour filled cavities or bubbles in a flowing liquid dew to local fall in fluid pressure is called pump cavitation.

Pump cavitation can be avoided by ensuring that the suction pressure is always greater than that required by the pump.

37. A positive displacement pump has an overall efficiency of 87% and volumetric efficiency of93%. What is its mechanical efficiency? AU Dec2008

Overall efficiency = Volumetric efficiency X Mechanical efficiency

Mechanical efficiency = 87/93 x 100 = 93.5 %

38. List the different types of Actuators. AU May2008

i. Hydraulic motor--continuous rotary motion.
ii. Semi-rotary actuator-limited angle movement.
iii. Hydraulic cylinder-linear motion

39. A van of 16,000N is to be lifted using a hydraulic lift as shown in Fig 2.Determine the force required to lift the van if areas AA = 0.005 m^2 and AB = 0.4 m^2. (AU Nov/Dec 2021)

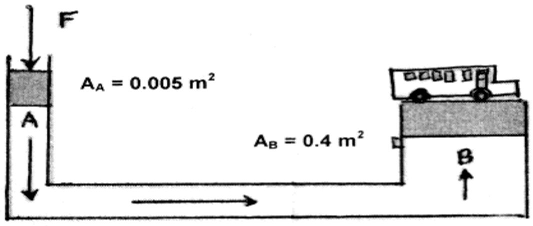


Fig. 2 Hydraulic lift

Given data

Force to be lifted = 16,000N

Area at AA = 0.005 m^2

Area at AB = 0.4 m^2

$P_A = P_B$

$F_A/A_A = F_B/A_B$

$F_A/0.005 = 16000/0.4$

$F_A = 16000 \times 0.005 / 0.4 = 2000N$

PART – B &C

1. (i) What are the functions of a fluid in any fluid power system? AU June 2007

Functions of a Fluid in any Fluid Power System:

1. To transmit power (Basic purpose)
2. To lubricate moving parts;
3. To seal gaps and clearances between mating components
4. To dissipate heat generated by internal friction.
5. To prevent rust and Corrosion.
6. To remove unwanted and harmful impurities from the system.

(ii) Compare the various characteristics of the liquid and gaseous fluid in fluid power system. (AU- June 2007)

S.NO	Liquid	Gas
1	Possess a definite volume for a given mass, but conforms to the shape of the container	Has a definite mass, but does not possess a definite volume and conforms to the shape of the container
2	Since it possess a definite volume, it forms a free surface if the volume of the container is greater than the volume of	Since it does possess the definite volume, it expends and occupies the whole volume of the container.
3	Incompressible fluid	Compressible fluid
4	Spacing between the molecules is relatively large when compared to solids, but relatively	Spacing between the molecules is Extremely large when compared to solids and liquids.
5	Can be contained in open vessel	Always need to be contained in a closed Vessel

(iii) Enumerate the properties that a good hydraulic fluid should posses. AU-June 2007

Explain any five desirable properties of hydraulic fluids (AU Nov/Dec2021)

1) High corrosive resistant properties
2) Good lubrication properties to reduce friction and wear
3) Good sealing properties
4) Good heat transfer capabilities
5) Non effected by temperature changes
6) Free from acidity and should be non-toxic
7) High Flash point and low pour point
8) Chemically and environmentally stable
9) Less volatile
10) High degree of incompressibility
11) Ideal viscosity
12) Good fire and foam resistant properties

13) Low density\readily available
14) Inexpensive

2. i) what are the advantages of oil hydraulic systems over other methods. (AU Dec 2006)

1) Multiplication and variation of force:
Linear or rotary force can be multiplied from a fraction of an ounce to several hundred tons of output.

2) Easy, accurate control: You can start, stop, accelerate, decelerate, reverse or position large forces with great accuracy. Analog (infinitely variable) and digital (on/off) control are possible. Instantly reversible motion- within less than half a revolution can be achieved.

3) Multi-function control:
A single hydraulic pump or air compressor can provide power and control for numerous machines or machine functions when combined with fluid power manifolds and valves.

4) High horsepower, low weight ratio:
Pneumatic components are compact and light weight. You can hold a five horse power hydraulic motor in the palm of your hand.

5) Low speed torque:
Unlike electric motors, air or hydraulic motors can produce large amounts of torque (twisting force) while operating at low speeds. Some hydraulic and air motors can even maintain torque at zero speed without overheating.

6) Constant force or torque:
This is a unique fluid power attribute.

7) Safety in hazardous environments:
Fluid power can be used in mines, chemical plants, near explosives and in paint applications because it is inherently spark-free and can tolerate high temperatures.

8) Established standards and engineering:
The fluid power industry has established design and performance standards for hydraulic and pneumatic products through NFPA, the National Fluid Power Association and ISO, the International Organization for Standardization.

ii) What are the desirable properties of hydraulic fluids? Discuss any eight of them in detail. AU- Dec 2007

a) Viscosity:
Viscosity is a measure of the fluid’s internal resistance offered to flow.

$$F = \mu A\,(du/dy)$$

$$(F/A) = \tau = \mu\,(du/dy) = \mu\,(u/y)$$

b) Viscosity Index:
The rate of change of viscosity with temperature is indicated on an arbitrary scale called viscosity Index (V.I)

Where, **Viscosity Index = L – U / L – H × 100**

L – SSU viscosity of reference oil at 38° C with a viscosity index of 0.
H – SSU viscosity of reference oil at 38° C with a viscosity index of 100.
U – SSU viscosity of oil at 38° C whose viscosity index is to be calculated.

c) Oxidation Stability:
Chemical stability is another property which is exceedingly important in the selection of a hydraulic liquid. It is defined as the liquid’s ability to resist oxidation and deterioration for long

periods. All liquids tend to undergo unfavorable changes under severe operating conditions. This is the case, for example, when a system operates for a considerable period of time at high temperatures.

d) Demulsibility:

The ability of hydraulic fluid to separate rapidly from moisture and successfully resist emulsification is known as ‘demulsibility’.

e) Lubricity:

Wear results in increased clearance which leads to all sorts of operational difficulties including fall of efficiency. At the time of selecting a hydraulic iol, care must be taken to select one which will be able to lubricate the moving parts efficiently.

f) Rust Prevention:

The moisture entering into the hydraulic system with air causes the parts made ferrous materials to rust. This rust if passed through the precision-made pumps and valves may scratch the nicely polished surfaces. So, additives named ‘inhibitors’ are added to the oil to keep the moisture away from the surface.

g) Pour Point:

The temperature at which oil will congeal is referred to as the pour point, the lowest temperature at which the oil is able to flow easily. It is great importance in cold countries where the systems are exposed to very low temperatures.

h) Flash Point and Fire Point:

Flash point is the temperature at which a liquid gives off vapour in sufficient quantity to ignite momentarily or flash when a flame is applied.

The minimum temperature at which the hydraulic fluid will catch fire and continue burning is called the fire point.

i) Neutralization Number:

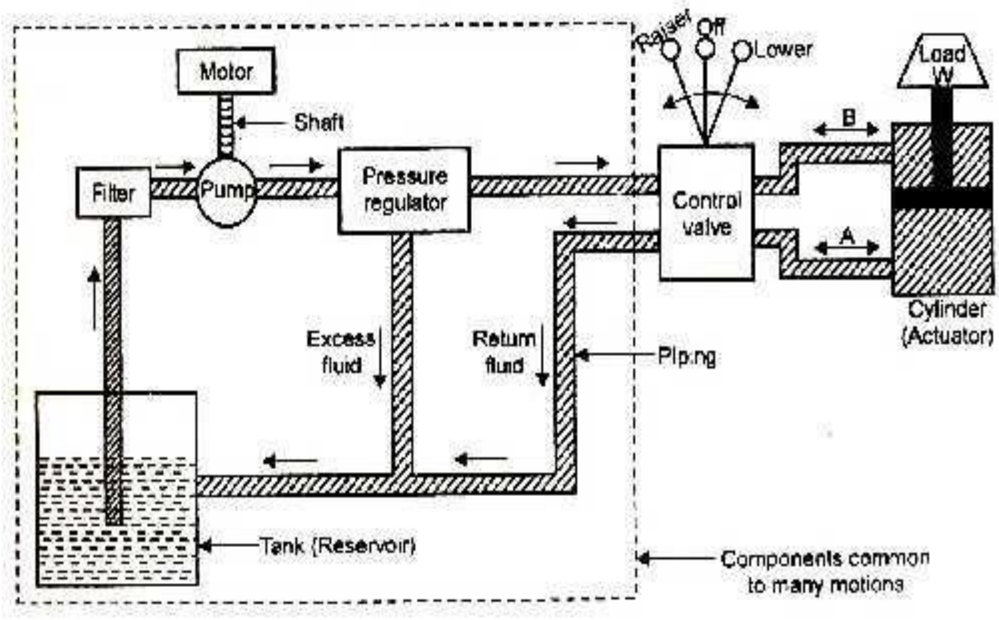
The neutralization number is a measure of the acidity or alkalinity of a hydraulic fluid. This is referred to as the PH value of the fluid. High acidity causes the oxidation rate in an oil to increase rapidly.

$$\textbf{Neutralisation Number} = \frac{\textbf{Total ml of Titrating solution}}{\textbf{Weight of sample used}} \times 5.61$$

3. Explain the hydraulic and pneumatic fluid power system. (AU Dec 2006)

Hydraulic Fluid power systems [Fluid- Liquid]:

Hydraulic systems are power –transmitting assemblies employing liquid as a fluid for transmitting energy from energy – generating source to an energy – use area to accomplish work. Figure shows the simple circuit of hydraulic systems with basic components.



Functions of Components:

Hydraulic Actuator:

It is a device used to convert the fluid power into mechanical power to do useful work.

Hydraulic pump:

It is used to force the fluid to the rest of the hydraulic circuit from the reservoir.

Valves: circuit.

Valves are used to control the direction, pressure and flow rate of a fluid flowing through the

External Power supply (Motor):

It is required to drive the pump.

Reservoir:

It is used to hold the hydraulic liquid usually hydraulic oil.

Piping systems:

It carries the hydraulic oil from one place to another.

Fitters: Fitters are used to clean the hydraulic oil used in that circuit.

Pressure regulator:

Pressure regulator regulates i.e maintains the required level of pressure in the hydraulic fluid.

Working Principle:

1. It is a closed loop type with fluid transferred from storage tank to one side of the piston and returned from the other side of the piston to the tank.
2. Fluid is drawn from the tank by a pump which produces fluid flow at the required level of pressure.
3. If the fluid pressure exceeds the required level, then the excess fluid will return back to the reservoir until the pressure regulates to the required level.

4. When the position of valve is changed to raiser position, the pipe pressure line is connected to port A and thus the load is raised.
5. When the position of valve is changed to lower position, the pipe pressure line is connected to port B and thus the load is raised.
6. When the valve is in centre position, the valve locks the fluid into the cylinder causing all the pump output fluid to return the tank through pressure regulator.

Advantages:

1) Large load capacity with almost high accuracy and precision.
2) Smooth movement
3) Automatic lubricating provision to reduce wear.
4) Division and distribution of hydraulic power is simpler and easier than other forms of energy.
5) Limiting and balancing of hydraulic forces are easily performed.

Disadvantages:

1) Hydraulic Elements needs to be machined to a high degree of precision.
) Leakage of Hydraulic Oil poses problems to hydraulic operators.
3) Special treatment is needed to protect them from rust, corrosion, dirt etc
4) Hydraulic oil may pose problems if it disintegrates due to aging and chemical deterioration.
5) Hydraulic oils are messy and almost highly flammable.

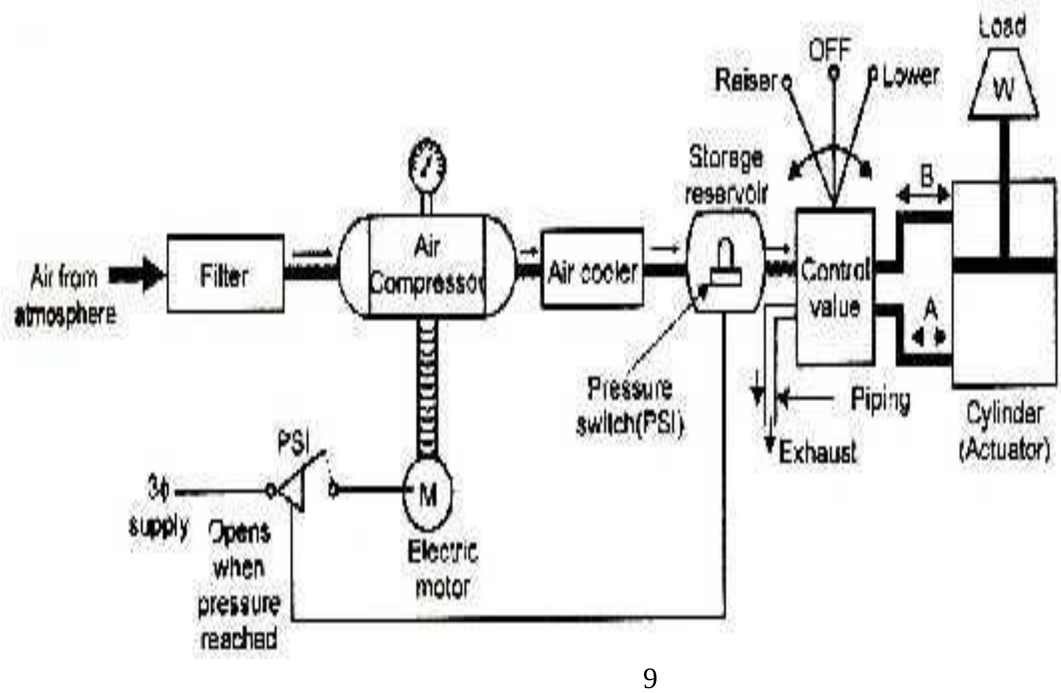
Pneumatic Fluid power systems [Fluid- Compressed Air]:

Pneumatic system carries power by employing compressed gas generally air as a fluid for transmitting the energy from an energy – generating source to an energy –use area to accomplish work. Figure shows the simple circuit of a pneumatic system with basic components.

Functions of Components:

Pneumatic actuator: It converts the fluid power into mechanical power to do useful work. Compressor: It is used to compress the fresh air drawn from the atmosphere.
Storage reservoir: It is used to store a given volume of compressed air.

Valves: It is used to control the direction, flow rate and pressure of compressed air. External Power supply (Motor): It is used to drive the compressor.
Piping system: It carries the pressurized air from one location to another.



Working Principle:

1. It is a open loop type as the air after the work done is simply vented to the atmosphere.
2. Air is drawn from the atmosphere through air filter and raised to required pressure by an air compressor.
3. As the pressure rises, the temperature also rises and hence air cooler is provided to cool the air with some preliminary treatment to remove the moisture.
4. Then the treated pressurized air needs to get stored to maintain the pressure. With the storage reservoir, a pressure switch is fitted to start and stop the electric motor when pressure falls and reached the required level, respectively.
5. The three-position change over control valve delivering air into the cylinder operates in a similar any to its hydraulic circuit.

Advantages:

1) Low inertia effect of pneumatic components due to light density of air.
2) System is light in weight.
3) Comparatively easy operations of valves.
4) Power losses and leakages are less in pneumatic systems.
5) Low Cost.

Disadvantages:

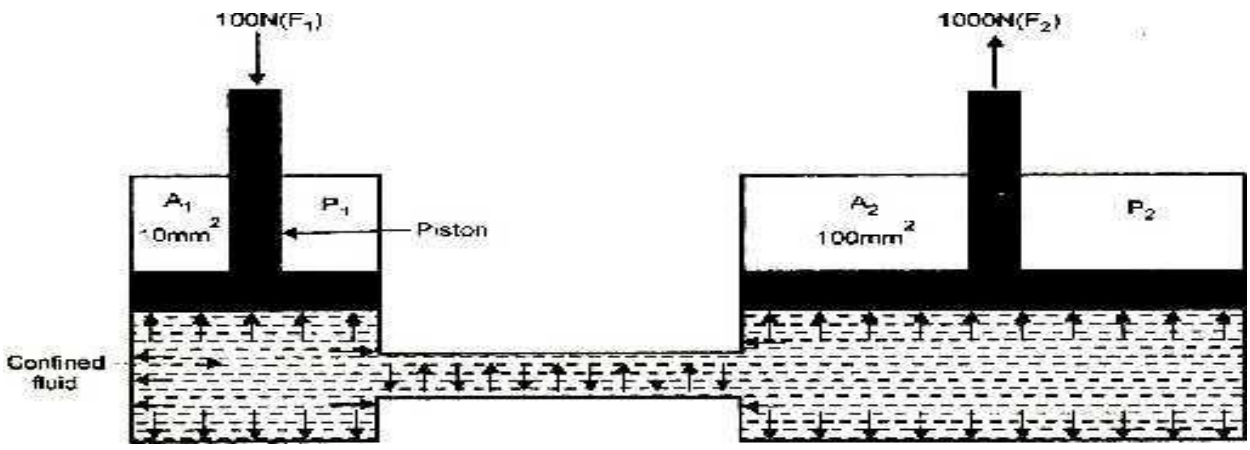
1) Suitable only for light loads or small loads.
2) Availability of the assembly components is doubtful.

4. State Pascal's law; explain any application of Pascal's law with neat sketch. (AU Dec 2011)

Pascal's law:

The pressure generated on a confined fluid at rest is transmitted equally undiminished in all directions throughout the fluid and acts at right angles to the containing surfaces.

$$P1 = P2$$
$$F1/A1 = F2/A2$$
$$100/10 = F2/100$$
$$F2 = 1000N$$

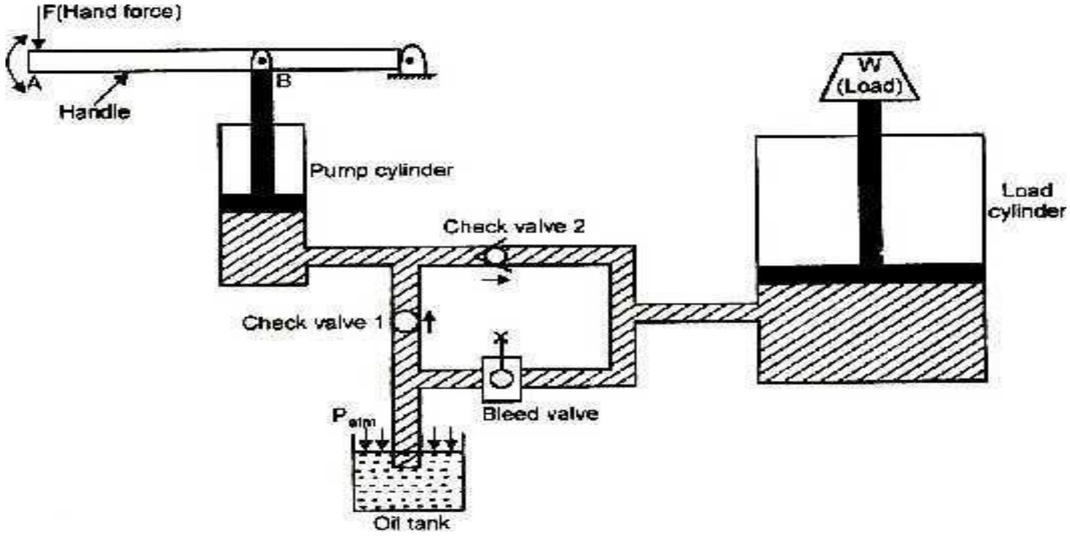


Application of Pascal's law:

1) Hand operated Hydraulic Jack:

- This system uses a piston-type hand pump to power a hydraulic load cylinder for lifting loads,It consists of handle ABC, pivoted about point C and a piston rod is pinned to it at point B. When handle is pulled up at A, the piston rises and valve creates a vacuum in the space below it thus draws the oil from the tank through check valve1.This check valve allows flow to pass in only one direction, as indicated by the arrow.

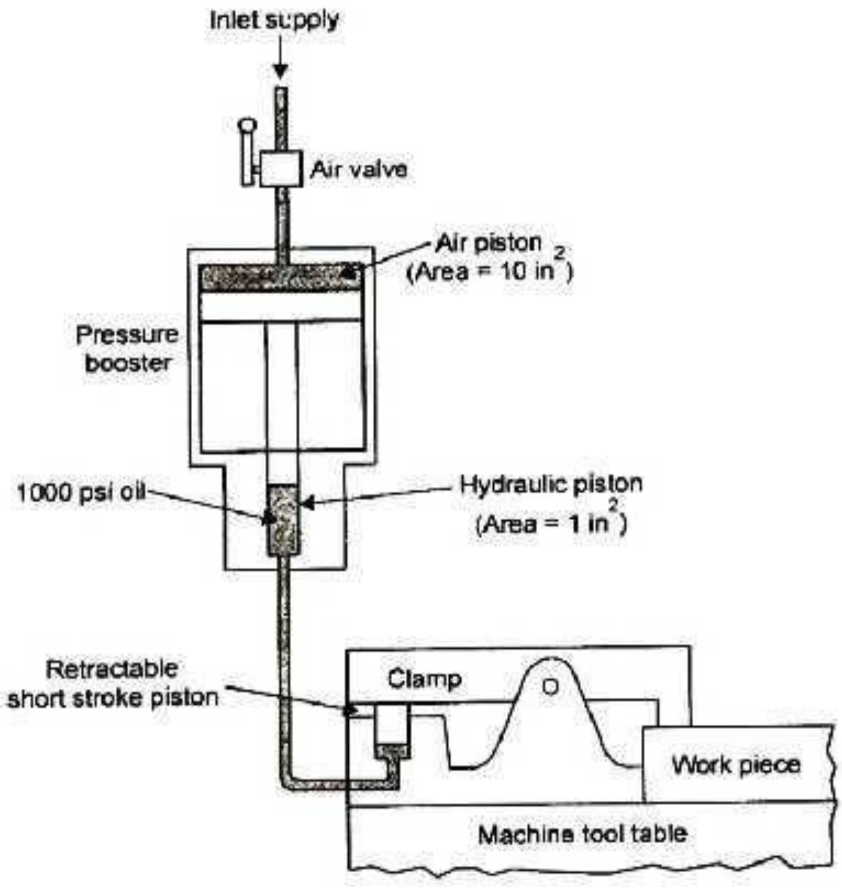
- When the handle is pushed down at A, the pump cylinder ejects the oil to the load cylinder through check valve2. Pressure builds up below the load piston and thus lifts theload. Bleed valve is a hand-operated valve, which opened to lower the load by bleeding the oil from the load cylinder back to the oil tank.



2) Air-to-Hydraulic pressure Boosters:

- The device uses shop air to increase hydraulic pressure needed for operating hydrauliccylinders requiring small to medium volumes of higher-pressure oil.

- It consists of a large air piston cylinder driving a small hydraulic cylinder to clamp awork piece to a machine tool table by supplying high-pressure oil.



5. Compare and contrast between hydraulic, pneumatic, and Electromechanical power systems. AU June 2007

S. NO	DESCRIPTION	HYDRAULIC SYSTEM	PNEUMATIC SYSTEM	ELECTRICAL/ELECTRO – MECHANICAL
1	Energy	Electrical energy is used to drive the hydraulic pumps, which	Electrical energy is used to drive the motor of the compressor, which	Electrical energy is used to drive the
2	Medium	Pressurized liquid	Compressed air/ gas	There is no medium used in this system, rather the energy is transmitted
3	Energy storage	Accumulator (Limited)	Reservoir (Good)	Batteries (Limited)
4	Regulators	Hydraulic valves	Pneumatic valves	Variable frequency
5	Transmitters	Transmitted through hydraulic cylinders, and hydraulic rotary actuators.	Transmitted through Pneumatic cylinders, Pneumatic rotary drives, and Pneumatic rotary actuators.	Transmitted through the Mechanical components like gears, cams, screw-jack, etc
6	Distribution system	Limited, basically a local facility. Up to 100 m flow rate(v)= 2-6 m/s	Good, can be treated as a plant wide service. Up to 1000 m, flow rate(v) = 20-40 m/s	Excellent, with minimal loss
7	Operating speed	V=0.5 m/s	V=1.5 m/s	
8	Positioning accuracy	Precision up to ±μm can be achieved depending on	Without load change, precision of 1/10 mm is possible	Precision to up to ±μm and easier to achieve.
9	Stability	High, since oil is almost incompressible and pressure level is considerably high	Low, since air is compressible	Very good values can be achieved using mechanical links
10	Forces	Protected against overload, with high system pressure of up to 600 bars, very large forces can be generated. F<3999 kN	Protected against overload. Forces are limited by pneumatic pressure and cylinder diameter. F < 30 k N at 6 bar	Not over-loadable. Poor efficiency due to downstream mechanical elements. Very high forces can be realized.
11	Energy cost	Medium	Highest	lowest
12	Linear actuators	Hydraulic cylinders. It can produce very high force.	Pneumatic cylinders. It can produce medium force.	Short motion via solenoid, otherwise via mechanical
13	Rotary actuators	Hydraulic rotary drives And hydraulic rotary actuators. 1. Low speed 2. High turning moment 3. Good control	Pneumatic rotary drives and Pneumatic rotary actuators. 1. Wide speed range 2. Accurate speed 3. Difficult to control	AC and DC motors – Simple and Powerful. AC motors – Cheap DC motors – better control

6. (i) How to calculate the frictional losses in the valves and fittings. (AU May 2008)

Pressure drops are due to valves, expansions, contractions, bends, elbows, tees and pipe fittings.

The losses in valves and fittings in hydraulic systems are frequently computed in terms of equivalent length of hydraulic tube.

- Equivalent lengths can then be substituted in the Darcy-Weisbach equation to solve for total pressure loss in the system.

The formula for computing equivalent length is

Equivalent length L_e = KD/f (m)

Where,

K – Factor for valve/fitting (no dimension)
D – Inner Diameter of fitting (m)
F – Friction factor (no dimension)

The K factor value for several fittings and valves is given in below

Valve or fittings	K- Factor
Globe valve : Wide open	10.0
½ open	12.5
Gate valve : Wide Open	0.19
¾ open	0.90
½ open	4.5
¼ open	24.0
Return bend	2.2
Standard tee	1.8
Standard Elbow	0.9
45° Elbow	0.42
90° Elbow	0.75
Ball check valve	4.0
Poppet check valve	3.0

Calculating pressure drop for a hydraulic circuit involves

1) Determining the floe velocity through the circuit plumbing
2) Computing the Reynolds number(Re)
3) Determining the friction factor(f)
4) Calculating the equivalent length for each of the fittings and valves.
5) Combining the series of equivalent lengths into a total equivalent length(Le)
6) Calculation of head loss for total equivalent length using Darcy – Weisbach equation
7) Final calculation to determine the total pressure drop pressure drop in the circuit

(ii) Define Reynolds Number. AU, Dec 2007

It is dimensionless number for predicting the nature of flow (laminar or turbulent) in a given situation and expressed as

Where,

R_e = Reynolds Number (non-dimensional)

ρ = density (kg/m^3)

v = velocity of flow (m/s)

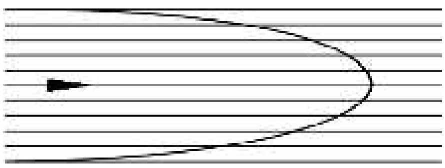
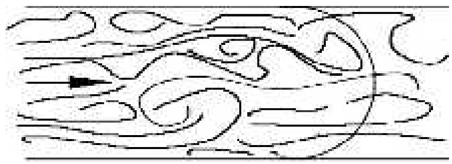
D Inside diameter of pipe (m)

μ = Absolute viscosity of the fluid (Ns/m^2)

ν = kinematic viscosity (m^2/s)

i) For Laminar flow, R_e value is less than 2000.
ii) For Turbulent flow, R_e value is Greater than 4000.
iii) For critical flow, R_e value is varies between 2000 and 4000 and assumed as turbulent flow for calculations. This is an unpredicted flow type.

(iii) Differentiate between laminar and turbulent flow. AU-May 2008

Si. No.	Laminar flow	Turbulent flow
1.	Fluid particles move in layers with one layer of fluid sliding smoothly over an adjacent	Fluid particles move in an entirely haphazard or erratic
2.	Fluid particle move in well defined paths and they remain same relative position at successive cross section of the flow passage.	Fluid particles move in an unpredicted path that results in a rapid and continuous mixing of the fluid
3.	This type of flow generally occurs in smooth pipe when velocity of flow is low.	This type of flow occurs in rivers, canals, streams, water supply
4.	There is no eddies or vortices present.	Eddies or vortices present in this type of flow.
5.	Laminar flow occurs in the liquids having high viscosity.	This flow occurs in liquids having low viscosity.
6.		

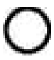
7) Draw any six fluid power symbols? (AU Dec 2007)

Lines
Continuous line - flow line

Dashed line - pilot, drain

Envelope - long and short dashes around two or more component symbols.

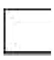
Circular
Large circle - pump, motor



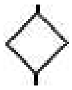
Small circle - Measuring devices

Semi-circle - rotary actuator

Square
One square - pressure control function
Two or three adjacent squares - directional control



Diamond
Diamond - Fluid conditioner (filter, separator, lubricator, heat exchanger)



Miscellaneous Symbols
Spring

Flow Restriction

Triangle
Solid - Direction of Hydraulic Fluid Flow

Open - Direction of Pneumatic Flow

8.A hydraulic pump delivers at 60 bars, 120 lpm into a circuit laid on a horizontal plane. There are 4 elbows (k=0.75), one globe valve fully open (k=10), and a direction control valve (pressure drop=3 bar) with the inside dia of the pipe is 30mm .The total length of the straight run pipe is 20m and the specific gravity of the oil is 0.9. The kinematics viscosity of oil is .0001 m2/s. Determine the pressure in bar at the exits point of the pipe. AU-Ch, Dec 2006

Solutions:

Velocity of flow V = Q / A

$$= \frac{(120 \times 10^{3} / 60)}{\Pi /4 \times 0.03^{3}}$$

= 2.83 m/s

Reynolds number Re= *V* D/ v

= 2.83 x 0.03/ 0.0001

= 849

The Reynolds number is less than 2000. So the flow is laminar. Since the flow is laminar,

Friction factor f = 64/ Re

= 64 /849

= 0.075

K factors for the valves and fittings

4 elbows (K=0.75) = 3

1 Globe valve (K= 10) = 10 / 13

Equivalent length for fittings KD/f = (13x 0.03)/0.075= 5.2 m

Total equivalent length Le = Pipe length + Equivalent length for fittings= 20+ 5.2 =25.2m

Head Loss H_L =f (Le/D) (v^2/2g)

$= 0.075 \times (25.2/0.03) \times (2.83^2 / 2\times9.81) = 25.72$ m

Pressure drop in pipe and fittings = □H_L = $(0.9\times 1000 \times 9.81) \times 25.72 = 2.27 \times 10^5$ = 2.27 bar

Pressure drop in direction control valve = 3 bar

Pressure at the exit of the pipe = 60 – (2.27+3) = 54.73 bar.

9. i) What are the factors to be selected in selection of a pump for automobiles lift. (AU May 2005)

i) Safe and maximum system working pressures.
ii) Allowable pump speeds.
iii) Rated pump performance.
iv) System flow rate requirements.
v) Suitability of variable displacement control.
vi) Volumetric and / overall efficiency.
vii) Operating reliability and durability.
viii) Life expectancy at variable loads and speeds.
ix) Cost and economic factors for overall system compatibility.
x) Oil characteristics and their relationship to rate of pump wear.
xi) Pump noise generation under different speeds, pressures and flow rates.
xii) System temperature.
xiii) Manufacturing characteristics: Component clearances and fit.
xiv) Compactness and power –to- weight ratio.

ii) How will you measure the pump performance? Explain each with suitable Examples? (AU May2005)

The performance characteristics of a pump can be represented in terms of overall efficiency. Overall efficiency, in turn, has two components: volumetric efficiency and mechanical efficiency. These 3 efficiencies are presented below

Volumetric Efficiency:

It is the ratio between the actual flow rate produced by the pump and the theoretical flow rate that the pump should produce.

Volumetric efficiency

= actual flow rate produced by the pump/ theoretical flow rate that the pump should produce x 100

Volumetric efficiency = $Q_A / Q_T \times 100$

Significance: the volumetric efficiency indicates the amount of leakage within the pump. The lower the internal slip losses, the higher the volumetric efficiency.

For zero slip, the volumetric efficiency is 100.

Mechanical Efficiency:

It is the ratio between the theoretical power required to operate the pump and the actual power delivered to the pump

Mechanical efficiency = theoretical power required to operate the pump/actual power delivered to pump x 100

Mechanical efficiency = $(P \times Q_T / T_A \times \omega)100$

Where,

P = Pump discharge pressure in N/m^2

QT= Angular speed of the pump in rad/s = $2 \pi N/ 60$, and N = Speed of the pump in r.p.m

Overall Efficiency:

It is the ratio between the actual power delivered by pump and the actual power delivered to pump

Overall efficiency = (Power output by pump/ actual power given by pump) x 100Mathematically the overall efficiency can also be written as

η_0 = Volumetric efficiency x Mechanical efficiency

$\eta_0 = \eta_{vol} \times \eta_{mech}$

Substituting equations, we get

$\eta_0 = (P . Q_A / T_A . \omega) \times 100$

Significance: The overall efficiency indicates the amount of energy losses by all means.

10.i) A pump has a displacement volume of 98.4 cm³. It delivers 0.00152 m³/s of oil at at 1000rpm and 70 bars. If the prime mover input torque is 124.3 N-m

a) What is the overall efficiency of the pump?

b) What is the theoretical torque required to operate the pump? AU May 2005

Given Data:

Displacement volume $V_D = 98.4\ cm^3 = 98.4 \times 10^{-6}\ m^3$
Discharge $Q_A = 0.00152\ m^3/s$
N = 1000 rpm
Pressure $P = 70\ bar = 70 \times 10^5\ N/m^2$
ActualTorque $T_A = 124.3\ N-m$
$\omega = 2\pi N/60 = 2\pi(1000)/60\ \omega = 104.72$ rad/s

To find over all efficiency of the pump ($\eta 0$)

We know that,

$$\eta 0 = (P \cdot Q_A / T_A \cdot \omega) \times 100$$

$$= \frac{(70\times10^5)(0.00152)}{124.3 \times 104.72} \times 100 = 81.74\ \%$$

To find the theoretical torque required to operate the pump (TT); We know that,

Theoretical Torque $T_T = V_D \times P / 2\pi$

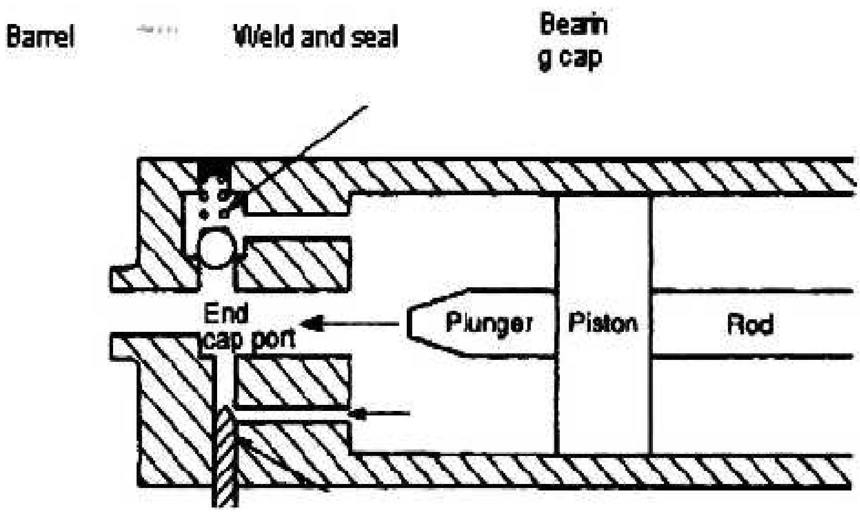
$= (98.4 \times 10^{-6})(70 \times 10^5)/2\pi$

$= 109.62$ N–m

ii) What is cylinder cushioning? Explain with diagram. (or) With a neat sketch explain the "end cushion" provided hydraulic cylinders. (AU Dec 2007)

End caps are generally cast (from iron or aluminium) and incorporate threaded entries for ports. End caps have to withstand shock loads at extremes of piston travel. These loads arise not only from fluid pressure, but also from kinetic energy of the moving parts of the cylinder and load.

These ends of travel shock loads can be reduced with cushion valves built into the end caps. In the cylinder shown in Figure, for example, exhaust fluid flow is unrestricted until the plunger is removed.



Cushioning

11.i) A pump has a displacement volume of 0.0819 *10-3 m3 it delivers 0.0758 m^3 /min at 1000rpm at 67 bar if the prime mover input torque is 100 N- m a) What is the overall efficiency,

b) What is the theoretical torque required to operate the pump. Au, Dec 2005

Solution:

Displacement volume $V_D = 0.0819 \times 10^3\ m^3$ / min
Speed N = 1000 rpm $98.4 \times 10^{-6}\ m^3$
Actual discharge $Q_A = 0.0758 m^3$ / min
N = 1000 rpm
Pressure P = 67 bar = $67 \times 10^5\ N / m^2$
Actual Torque T_A = 100 N–m

$\omega = 2\pi N/60 = 2\pi(1000)/60$ $\omega = 4.72$ rad/s

To find over all efficiency of the pump(η_0)

We know that,

$$\eta_0 = (P.Q_A / T_A . \omega) \times 100$$

$$= \frac{(67 \times 10^5 (0.0758/60)}{100 \times 104.72} \times 100 = 80.83\ \%$$

To find the theoretical torque required to operate the pump(T_T);

We know that,

$$T_T = V_D \times P / 2\pi$$

$$= (0.0819 X 10^{-3}) (67 \times 10^5) / 2\pi$$

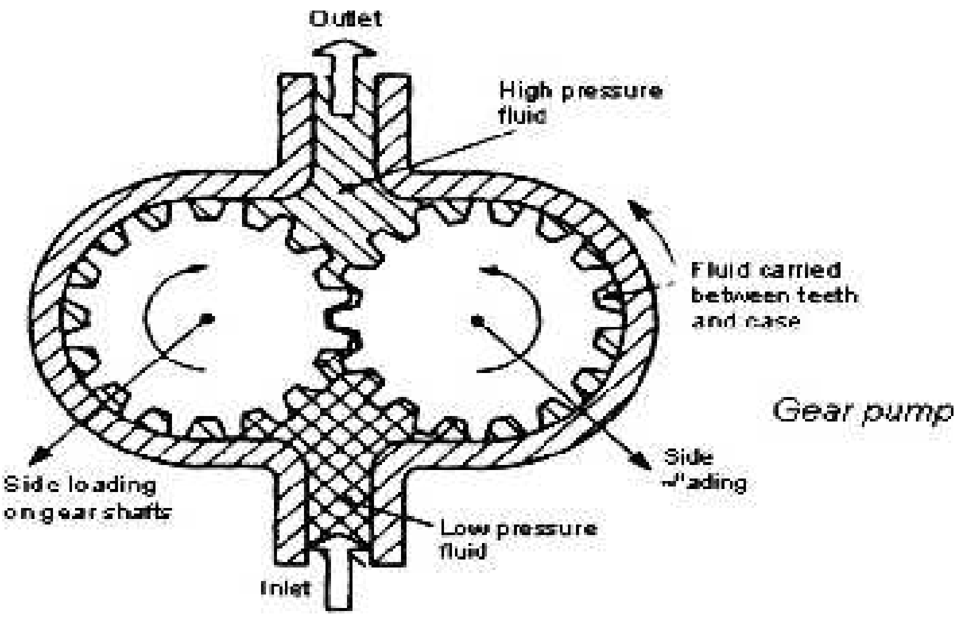
$$= 87.33\ N\text{-}m$$

12. Explain the construction and working of gear pump. Au Dec 2007

Gear pumps:

The simplest and most robust positive displacement pump, having just two moving parts, is the gear pump. Its parts are non-reciprocating, move at constant speed and experience a uniform force. Internal construction, shown in Figure 1, consists of just two close meshing gear wheels which rotate as shown. The direction of rotation of the gears should be carefully noted; it is the opposite of that intuitively expected by most people.

As the teeth come out of mesh at the centre, a partial vacuum is formed which draws fluid into the inlet chamber. Fluid is trapped between the outer teeth and the pump housing, causing a continual transfer of fluid from inlet chamber to outlet chamber where it is discharged to the system.



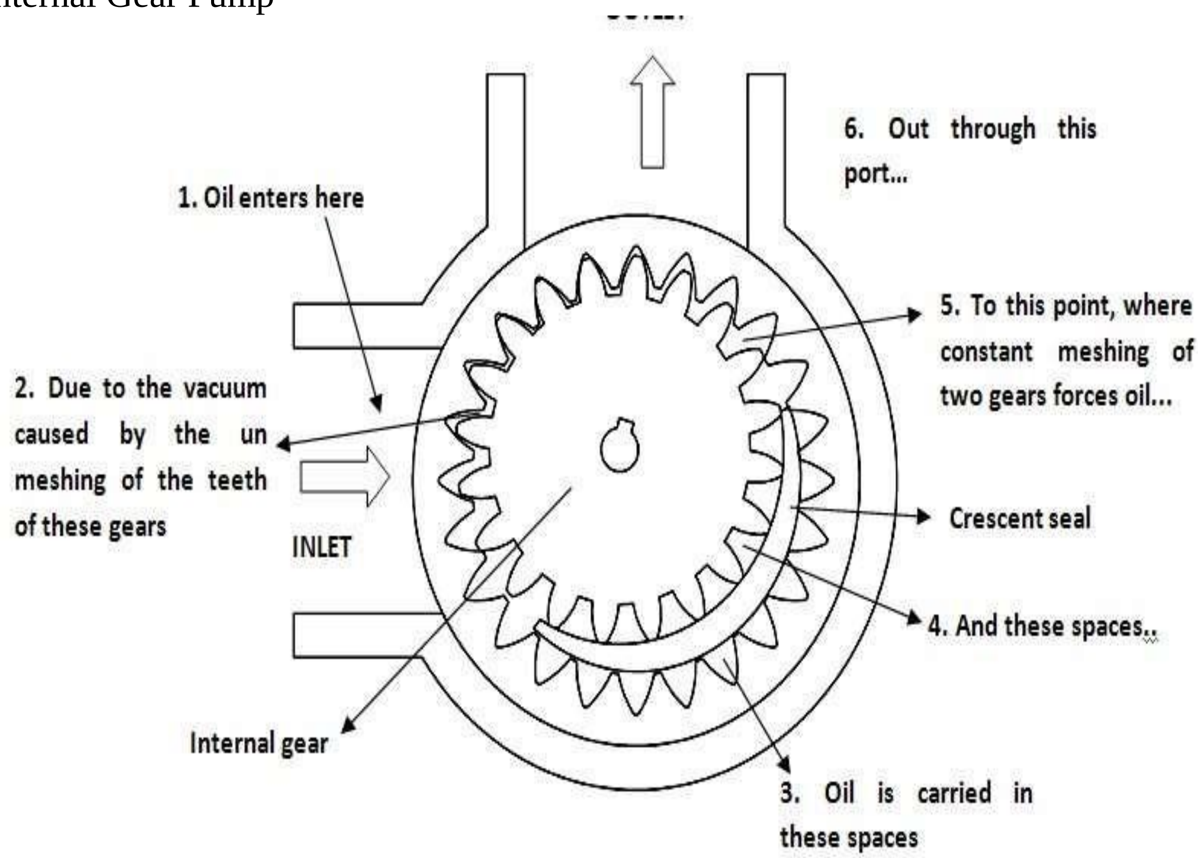
External Gear Pump

Pump displacement is determined by: volume of fluid between each pair of teeth; number of teeth; and speed of rotation. Note the pump merely delivers a fixed volume of fluid from inlet port to outlet port for each rotation; outlet port pressure is determined solely by design of the rest of the system.

Performance of any pump is limited by leakage and the ability of the pump to withstand the pressure differential between inlet and outlet ports. The gear pump obviously requires closely meshing gears, minimum clearance between teeth and housing, and also between the gear face and side plates. Often the side plates of a pump are designed as deliberately replaceable wear plates.

Wear in a gear pump is primarily caused by dirt particles in the hydraulic fluid, so cleanliness and filtration are particularly important.

Internal Gear Pump



The another variation called the intemal gear pump, where an extemal drivengear wheel is connected to a smaller internal gear, with fluid separation as gears disengage being performed by a crescent-shaped moulding.

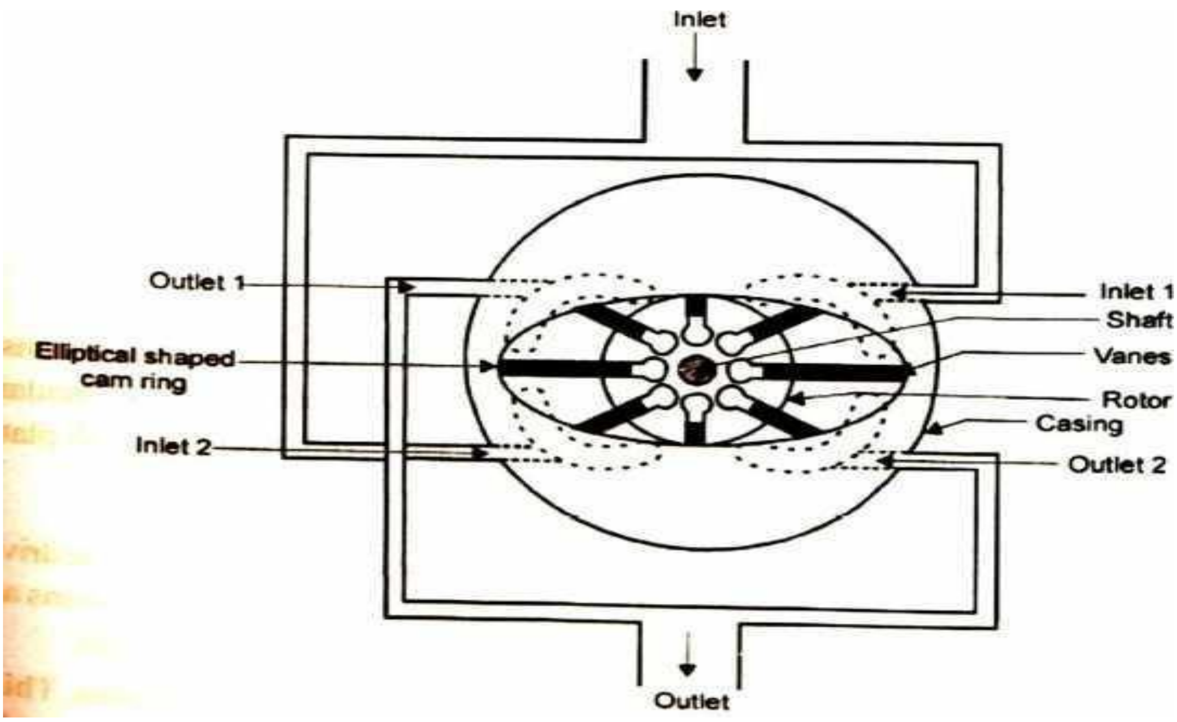
Yet another variation on the theme is the gerotor pump of Figure 2.3, where the crescent moulding is dispensed with by using an internal gear with one less tooth than the outer gear wheel. Internal gear pumps operate at lower capacities and pressures (typically 70 bars) than other pump types.

13 (i) With a neat sketch explain the principal construction working advantages, limitations and applications of a non-pressure compensated reciprocating vane pump. (AU Dec 2006) (Balanced Vane pump)

Balanced vane pump:

- A balanced vane pump is one that has two inlet and two outlet ports which arediametrically opposite to each other and thus complete hydraulic balance is achieved.

- These two inlet and outlet ports are combined as a common inlet and outlet withinthe housing as shown in figure.



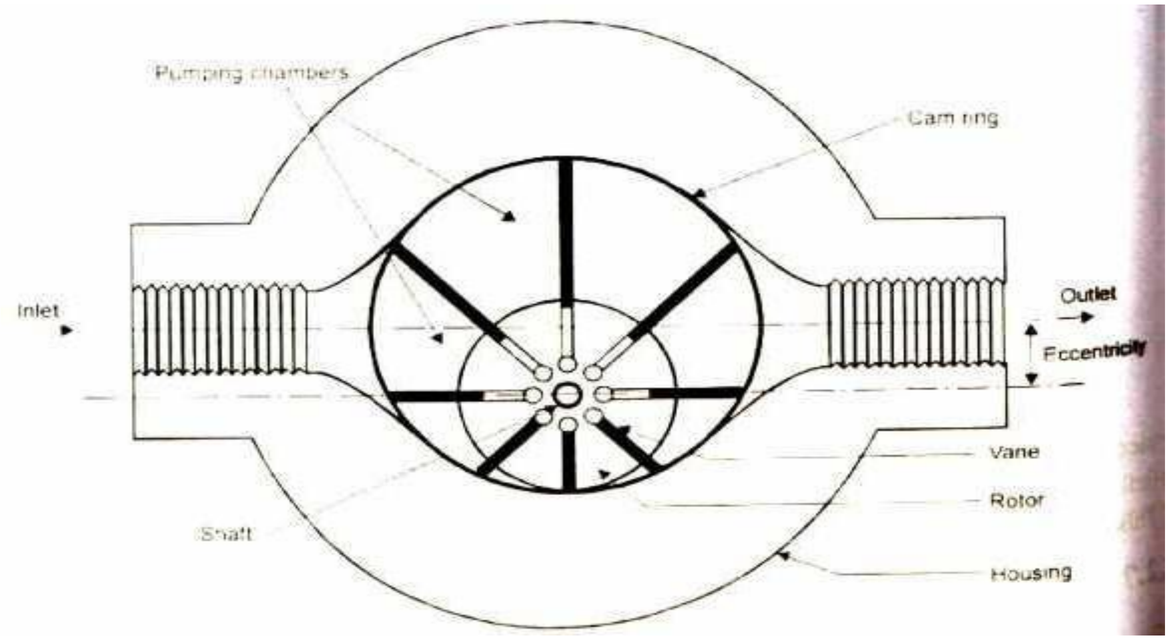
- When the rotor rotates inside a elliptical shaped cam ring, the vanes strokes twiceper revolution of pump shaft. Thus, pumping chambers undergo an increase or decrease in volume twice per cycle due to the above effort.

- For every time volume increase, the fluid is drawn into the pump through the inlet port.
- Conversely, for every time volume decrease, the fluid is forced out of the pumpthrough the outlet port.

(ii) How the capacity of a variable displacement vane pump is adjusted? Explain with a Diagram. Au Dec 2007 (Unbalanced vane pump)

Unbalanced vane pump:

- This pump has a cylindrical rotor with radial slots in which flat radial vanes (blades) can slide freely like plunger in cylindrical barrel.
- The rotor is keyed with the drive shaft and rotates inside a cam ring. The rotor is mounded eccentrically within the cam ring as shown in figure.
- The delivery rate of the pump depends on the degree of offset of the rotor with respect tothe cam ring. Hence, vane pump is also known as variable displacement pump.



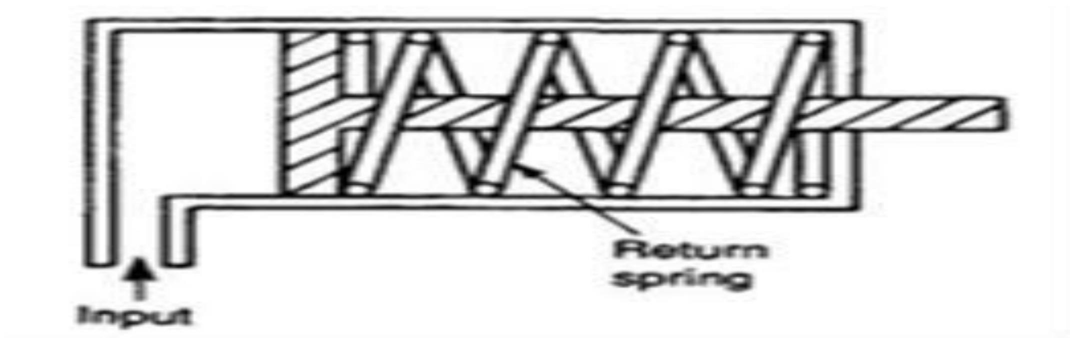
- As the rotors rotates, the vanes are pushed out against the surface of the cam ring by centrifugal force, which in turn, the vanes are kept in contact with the cam surface(camring).
- The vanes divide the space between the rotor and the cam ring into a series of smallpumping chambers.
- During the revolution of one half of rotation, the pumping chambers between thevanes are opened near the inlet. This action creates a partial vacuum at its inlet. So,the fluid from the
- Reservoir is drawn into the pump through the inlet port and fills the void.
- The fluid is carried between the vanes to the outlet. During second half of rotor rotation, the vanes are pushed back to their slots and thus the pressure is increased. This action forces the fluid out of the pump through the outlet port.

14. Classify the hydraulic actuators and explain any two types of special actuators. AU Dec 2011

Single acting cylinder
Double acting cylinder
Telescoping cylinder

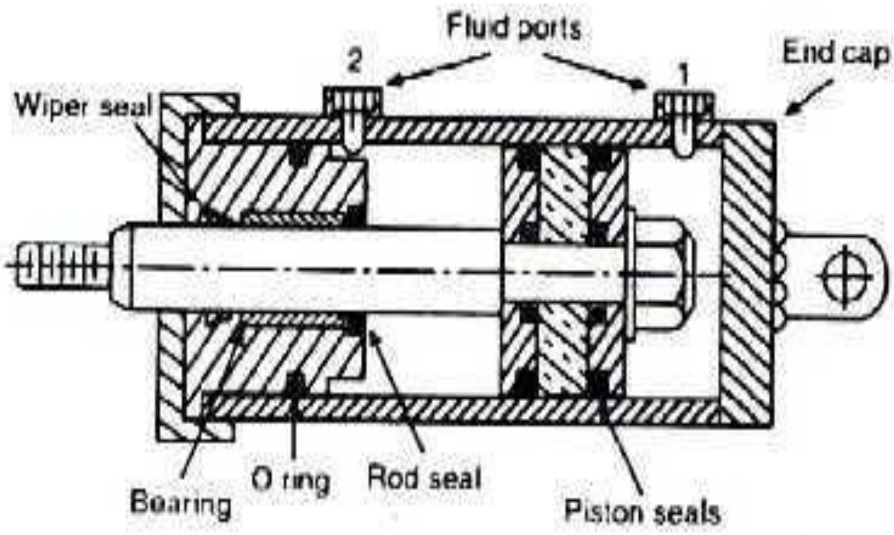
SINGLE ACTING CYLINDER:

A single acting hydraulic cylinder is designed to apply in only one direction.



- It consists of a piston inside a cylinder housing called a barrel. Attached to one end of the piston is a rod which extends outside. At the other end (blank end) is a port for the entranced and the exit of oil.
- A single acting cylinder can exert a force only in the extending direction, as fluid from the pump enters through the blank end of the cylinder. Single acting cylinder do not hydraulic retract. Retraction is accomplished by using gravity or by the inclusion of a compression springat the rod end.

DOUBLE ACTING CYLINDER:



- A double acting cylinder capable of delivering forces in both directions. The barrelis made of seamless steel tubing, honed to a fine finish on the inside surface.
- The piston which is made of ductile iron contains U cup packings to seal the leakagebetween the piston and the barrel. The port are located in the end caps which are secured to the barrel by tie rods.
- The load of the piston rod at the neck is taken by a rod bearing, which is generally madeof brass or bronze.
- A rod wiper is provided at the end of the neck to prevent foreign particals and dust fromentering into the cylinder along with the piston rod.

Telescopic Cylinder:

The stroke of a simple cylinder must be less than barrel length, giving at best an extended/retracted ratio of 2:1. Where space is restricted, a telescopic cylinder can be used. Figure 1 shows the construction of a typical double-acting unit with two pistons. To extend, fluid is applied to port A. Fluid is applied to both sides of piston 1 via ports X and Y, but the difference in areas between sides of piston 1 causes the piston to move to the right.

To retract, fluid is applied to port B. A flexible connection is required for this port. When piston 2 is driven fully to the left, port Y is now connected to port B, applying pressure to the fight-hand side of piston 1 which then retracts.

The construction of telescopic cylinders requires many seals which makes maintenance complex. They also have smaller force for a given diameter and pressure, and can only tolerate small side loads.

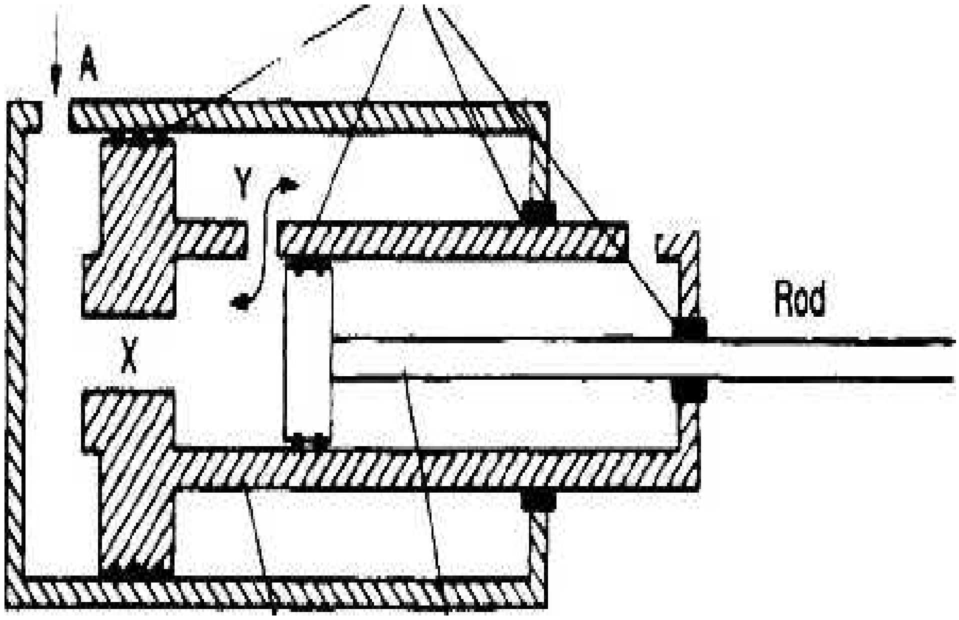


Figure. 1. Two-stage telescopic Cylinder

Pneumatic cylinders are used for metal forming, an operation requiting large forces. Pressures in pneumatic systems are lower than in hydraulic systems, but large impact loads can be obtained by accelerating a hammer to a high velocity then allowing it to strike the target.

15. A pump has a displacement of 80 cm3. It delivers 1.25 Lps at 1200 rpm and 75 bar. ***If the primemover input torque is 110 N-m,***

(1) Find the overall efficiency of the pump.
2) What is the theoretical torque required to operate the pump? (AU June 2007)

Given Data:

Displacement volume $V_D = 80cm^3 = 80 \times 10^{-6}\ m^3$
Discharge $Q_A = 1.25$ Lps $= 1.25 \times 10^{-3}\ m^3/s$
Speed N = 1200 rpm
Pressure $P = 75$ bar $= 75 \times 10^5\ N / m^2$
Torque T = 90 N . m

Solution:

$\omega = 2\pi N/60 = 2\pi(1200)/60$ $\omega = 125.66$ rad/s

To find overall efficiency of the pump ($\eta 0$)

We know that the volumetric efficiency of a pump

$$\eta 0 = (P \cdot QA / TA \cdot \omega) \times 100$$

$$= \frac{(75 \times 10^5 (1.25 \times 10^{-3})}{90 \times 125.66} \times 100 = 82.89\ \%$$

To find the theoretical torque required to operate the pump (T_T);

We know that theoretical torque

$$T_T = V_D \times P / 2\pi$$

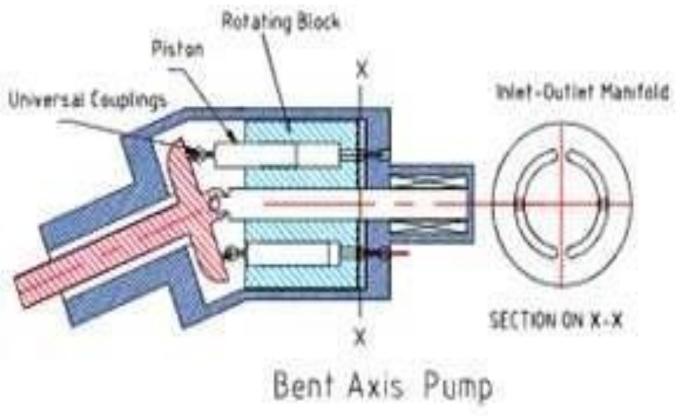
$$= (80 \times 10^{-6})(75 \times 10^{5}) / 2\pi$$

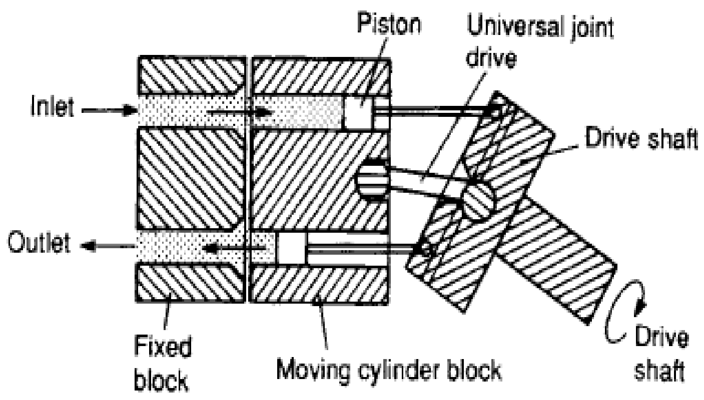
$$= 95.49\ N\text{–}m$$

16. Explain the construction and working of different types of piston pump with neat sketch. With a neat sketch, explain the working principle of a swash plate axial piston pump and mention how the displacement can be varied. (AU Nov/Dec2021)

- A **piston pump is similar to reciprocating engine**. It can **draw in liquid when retracts** in cylinder **and discharge it when it extends**.
- There are two basic types of piston pumps:
  Axial design: Pistons moving to axis of cylinder block - Bent axis, Swash plate configuration
  Radial design: Pistons arranged radially in a cylinder block

Axis piston pump (Bent axis design)

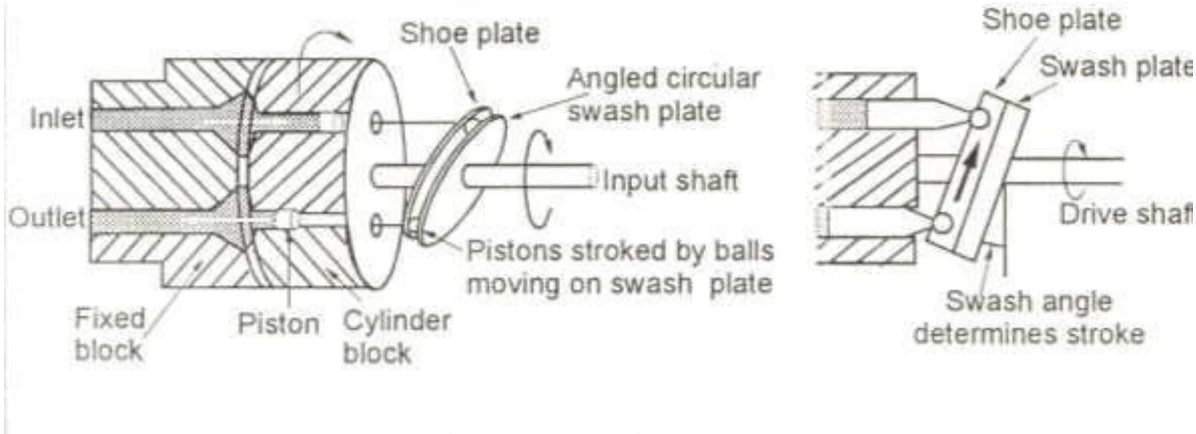




- Cylinder block contains **number of pistons arranged in circle**
- **Piston rods** are **connected to drive shaft flange by ball & socket** joints
- **Universal link** for alignment and for positive drive

In line / Axial piston pump with swash plate

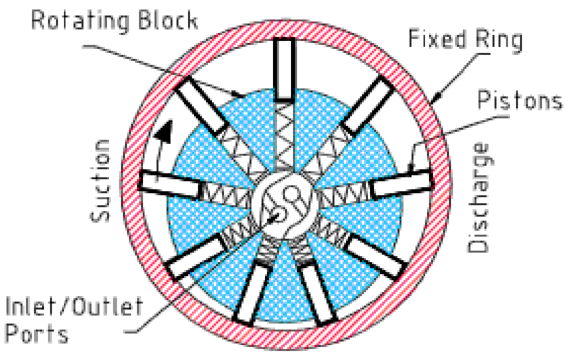
- **Cylinder block and drive shaft** are **in line**.
- In this pump, **multiple pistons are arranged in a rotating cylinder**. The pistons stroked by a **fixed angled plate** which is known as swash plate. **Each piston has contact with the swash plate** by rotating shoe plate linked to it.
- When the **cylinder rotates**, the **pistons reciprocate** because the piston shoes follow the angled surface of the swash plate. Pump **capacity** can be **changed by altering the angle of the swash plate.**
- If we increase the angle, the capacity will be increased. If the **swash plate is vertical**; **then the capacity will be zero** and even the flow can be reversed by changing the angle of swash plate.



Axial pump with swash plate

- So the angle of tilt of the swash plate determines the piston stroke and therefore, determines the pump displacement and flow. Can be variable displacement pump.

Radial piston pump



Radial Piston Pump

- Consists of a pintle to direct fluid IN &OUT
- Piston remains in constant contact with fixed ring
- Can be made variable displacement pumpby changing eccentricity by moving fixed ring

17. Explain about Rotary motors with sketch. Au May 2008Rotary actuators:

Rotary actuators are the hydraulic or pneumatic equivalents of electric motors. For a given torque, or power, a rotary actuator is more compact than an equivalent motor, cannot be damaged by an indefinite stall and can safely be used in an explosive atmosphere. For variable speed applications, the complexity and maintenance requirements of a rotary actuator are similar to a thyristor-con-trolled DC drive, but for fixed speed applications, the AC induction motor (which can, for practical purposes, be fitted and forgotten) is simpler to install and maintain.

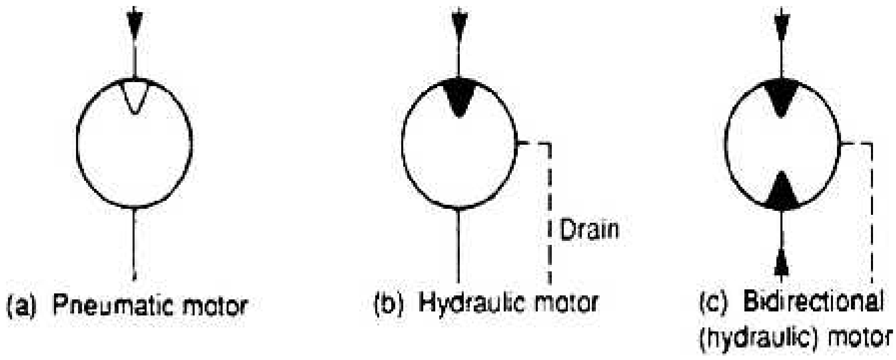


Figure. 1 Rotary actuator symbols

18. Mention differences between hydraulic and pneumatic systems.

Hydraulic system	Pneumatic system
Uses **incompressible** liquids like water / oil	Uses **compressed** gas like air
Used for **high forces**, relatively slower motions	Used for **low forces**, faster motions
Speed is limited	Very **high speed** is possible
Operates at **high pressure**	Operates at low pressure
Can handle **high load**	Can handle **low to medium load**
Pump is necessary	**Compressor** is used
No noise is produced	A **lot of noise** is produced
Resistances to fluctuating load	**Non-resistant to fluctuating load**.
High accuracy and **precision**	Relatively **low accuracy** and **precision**.
Suitable for feed movement in m/c tools	**Unsuitable** for feed movement in m/c tools.
Most **expensive**.	**Less expensive**.
. **Installation** of the system is **complex**.	. **Installation** is **less complicated**.
Cavitation is a big problem.	**No cavitation** problem.
Ex.: Hydraulic brakes, Jacks, Forklift, Cranes, Hydraulic lifts, etc.	Ex.: Air brakes, Nail gun, Cylinders, actuators, Jackhammers, Air gun, etc.

UNIT 2 HYDRAULIC ACTUATORS AND CONTROL COMPONENTS

Hydraulic Actuators: Cylinders – Types and construction, Application, Hydraulic cushioning–Hydraulic motors - Control Components : Direction Control, Flow control and pressure control valves – Types, Construction and Operation – Servo and Proportional valves – Applications –Accessories : Reservoirs, Pressure Switches – Applications – Fluid Power ANSI Symbols –Problems.

1. What is the function of a hydraulic actuator?

A hydraulic actuator is used for converting hydraulic energy into mechanical energy

2. How can you classify the hydraulic actuators?

1 Linear actuators (also called "hydraulic cylinders), and
2. Rotary actuators (also called "hydraulic motors').

3. What is the function of a hydraulic cylinder?

The hydraulic cylinder is used to convert fluid power into linear mechanical force and Motion.

4. Mention few applications of hydraulic cylinder.

The hydraulic cylinders are basically used for performing work such as pushing, pulling tilting, and pressing in a variety of engineering applications such as in material handling equipment, machine tools, construction equipment, and automobiles.

5. Name different types of hydraulic cylinders.

Single Acting Cylinders,
Double Acting Cylinder
Telescoping Cylinders,
Tandem Cylinder, And
Through Rod Cylinder.

6. Application of semi rotary actuator

- The turning components over in a drilling jig,
- Providing a wrist action on a pick-and-place device or operating process valves.

7. Define Motor

It is a rotating machine that transforms electrical energy into mechanical energy.

8. Differentiate between a single-acting and a double-acting hydraulic cylinder.

Single-acting hydraulic cylinders can deliver a force in only one direction. But in double-acting cylinders, liquid pressure can be applied to either side of the piston, thereby providing a hydraulic force in both directions.

9. What is the purpose of seals in hydraulic system?

The seals are used to prevent the internal and external leakages of hydraulic system.

10. What is a telescopic cylinder? When is it normally used?

A telescopic cylinder consists of a series of rams (pistons) nested in a telescopic assembly which provide a long extension.

Telescopic cylinders are useful for application requiring a long stroke but with only limited space available for the unexpended ram.

11. What are tandem cylinders? When are they normally used?

- A tandem cylinder is one in which two or more piston rod combinations are assembled as a rigid unit with all pistons mounted on single rod.

- The cylinders are used to obtain a low-force, high-speed action followed by a high- force, low-speed action.

12. Name few cylinder mountings.

1. Side foot mount, 2. Centerline mount,
3. End foot mount, 4. Side-flush mount,
5. Rear flange mount, 6. Front flange mount,
7. Clevis mount, 8.Basic mount. etc

13. What is the function of a hydraulic motor (or rotary actuator)?

The function of a hydraulic motor (or rotary actuator) is to convert hydraulic energy into rotary mechanical energy.

14. Name the basic types of rotary actuators. Which will provide the maximum degree of rotation?

- Types: 1. Continuous rotary actuator, and
  (a) Gear motor, (b Vane motors, and (c) Piston motors.
- 2. Limited rotation hydraulic motors.
  (a)Van type, and (b) Piston type.
- Continuous rotary actuators will provide the maximum degree of rotation.

15. With respect to hydraulic motors, define the terms volumetric and mechanical efficiency.

$$(\eta_{vol})\text{motor} = \frac{\text{Theoretical flow rate motor should consume}}{\text{Actual flow rate consumed by motor}} \times 100$$

$$* \ (\eta_{\text{mech}})\text{motor} = \frac{\text{Actual torque delivered by motor}}{\text{Torque motor should theoretically deliver}} \times 100$$

16. What are the three important parameters that should be controlled in a hydraulic system ?

1. Pressure, 2. Flow direction, and 3. Flow rate

17. What are control (or hydraulic) valves?

Control valves are devices used to control pressure, flow direction, or flow rate in hydraulic circuits.

18. What is the function of a DCV ?

The function of a directional control valve (DCV) is to control the direction of flow in a hydraulic circuit.

19. What is the function of check valves?

Check valves are used:

(i) To allow free flow in only one direction, and
(ii) To prevent any flow in the other direction.

20. What does a 4/3 control valve represent?

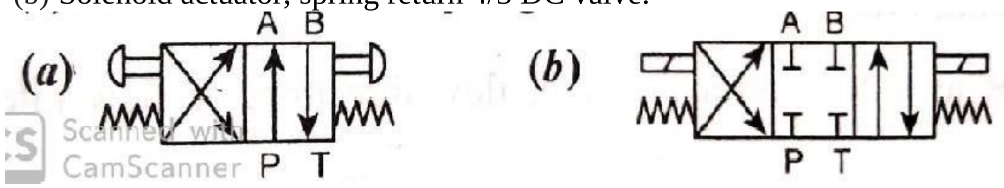
A 4/3 control valve has 4 ways and 3 positions.

21. What are the different valve actuation methods used?

1. Manual actuation, 2. Mechanical actuation,
3. Electrical actuation, and 4. Fluid actuation.

22. Draw the graphic symbol for the following DC valves :

(a) Push button operated, four way, two position, spring offset DC valve, and
(b) Solenoid actuator, spring return 4/3 DC valve.



23. Name various types of pressure control valves.

1. Pressure limiting (or relief) valves, 2. Pressure reducing valves,
3. Sequence valves, 4. Counter balance valves, and
5. Unloading valves.

24. **What is the use of a pressure relief valve in a hydraulic system?** Pressure relief valve is essential in all hydraulic systems' – Justify.(AU Nov/Dec2021)

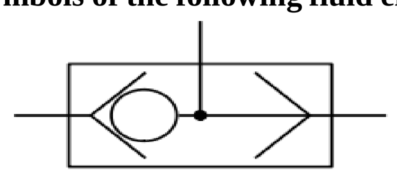
Hydraulic systems are designed to operate within a preset pressure range. This range is a function of the forces the actuators in the system must generate to do the required work. Without controlling or limiting these forces, the fluid power components (and expensive equipment) could be damaged. Relief valves avoid this hazard. They are the safeguards which limit maximum pressure in a system by diverting excess oil when pressures get too high. So, Pressure relief valve is essential in all hydraulic systems.

25. What is the use of a hydraulic fuse ?

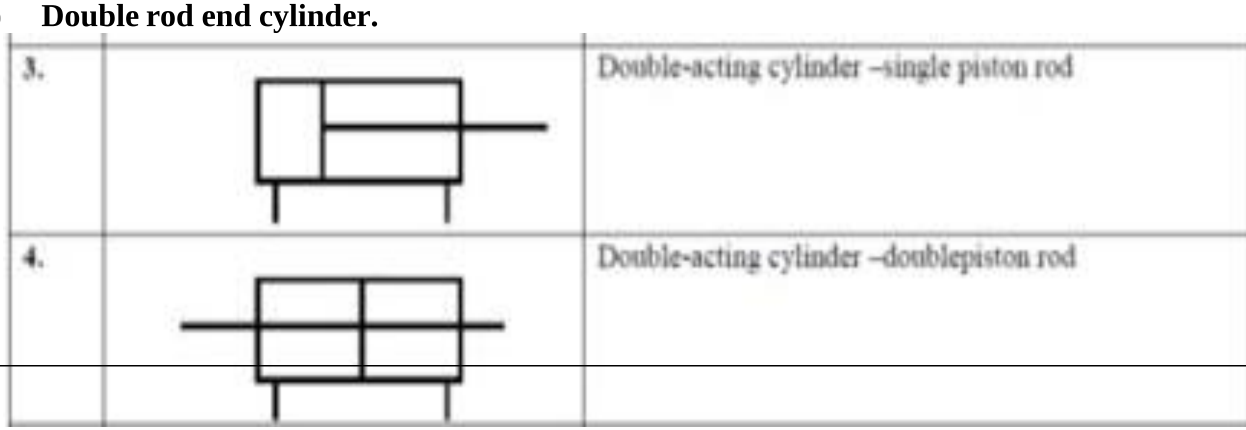
The hydraulic fuse, analogous to an electrical fuse, is used to prevent the system pressure from exceeding beyond the allowable limit in order to protect the system components from damage.

26. Sketch the ISO symbols of the following fluid elements: (AU Nov/Dec2021)

(a) Shuttle valve



(b) Double rod end cylinder.



(PART-B & C)

1. What are Actuators? Types of Hydraulic Actuators

- Actuators are the devices used for converting hydraulic energy into mechanical energy.
- In other words, actuators perform a function just opposite to that of the pumps.
- The pressurized hydraulic fluid delivered by the hydraulic pump is supplied to the actuators, which converts the energy of the fluid into mechanical energy. This mechanical energy is used to get the work done.
- The hydraulic actuators produce linear, rotary, or oscillating motion.
- They can be used for lifting, tilting, clamping, opening, closing, metering, mixing turning, swinging, counterbalancing, bending and for many other operations.
- Special applications are on roll-over devices, conveyors, valve operators, printing presses, rock drills, dies, clamps, machine tools, etc.

Types of Hydraulic Actuators

Based on the type of motion actuators produce, they are categorized into two:

1. Linear actuators (also called 'hydraulic cylinders') and
2. Rotary actuators (also called 'hydraulic motors')

   a) Continuous rotary actuators (or simply hydraulic motors), and

   b) Limited rotation rotary actuators (also called "oscillation fluid motors'). The linear actuators generate motion in a straight line to perform the work. The rotary actuators generate rotary output motion to perform the work.

LINEAR ACTUATORS (OR HYDRAULIC CYLINDERS)

Introduction

- A linear actuator or hydraulic cylinder is a fluid motor that generates linear motion. In other words, hydraulic cylinder is a device which converts fluid power into linear mechanical force and motion
- The hydraulic cylinders are basically used for performing work such as pushing, pulling, tilting. and pressing in a variety of engineering applications such as in material handling equipment, machine tools, construction equipment, and automobiles.
-

Types of Hydraulic Cylinders

The linear hydraulic cylinders can be classified into many types based on various criteria. Some of them are given below:

1. Based on the cylinder action:

(a) Single acting cylinders, and

(b) Double acting cylinders.

2. Based on the cylinders' design :

(a) Plunger or ram cylinders,

(b) Telescoping cylinders,

(c) Tandem cylinders,

(d) Cable cylinders,

(e) Diaphragm cylinders,

(f) Bellow cylinders,

(g) Duplex cylinders, etc.

3. Based on the cushioning feature :

(a) Cushioned type hydraulic cylinders, and

(b) Non-cushioned type cylinders.

4. Based on the piston or plunger used :

(a) Piston type cylinders, and

(b) Plunger type cylinders

. 5. Based on the cylinders' movement :

(a) Rotating type cylinders, and

(b) Non-rotating type cylinders.

SINGLE ACTING CYLINDERS

Introduction

As the name suggests, single-acting cylinders can deliver a force in only one direction. The single-acting cylinder is the simplest type of all hydraulic cylinders.

Construction

Single-acting cylinder has only one port at one end of the cylinder barrel to allow the hydraulic fluid. The schematic representation of a single-acting cylinder is depicted in Fig.(a). Fig.(b) show its symbolic representation. It is designed in such a way that the extending movement is forced by hydraulic fluid and the piston is retracted by gravity or u compression spring.

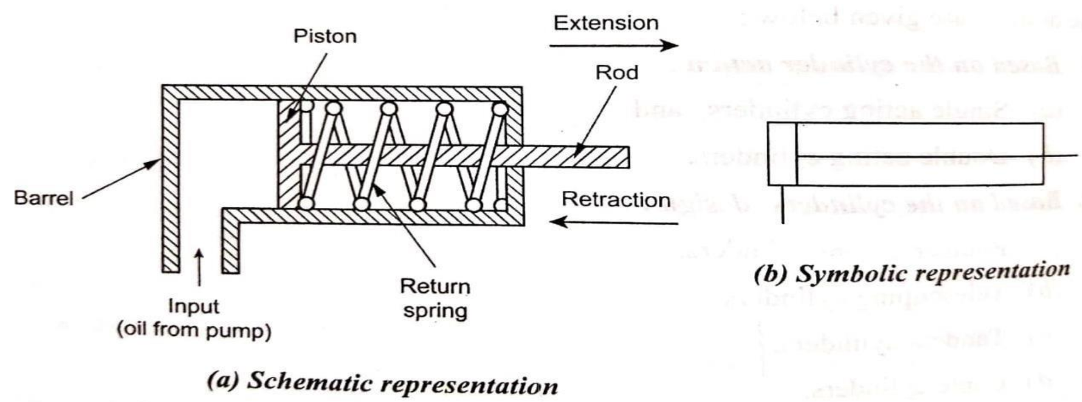


Fig. Single-acting hydraulic cylinder

The piston is assembled inside a cylindrical housing called barrel. To maintain the close fitting between the piston and barrel, piston seal is attached at the circumference of the piston A rod is connected to the piston and extended out of the barrel to deliver the force. At other end of the barrel, there is a port for the fluid.

Operation

During the extending action, the force is applied by the pressurized fluid. The force applied to a piston depends on both the area of the piston and the pressure of the fluid mathematically; the force applied is given by

$$F = P \times A$$

where P = Pressure of the fluid,

A = Area of the piston $= \frac{\pi}{4} D^2$, and

D = Diameter of the piston.

In single-acting cylinders, pistons do not retract hydraulically. But the retraction is accomplished by using gravity or by using the compression spring as shown in Fig.6.1 (a). If a cylinder is employed to lift a load, then the load itself can retract the piston.

Advantages and Disadvantages of Single-Acting Cylinders

* The single-acting cylinders are very simple to operate, and compact in size.

* The single-acting cylinders with spring return cannot be used for larger stroke lengths.

Gravity-Return Single-Acting Cylinder.

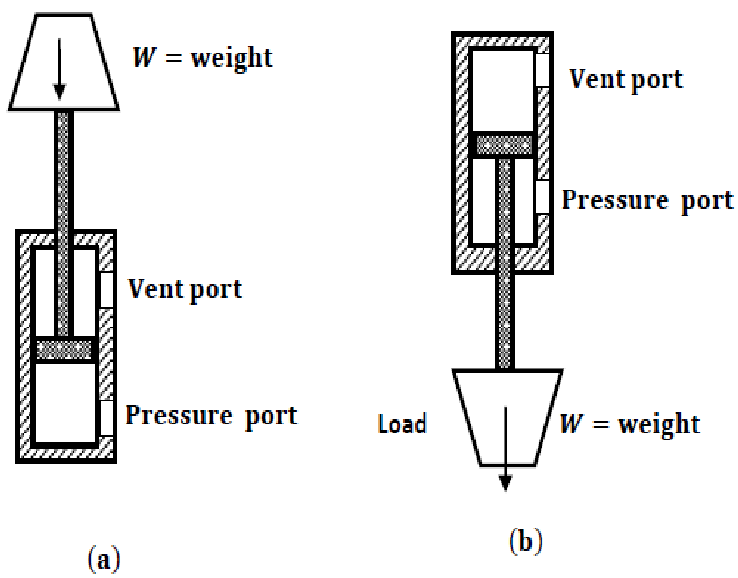


Figure 1.2 Gravity-return single-acting cylinder: (a) Push type; (b) pull type

Shows gravity-return-type single-acting cylinders. In the push type [Fig. (a)], the cylinder extends to lift a weight against the force of gravity by applying oil pressure at the blank end. The oil is passed through the blank-end port or pressure port.

The rod-end port or vent port is open to atmosphere so that air can flow freely in and out of the rod end of the cylinder. To retract the cylinder, the pressure is simply removed from the piston by connecting the pressure port to the tank.

This allows the weight of the load to push the fluid out of the cylinder back to the tank. In pull-type gravity-return-type single-acting cylinder, the cylinder [Fig. (b)] lifts the weight by retracting. The blank-end port is the pressure port and blind-end port is now the vent port. This cylinder automatically extends whenever the pressure port is connected to the tank.

2. Explain construction and working of spring return single acting cylinder.

Spring-Return Single-Acting Cylinder

A spring-return single-acting cylinder is shown in Fig.1.3.In push type [Fig. 1.3(a)], the pressure is sent through the pressure port situated at the blank end of the cylinder. When the pressure is released, the spring automatically returns the cylinder to the fully retracted position. The vent port is open to atmosphere so that air can flow freely in and out of the rod end of the cylinder.

Figure 1.3(b) shows a spring-return single-acting cylinder. In this design, the cylinder retracts when the pressure port is connected to the pump flow and extends whenever the pressure port is connected to the tank. Here the pressure port is situated at the rod end of the cylinder.

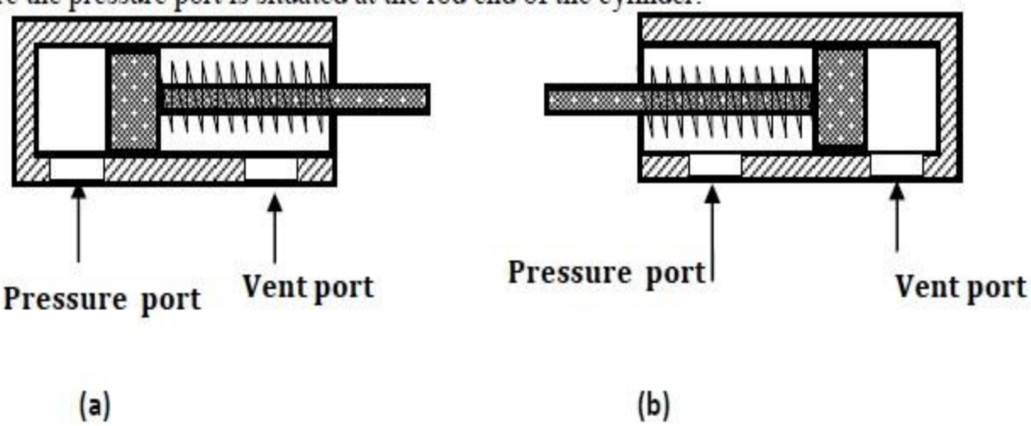


Figure 1.3 (a) Push- and (b) pull-type single-acting cylinders

1.2.2 Double-Acting Cylinder

There are two types of double-acting cylinders:

- Double-acting cylinder with a piston rod on one side.
- Double-acting cylinder with a piston rod on both sides.

1.2.2.1 Double-Acting Cylinder with a Piston Rod on One Side

Figure 1.4 shows the operation of a double-acting cylinder with a piston rod on one side. To extend the cylinder, the pump flow is sent to the blank-end port as in Fig. 1.4(a). The fluid from the rod-end port returns to the reservoir. To retract the cylinder, the pump flow is sent to the rod-end port and the fluid from the blank-end port returns to the tank as in Fig.1.4(b).

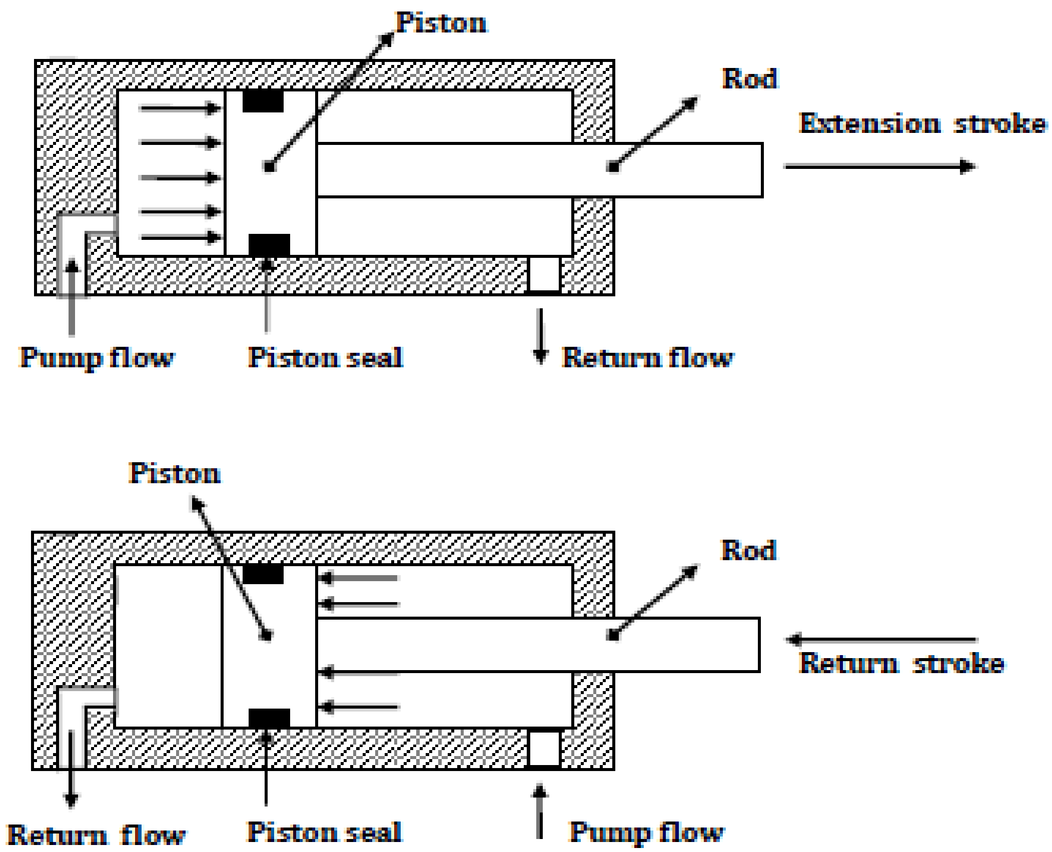


Figure 1.4 Double-acting cylinder with a piston rod on one side

1.2.2.2 Double-Acting Cylinder with a Piston Rod on Both Sides

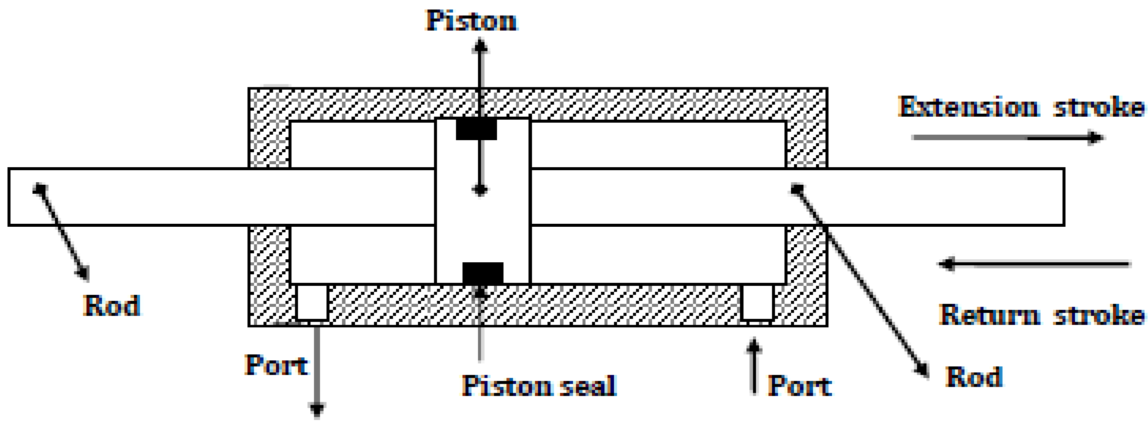


Figure 1.5 Double-acting cylinder with a piston rod on one side

A double-acting cylinder with a piston rod on both sides (Fig.1.5)is a cylinder with a rod extending from both ends. This cylinder can be used in an application where work can be done by both ends of the cylinder, thereby making the cylinder more productive. Double-rod cylinders can withstand higher side loads because they have an extra bearing, one on each rod, to withstand the loading.

3. Explain the Working principle of Telescopic Cylinder

A telescopic cylinder is used when a long stroke length and a short retracted length are required. The telescopic cylinder extends in stages, each stage consisting of a sleeve that fits inside the previous stage. One application for this type of cylinder is raising a dump truck bed. Telescopic cylinders are available in both single-acting and double-acting models. They are more expensive than standard cylinders due to their more complex construction.

They generally consist of a nest of tubes and operate on the displacement principle. The tubes are supported by bearing rings, the innermost (rear) set of which have grooves or channels to allow fluid flow. The front bearing assembly on each section includes seals and wiper rings. Stop rings limit the movement of each section, thus preventing separation. When the cylinder extends, all the sections move together until the outer section is prevented from further extension by its stop ring. The remaining sections continue out-stroking until the second outermost section reaches the limit of its stroke;this process continues until all sections are extended, the innermost one being the last of all.

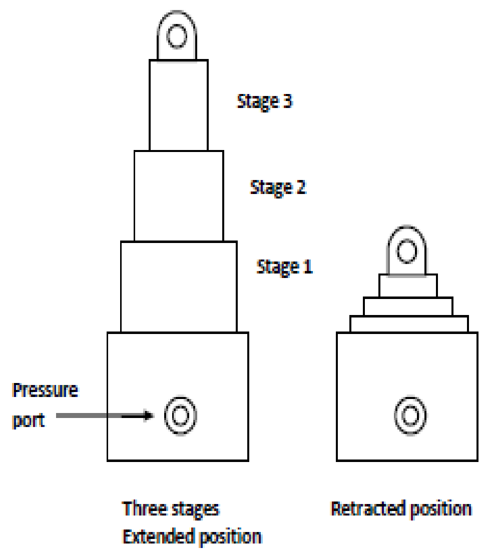


Figure 1.6 Telescopic cylinder

For a given input flow rate, the speed of operation increases in steps as each successive section reaches the end of its stroke. Similarly, for a specific pressure, the load-lifting capacity decreases for each successive section.

Applications

- Telescopic cylinders are used commonly is trucks used in construction,
- Vehicle trailers,
- Garbage and dump trucks,
- A range of equipment used in the agricultural industry.

4. Explain the working of a proportional pressure relief valve
(AU Nov/Dec2021)

One of the most important pressure controls is the relief valve. Its primary function is to limit the system pressure. Relief valve is found in practically all the Hydraulic system. It is normally a closed valve whose function is to limit the pressure to a specified maximum value by diverting pump flow back to the tank. There are two basic design, a) direct operated or inertia type, b) the pilot operated design (compound relief valve)

<u>Direct type of relief valve</u>: The direct type of relief valve has two basic working port connections. One port is connected to pump and the other to the tank. The valve consists of a spring chamber (control chamber) with an adjustable bias spring which pushes the poppet to its seat, closing the valve.

A small opening connecting the tank is provided in the control chamber to drain the oil that may collect due to leakage, thereby preventing the failure of valve. System pressure opposes the poppet, which is held on its seat by an adjustable spring.

The adjustable spring is set to limit the maximum pressure that can be attained within the system. The poppet is held in position by spring force plus the dead weight of spool. When pressure exceeds this force, the poppet is forced off its seat and excess fluid in the system is bypassed back to the reservoir. When system pressure drops to or below established set value, the valve automatically reseats. Fig 4.27a shows a direct pressure relief valve. Fig 4.27b shows the symbol

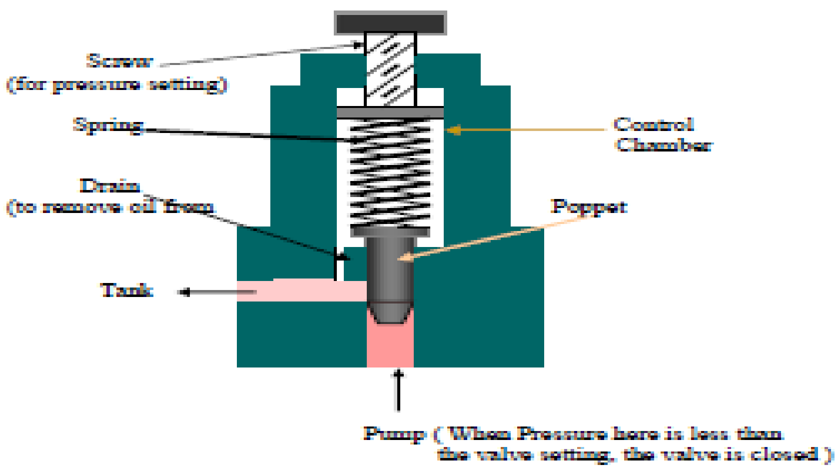


Fig 4.27a. <u>Pressure Relief Valve</u>

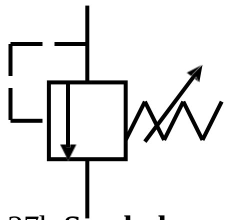


Fig 4.27b.**Symbol**

5. A pressure relief valve has a pressure setting of 69 bars. a) Compute the hydraulicpower loss across this valve if it returns all the flow back to the tank from a 0.0013m^3/s discharge pump. b) If unloading valve is used to unload the pump and if the pump discharge pressure during unloading equals 1.72 bars, how much power is being wasted ?

Solution :

b) Pressure setting, p= 69 bars = $69*10^5$ N/m^2

Discharge, Q = 0.0013m^3/ s

Power=?

We know, Hydraulic Power = **p * Q** watts

Hydraulic power loss = $69*10^5*0.0013$ = **8970 watts** **Ans**

b) Discharge pressure during unloading p = 1.72 bars

Hydraulic power loss = $1.72*10^5*0.0013$ = **223.6 watts** **Ans**

One can see that by using unloading valve to unload the pump flow, the power loss is very much less compared to that of relief valve.

6. Explain the working of sequence valve with neat sketches. Illustrate the working of a Sequencing valve (AU Nov/Dec 2021)

A sequence valve's primary function is to divert flow in a predetermined sequence. It is a pressure- actuated valve similar in construction to a relief valve and normally a closed valve. The sequence valve operates on the principle that when main system pressure overcomes the spring setting, the valve spool moves up allowing flow from the secondary port.

A sequence valve may be direct or remote pilot- operated. These valves are used to control the operational cycle of a machine automatically. Sequence valve may be directly operated as shown in the fig 4.29b. The valve consists of a spring chamber (control chamber) with an adjustable bias spring for setting the pressure. It consists of

2 ports, one main port connecting the main line and other (secondary port) connected to the secondary circuit. Usually the secondary port is closed by the spool. A small opening connecting the tank is

provided in the control chamber to drain the oil that may collected due to leakage, thereby preventing the failure of valve. The pressure is effective on the end of the spool. This pressure will urge the spool against the spring once and at the preset value of the spring allows a passage from the primary to the secondary port. For remote operation it is necessary to close the passage used for direct operation by plugging and provide a separate pressure source as required for the operation of the spool in the remote operation mode.

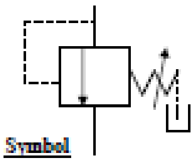


Fig 4.29a. Symbol

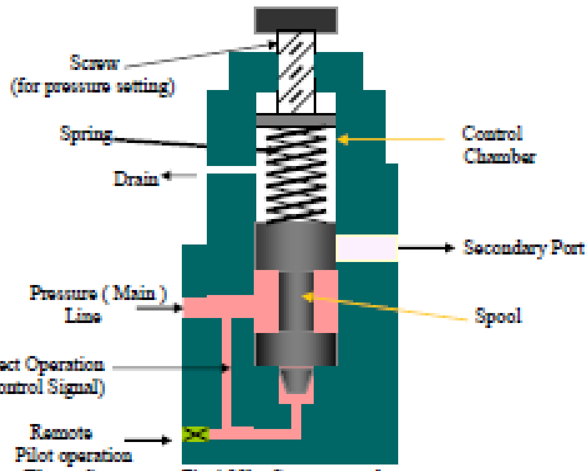


Fig 4.29b. Sequence valve

7. Explain details about Hydraulic cylinder cushioning. With a neat sketch, brief oncushioning in hydraulic cylinders (AU Nov/Dec2021)

When cylinders reach the end of their stroke, the pressure rises quickly, creating a shock wave in the hydraulic circuit. Cushioning is done to reduce this stock. The concept, shown in Fig. 7.6, is quite simple. First, we consider the case in which the cylinder is retracting. The spear closes off the large opening where the fluid is exiting the cap end of the cylinder. Fluid must now flow out the small opening past a needle valve. This valve adjusts the orifice and sets the back pressure that develops in the cap end. The resultant force slows the piston so that it "coasts" to a stop. The resultant pressure shock in the main circuit is significantly reduced.

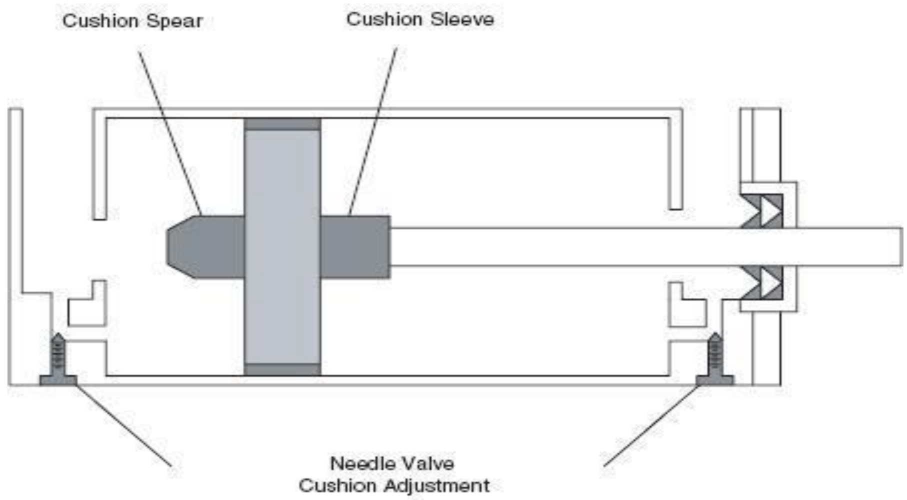


FIGURE 7.6
Schematic showing a technique for cushioning a hydraulic cylinder.

The same technique is used to cushion the cylinder when it is extending. In this case, a sleeve is mounted on the rod to close the main opening so that flow goes through the orifice.
To understand cushioning, it is appropriate to review a basic principle of fluid power. Always ask the question, what is happening at the relief valve? We will consider the case where a fixed displacement pump is supplying the flow to extend the cylinder.

When the spear closes the large opening, the fluid must flow past the needle valve. The resultant pressure drop increases the back pressure on the rod end. The pump must build a higher pressure on the cap end. This cap end pressure must build to the point where the relief valve cracks open before the cylinder will slow.

Remember, a fixed displacement pump puts out a given volume of oil for each revolution. Neglecting pump leakage, this oil either goes to the cylinder or through the relief valve. The adjustments made to the needle valve on the cylinder interact with the characteristics of the relief valve (and to a lesser degree with other components in the circuit) to produce a given deceleration rate.
A number of techniques have been developed to cushion cylinders. Large cylinders are cushioned with some type of stepped procedure that decelerates the piston in increments. Manufacturer's literature can be referenced for the back-pressure curves generated by these techniques.

The ANSI symbol for a cylinder cushioned on both ends is given in Fig. 7.7. The arrow through the cushion block indicates that the cushioning is adjustable.

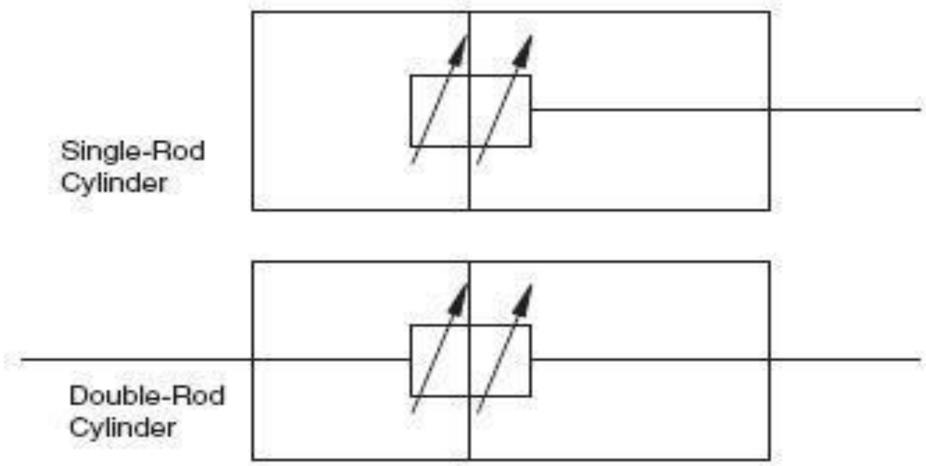
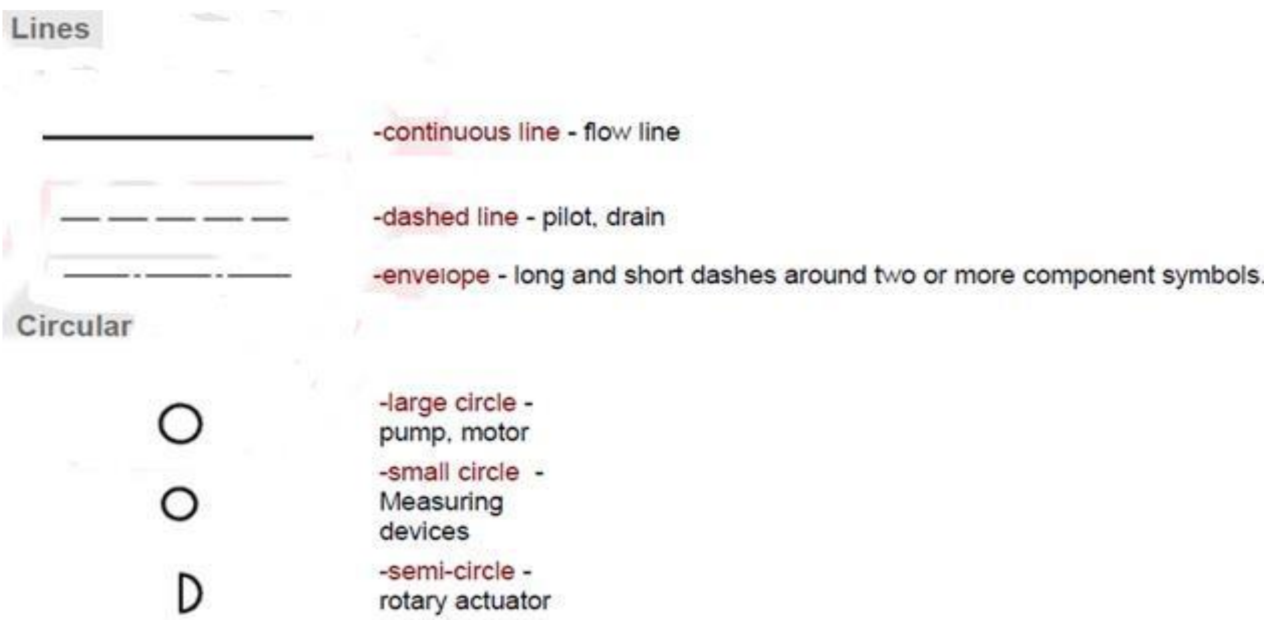


FIGURE 7.7
ANSI symbols for single- and double-rod cushioned cylinder.

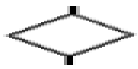
8. Fluid power ANSI symbols



Square

-one square - pressure control function
-two or three adjacent squares - directional control

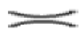
Diamond



-diamond - Fluid conditioner (filter, separator, lubricator, heat exchanger)

Miscellaneous Symbols

-Spring



-Flow Restriction

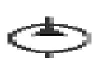
Triangle

-solid - Direction of Hydraulic Fluid Flow

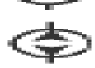
-open - Direction of Pnematic flow

Pumps and Compressors

Fixed Displacement hydraulic pump

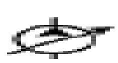


– unidirectional



– bidirectional

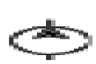
Variable displacement hydraulic pump

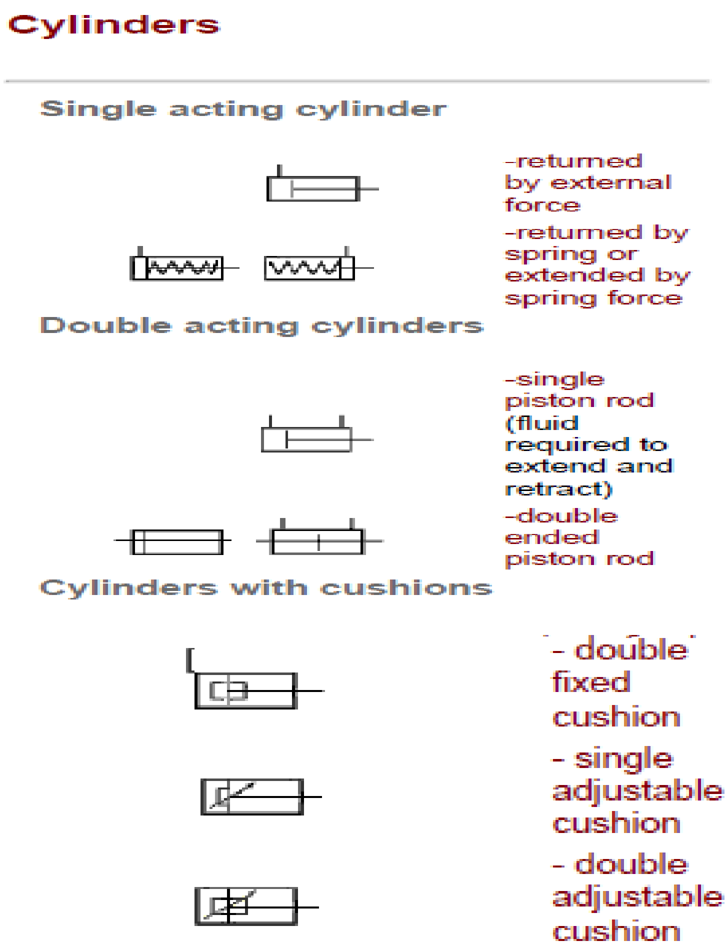


– unidirectional

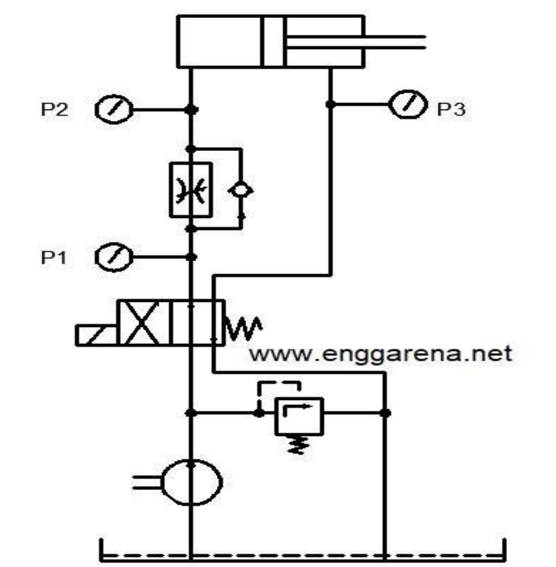
– bidirectional

Compressor





9. With the aid of neat sketches describe meter-in and meter-out hydraulic circuits and state their significance. (AU Nov/Dec 2021)



Meter- in- circuit

In the meter-in circuit, the flow control valve is placed in the primary line, directly before the load.

The following pressure measures are taken at three different points

Pressure Gauge P1: It indicates the Place set by the pressure relief valve. This pressure is the input pressure to the throttle valve.

Pressure Gauge P2: It indicates the load pressure P2, which varies between 0 to Pmax, depending upon the load status.

Pressure Gauge P3: It indicates the cylinder output pressure P3=0.
In a meter-in circuit, speed control is achieved by changing the flow adjustment of the flow control valve, which controls the oil going to the head end of the cylinder.
It should be noted that the flow control in the given circuit is achieved in the forward direction only i.e. in return stroke the return flow from the head of the cylinder bypasses through the check valve.

Advantages of Meter In Circuit

- The main advantage of the meter in circuit is that the cylinder undertakes one side pressure with a valve corresponding to the real load.
- The relatively small friction due to pressure on one side, decided by the load of the piston sealing ensures it's long life.
- The uniform motion of the piston rod even at a very slow speed.
- Flow rate estimation is made based on the large piston area, which is a significant advantage when very small piston-rod speeds are to be achieved.

Flow control circuit: Meter-out

Meter OUT Circuit A typical meter out circuit is shown in figure. Here the flow control valve is installed in the return line metering the fluid being discharged. In that way, this circuit also gives the control over the actuating speed.

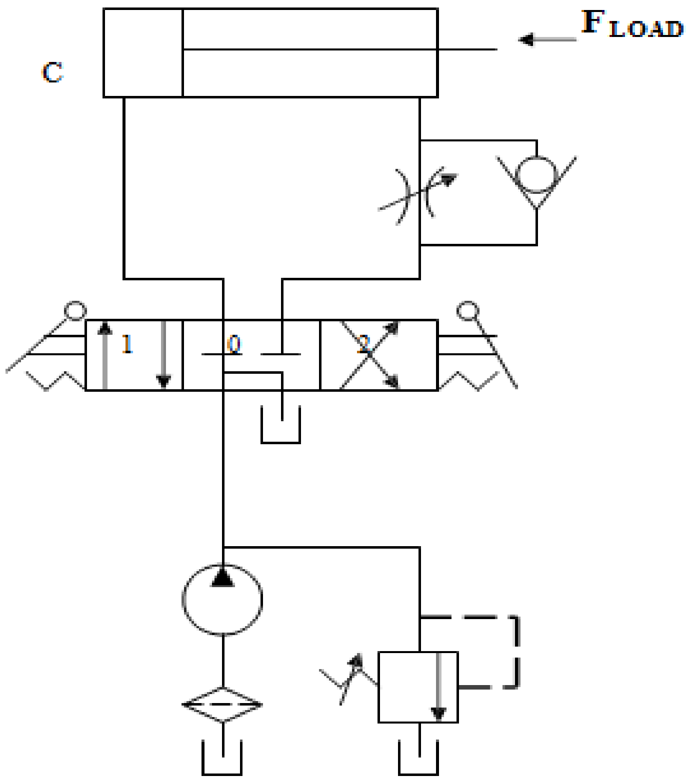
But this way of control offers altogether different characteristics to the circuit. Now, the circuit pressure has to overcome the load resistance and the pressure drop across the flow control valve. However, as the flow control valve is on the right side of the piston, the differential area will cause rise in the pressure.

This increased pressure helps to overcome the pressure drop across the flow control valve. As the system pressure required will be relatively low, it makes this circuit marginally more efficient on the extend stroke. Initially, the compensatory spool is fully open, and full pump flow is passed into the cylinder until piston moves forward building up pressure at the flow control valve.

The compensatory spool will now come into operation and restricts the flow to its correct value. Thus, there is an initial flow surge before the compensatory spool adjusts as in the case of 'meter-in'

When using meter-out system, the pressure in the rod-end of the cylinder must be carefully considered. With meter-out speed control, the quantity of oil leaving the cylinder is controlled. When the cylinder is extending, the oil from the rod-end is metered which a smaller quantity than that is flowing into the full-bore end.

Consequently, under extend conditions; meter-out flow control is not as sensitive as meter-in control. When the cylinder is retracting, the reverse is true. Meter-out circuits are best where negative loads may occur, because back pressure is maintained on the exhaust side of the actuator preventing erratic motion. Meter-out circuits provide accurate speed control even with reversing loads. However, as with the meter-in system, considerable heat will be generated when used with a fixed delivery pump and a wide range of piston speeds. Applications: Drilling, Boring, Reaming and tapping operations.



Meter – out Circuit.

Difference between meter in and meter out circuit

Meter in circuit	Meter out circuit
1. Flow control valve is placed in pressure line.	1. Flow control valve is placed in return line.
2.Rate of flow of oil is controlled at inlet of the actuator	2.rate of flow of oil is controlled at outlet of the actuator
3. Used for opposing load only.	3. used for both opposing load as well as running away load.
4. Pressure drop in FCV may reduce force developed.	4. Pressure drop in FCV will not affect force developed.
5.Suitable for very low piston rod speed	5. Suitable where very stable movement of actuators is needs.
6. Used where finer speed control is required.	6. suitable for drilling ,boring or reaming .

10. The speed of the winch is monitored by an electronic sensor and the output signals of the sensor have to act as input for a servo valve, which in turn decides the position of hydraulic cylinder. Suggest a suitable servo valve for the above application and explain its working principle. (AU Nov/Dec 2021)

Two-Stage Electro hydraulic Servo Valve

Two-stage servo valves are the most commonly used electro hydraulic servo valves in industries. Because, they can handle large flow at high pressure with a high sensitivity to control changes.

Construction

The construction and operation of a typical two-stage spool-type servo valve is illustrated infig. The two-stage configuration uses a pilot stage and a main stage.

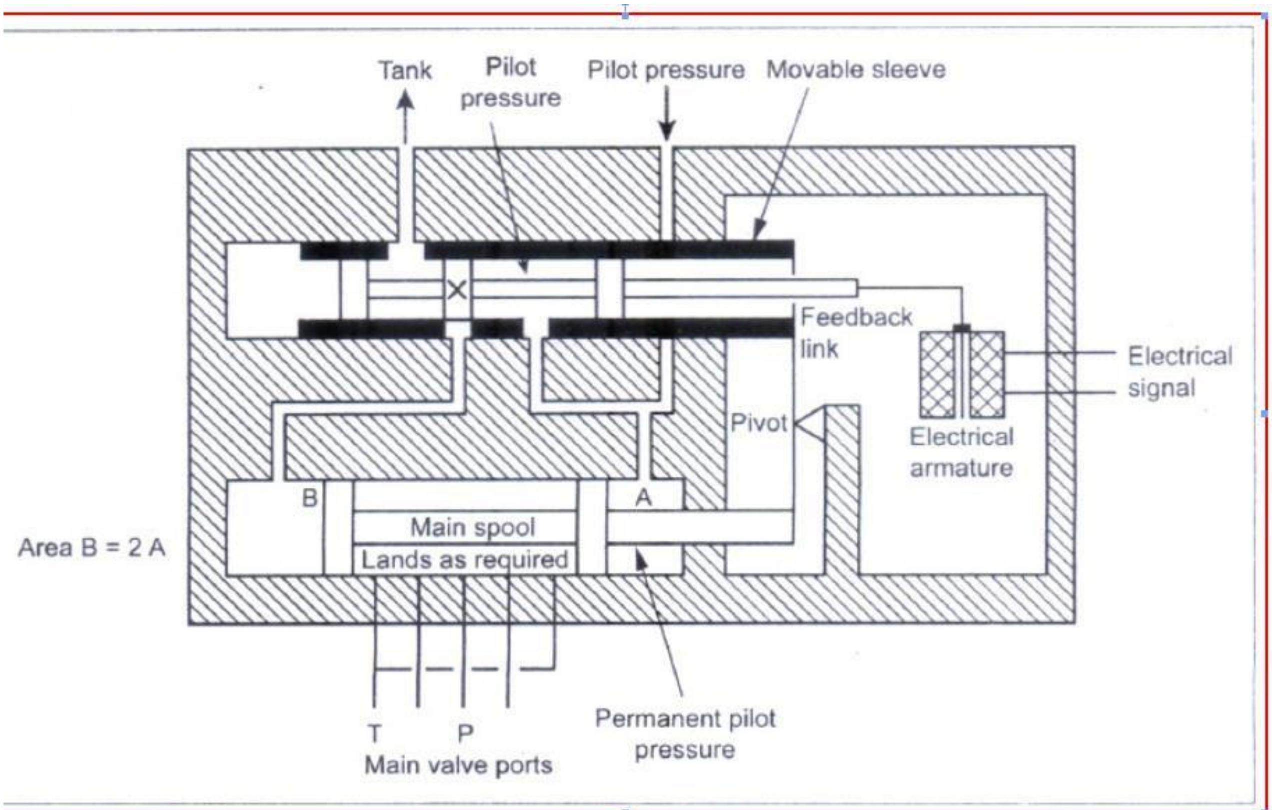


Fig.2.43. Two-stage electrohydraulic servo valve

As shown in Fig.2.43, this arrangement consists of a small pilot spool connected directly to the small spool of the pilot valve. The pilot spool moves within a sliding sleeve, mechanically linked to the main spool. The way that the effective area of the left hand end of the main spool is twice that of the right hand end.

Operation:

The operation is as follows:

The input electrical signal produces an armature deflection by an amount proportional to the command signal.

•The armature deflection is mechanically transmitted to the pilot spool by means of a stiff connecting wire. The direction of motion of the pilot spool depends on the input electrical signal.

• Suppose the electrical control signal causes the pilot spool to shift towards left. Now the land X allows the oil flow to the end B of the main spool. Since area B = 2A (Fig.2.43), the main spool shifts towards the right. This in turn pushes the sleeve left.

• The main valve stops moving when the hole in the pilot sleeve exactly aligns with the land on the pilot spool.

A change in electrical signal moving the pilot spool to the right reduces pressure at the left hand end of the main spool by bleeding fluid back to the tank.

This causes the main spool to move left until pilot sleeve and pilot lands are aligned. Thus the Main spool valve follows the pilot spool with equal, but opposite movements. The feedback linkage mechanically connects the main spool and pilot spool
So, any movement of the main spool is fed back to the pilot spool sleeve.
.

Thus the two stage servo valve can provide an extremely accurate flow modulation for fast and precise control of position, velocity and acceleration of the actuator.

UNIT III HYDRAULIC CIRCUITS AND SYSTEMS

Accumulators, Intensifiers, Industrial hydraulic circuits – Regenerative, Pump Unloading, Double-Pump, Pressure Intensifier, Air-over oil, Sequence, Reciprocation, Synchronization, Fail-Safe, Speed Control, Hydrostatic transmission, Electro hydraulic circuits, Mechanical hydraulic servo systems.

1. Name any six ancillary equipment commonly used in the hydraulic system.

1. Fluid reservoir,
2. Filters and strainers.
3. Heat exchangers,
4. Pressure and temperature switches.
5. Accumulators, and
6. Intensifier

2. What is the purpose of a fluid reservoir?

- ✓ Fluid reservoirs are basically used to provide a storage facility for the hydraulic fluid used by the system.
- ✓ In addition, the reservoirs also serve to separate entrained air, remove contaminants, and dissipate heat from the fluid.

3. What is the use of a shock absorber in hydraulic systems?

A shock absorber is a device that brings a moving load to a gentle rest through the use of metered hydraulic fluid.

4. What is the function of an accumulator? What electrical device is it analogous to?

- ✓ An accumulator is a pressure storage reservoir in which a non-compressible hydraulic fluid is retained under pressure from an external source.

- ✓ The function of hydraulic accumulator is analogous to that of a capacitor in an electrical circuit.

5. What are the three basic types of accumulators used in hydraulic systems?

1, Weight-loaded (or dead-weight) accumulators,
2. Spring-loaded accumulators, and
3. Gas-loaded accumulators.

6. What are three significant accumulator operating conditions?

1. Recharging condition.
2. Charging (the fluid to maximum pressure) condition, and
3. Discharging (the fluid to minimum pressure) condition.

7. What is the function of a pressure intensifier? What electrical device is it analogous to?

- ✓ Pressure intensifier, also known as pressure booster, is used to compress the liquid in a hydraulic system to a value above the pump discharge pressure.
- ✓ It is analogous to a step-up electrical transformer.

8. Define the term intensifier ratio.

$$\text{Intensifier ratio} = \frac{\text{Outlet pressure (P)}}{\text{Low inlet pressure (P)}} = \frac{\text{Area of large piston(A)}}{\text{Area of small piston (A)}}$$

9. What is meant by regenerative circuit?

A regeneration circuit cans double the extension speed of a single-rod cylinder without using a larger pump. This means that regeneration circuits save money because a smaller pump, motor, and tank can produce the desired cycle time. It also means that the circuit costs less to operate over the life of the machine.

10. What is the purpose of a regenerative circuit?

The regenerative circuit is used to increase the out-stroke speed of piston of a double - acting cylinder. In this circuit, the fluid from the rod end of the cylinder regenerates with the pump flow. Due to this volume of the fluid supplied to blind end of the cylinder is greater than the pump flow rate.

11. List any four advantages of air-over oil systems. (AU Nov/Dec2021)

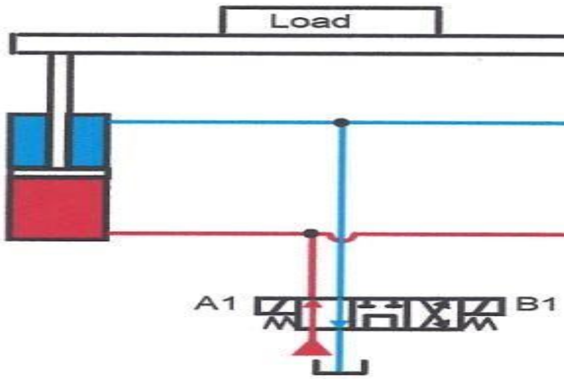
Air over oil offers a convenient source of clean power

air over oil cylinder design offers a low-cost, highly efficient means of converting compressed air to smooth fluid force

The smaller size of our air over oil cylinders allows for reduced bore size compared to standard multi-stage pneumatic cylinders

air over oil cylinders make less sound than a standard pneumatic cylinder

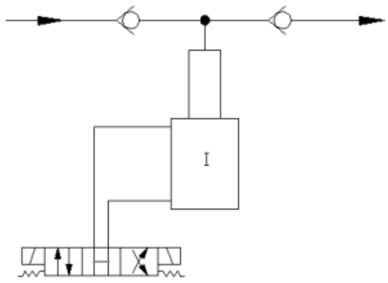
12. A hydraulic platform used to lift cars requires synchronous motion of two hydraulic cylinders. Sketch a circuit for synchronous movement of the two hydraulic cylinders (AU Nov/Dec2021)



13. What are the applications of hydro static transmission?

Hydrostatic transmission is suitable for applications that require variable output velocity or torque. Some of these applications include golf-course maintenance equipment, harvesters, tractors, trenchers, agricultural and large construction equipment.

14. Draw the sketch of single acting intensifier



15. What is meant by safety circuit? List any two names
Circuit that prevents malfunction by stopping the flow of current or sounding an alert
Open loop hydraulic system and closed loop hydraulic system are the two types of hydraulic system.

16. What is meant by speed control circuits?
Speed control circuit is **used to control the speed of pneumatic actuator**; this is achieved by controlling air supplied to the actuators. The air flow to actuator is controlled either the supply line or drain line.

(PART-B & C)

1. Explain Different Types of Circuit used In Hydraulic System with Neat Circuit Diagram.

Control of a Single-Acting Hydraulic Cylinder

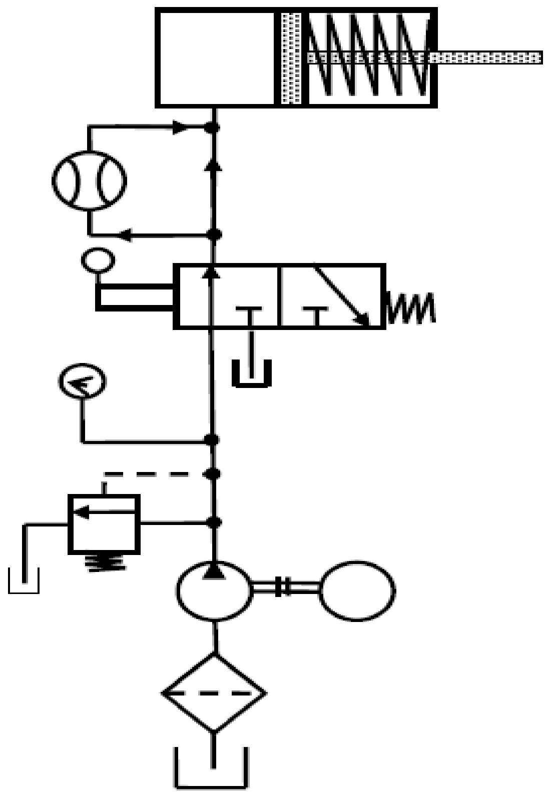


Figure 1.1 Control of a single-acting cylinder.

Figure 1.1 shows that the control of a single-acting, spring return cylinder using a three-way two-position manually actuated, spring offset direction-control valve (DCV). In the spring offset mode, full pump flow goes to the tank through the pressure-relief valve (PRV).

The spring in the rod end of the cylinder retracts the piston as the oil from the blank end drains back into the tank. When the valve is manually actuated into its next position, pump flow extends the cylinder.

After full extension, pump flow goes through the relief valve. Deactivation of the DCV allows the cylinder to retract as the DCV shifts into its spring offset mode.

Control of a Double-Acting Hydraulic Cylinder

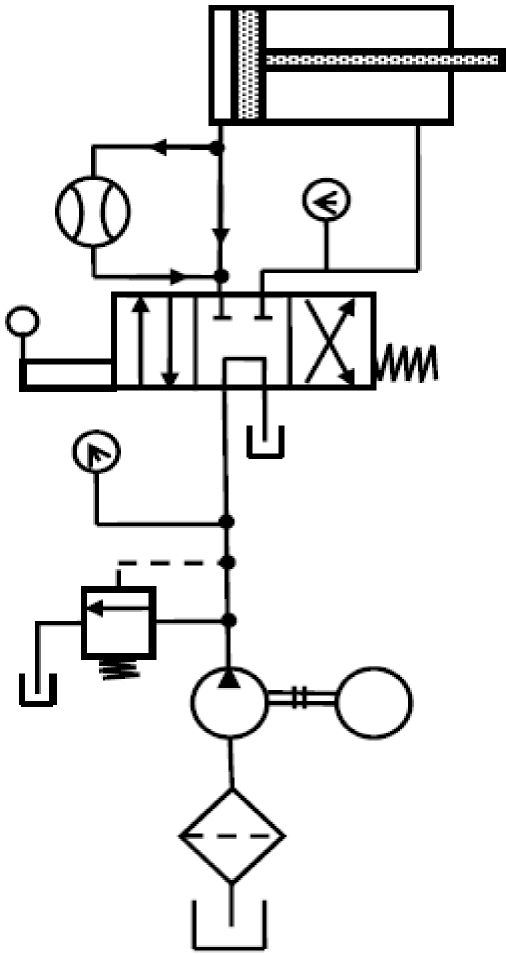


Figure 1.2 Control of a double-acting cylinder.

The circuit diagram to control double-acting cylinder is shown in Fig. 1.2. The control of a double-acting hydraulic cylinder is described as follows:

1. When the 4/3 valve is in its neutral position (tandem design), the cylinder is hydraulically locked and the pump is unloaded back to the tank.

2. When the 4/3 valve is actuated into the flow path, the cylinder is extended against its load as oil flows from port P through port A. Oil in the rod end of the cylinder is free to flow back to the tank through the four-way valve from port B through port T.

3. When the 4/3 valve is actuated into the right-envelope configuration, the cylinder retracts as oil flows from port P through port B. Oil in the blank end is returned to the tank via the flow path from port A to port T.

At the ends of the stroke, there is no system demand for oil. Thus, the pump flow goes through the relief valve at its pressure level setting unless the four-way valve is deactivated.

2. Write and explain the working principle of Regenerative Cylinder Circuit

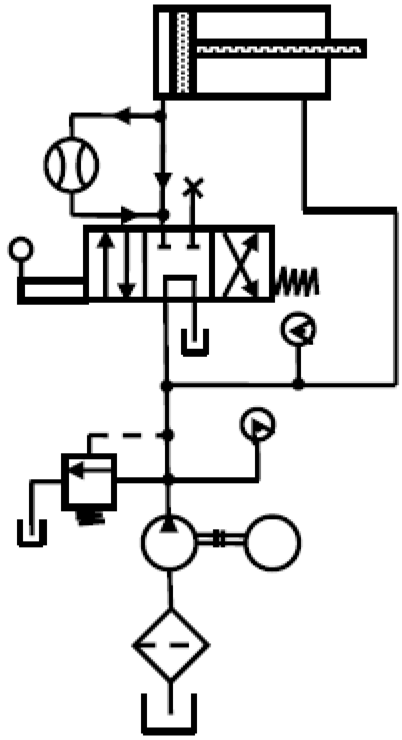


Figure 1.3 Regenerative circuits.

Figure 1.3 shows a regenerative circuit that is used to speed up the extending speed of a double-acting cylinder. The pipelines to both ends of the hydraulic cylinder are connected in parallel and one of the ports of the 4/3 valve is blocked by simply screwing a thread plug into the port opening. During retraction stroke, the 4/3 valve is configured to the right envelope.

During this stroke, the pump flow bypasses the DCV and enters the rod end of the cylinder. Oil from the blank end then drains back to the tank through the DCV.

When the DCV is shifted in to its left-envelope configuration, the cylinder extends as shown in Fig. 1.3. The speed of extension is greater than that for a regular double-acting cylinder because the flow from the rod end regenerates with the pump flow Q_p to provide a total flow rate Q_t .

3. Write and explain the working principle of Double-Pump Hydraulic System (AU Nov/Dec2021)

Illustrate the significance of an unloading valve in a double-pump hydraulic system.

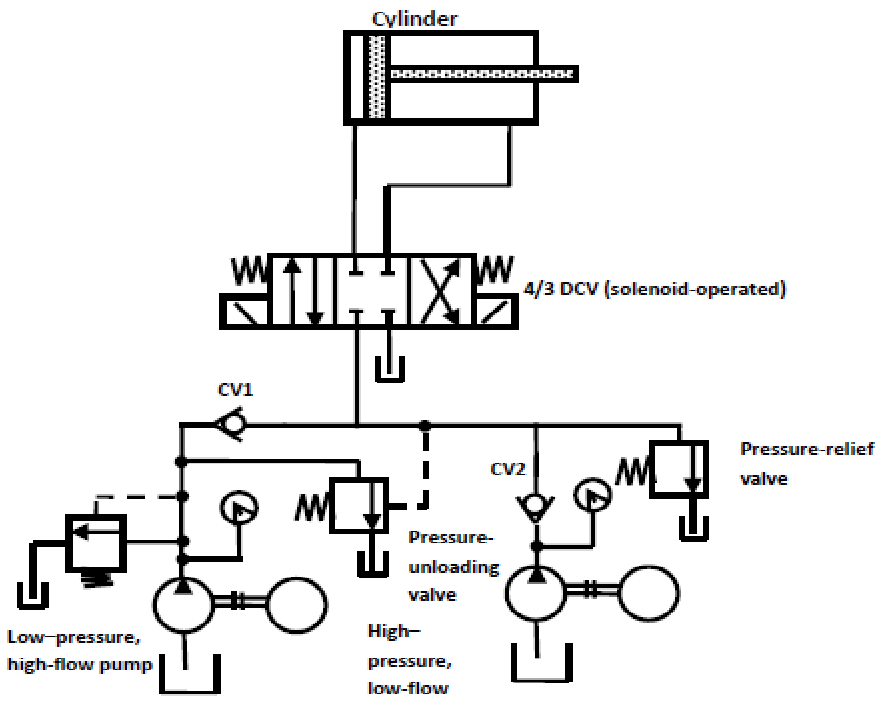


Figure 1.5 Double-pump circuit.

Figure 1.5 shows an application for an unloading valve. It is a circuit that uses a high-pressure, low-flow pump in conjunction with a low-pressure, high-flow pump. A typical application is a sheet metal punch press in which the hydraulic cylinder must extend rapidly over a great distance with low-pressure but high-flow requirements. This occurs under no load. However, during the punching operation for short motion, the pressure requirements are high, but the cylinder travel is small and thus the flow requirements are low.

The circuit in Fig. 1.5 eliminates the necessity of having a very expensive high-pressure, high-flow pump.

When the punching operation begins, the increased pressure opens the unloading valve to unload the low-pressure pump. The purpose of relief valve is to protect the high-pressure pump from over pressure at the end of cylinder stroke and when the DCV is in its spring-centered mode.

The check valve protects the low-pressure pump from high pressure, which occurs during punching operation, at the ends of the cylinder stroke and when the DCV is in its spring-centered mode.

The unloading valves are used for relieving the extra pressure in a system, that is at low pressure and connecting it to the tank when the delivery of the pump is not used.

4. Write and explain the working principle of Hydraulic Cylinder Sequencing Circuits

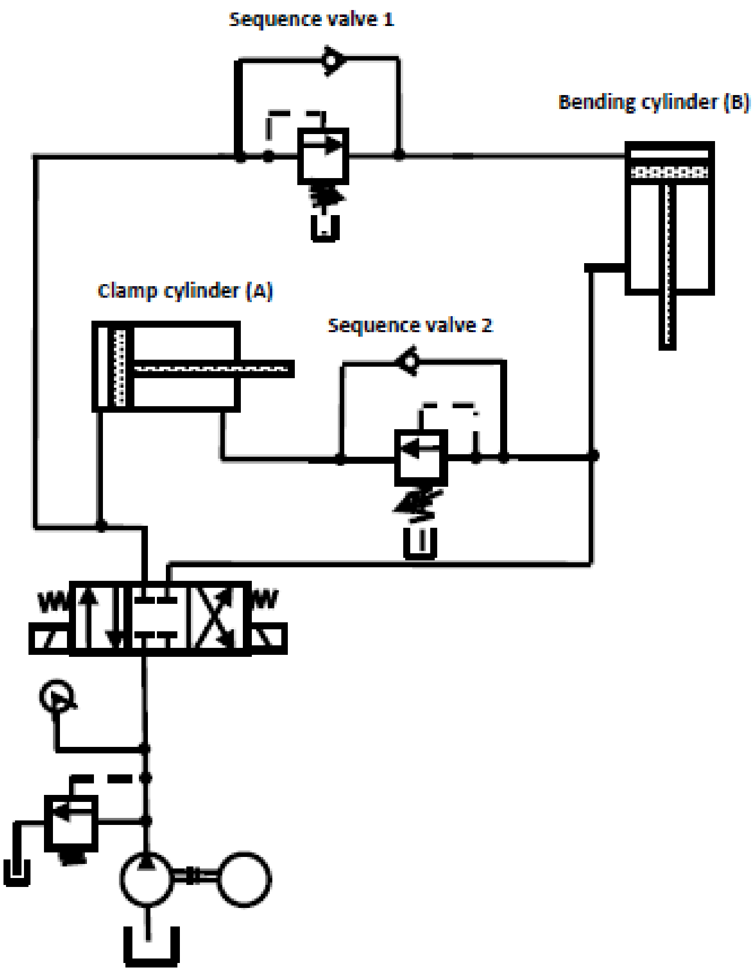


Figure 1.7 Sequencing circuit.

Hydraulic cylinders can be operated sequentially using a sequence valve. Figure 1.7 shows that two sequence valves are used to sequence the operation of two double-acting cylinders. When the DCV is actuated to its right-envelope mode, the bending cylinder (B) retracts fully and then the clamp cylinder (A) retracts.

This sequence of cylinder operation is controlled by sequence valves. This hydraulic circuit can be used in a production operation such as drilling. Cylinder A is used as a clamp cylinder and cylinder B as a drill cylinder. Cylinder A extends and clamps a work piece.

Then cylinder B extends to drive a spindle to drill a hole. Cylinder B retracts the drill spindle and then cylinder A retracts to release the work piece for removal.

5. Write and explain the working principle of Automatic Cylinder Reciprocating System.

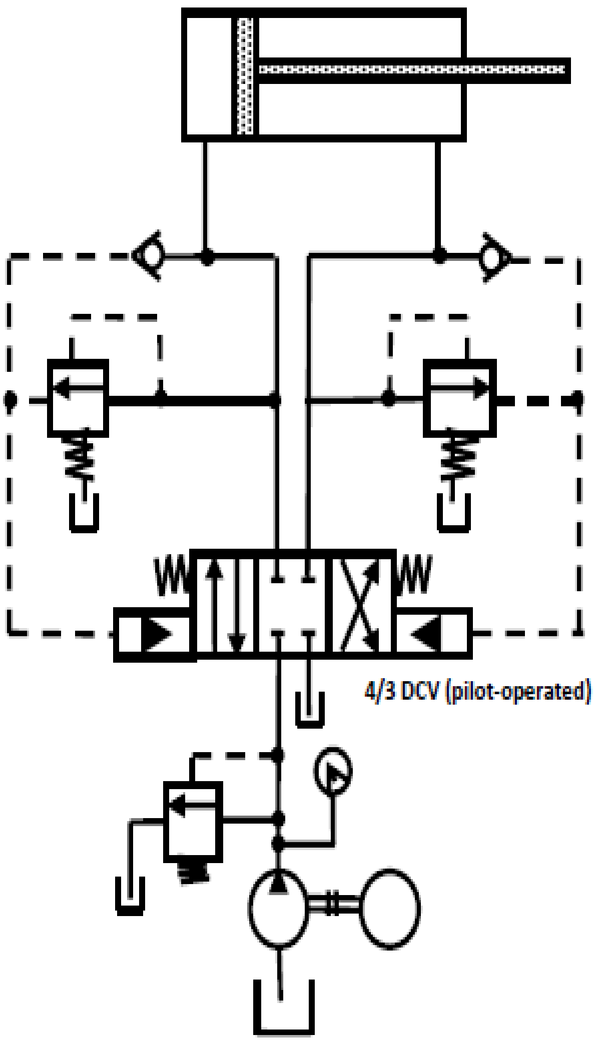


Figure 1.8 Sequencing circuit.

The hydraulic circuit shown in Fig. 1.8 produces continuous reciprocation of a double-acting cylinder using two sequence valves. Each sequence valve senses the completion of stroke by the corresponding build-up pressure.

Each check valve and the corresponding pilot line prevent the shifting of the four-way valve until the particular stroke of the cylinder is completed.

The check valves are needed to allow pilot oil to leave either end of the DCV while the pilot pressure is applied to the opposite end. This permits the spool of the DCV to shift as required.

6. Write and explain the working principle of Cylinder Synchronizing Circuits

In industry, there are instances when a large mass must be moved, and it is not feasible to move it with just one cylinder. In such cases we use two or more cylinders to prevent a moment or moments that might distort and damage the load.

For example, in press used for molding and shearing parts, the platen used is very heavy. If the platen is several meters wide, it has to be of very heavy construction to prevent the damage when it is pressed down by a single cylinder in the middle.

It can be designed with less material if it is pressed down with two or more cylinders. These cylinders must be synchronized. There are two ways that can be used to synchronize cylinders: Parallel and series.

Cylinders in Parallel

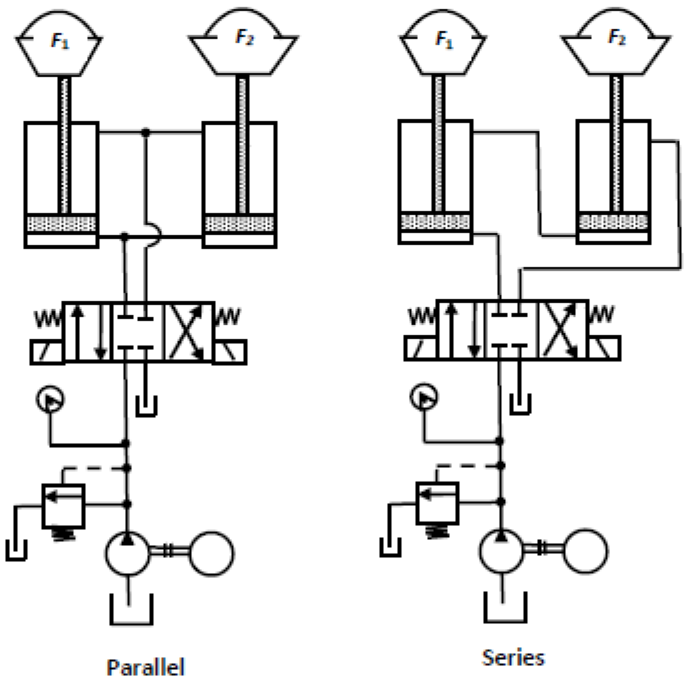


Figure 1.10 Cylinders in parallel and series.

Figure 1.10shows a hydraulic circuit in which two cylinders are arranged in parallel. When the two cylinders are identical, the loads on the cylinders are identical, and then extension and retraction are synchronized. If the loads are not identical, the cylinder with smaller load extends first. Thus, the two cylinders are not synchronized. Practically, no two cylinders are identical, because of packing(seals)friction differences. This prevents cylinder synchronization for this circuit.

Cylinders in Series

During the extending stroke of cylinders, fluid from the pump is delivered to the blank end of cylinder 1. As cylinder 1 extends, fluid from its rod end is delivered to the blank end of cylinder 2 causing the extension of cylinder 2. As cylinder 2 extends, fluid from its rod end reaches the tank.

For two cylinders to be synchronized, the piston area of cylinder 2 must be equal to the difference between the areas of piston and rod for cylinder 1

7. Write and explain the working principle of Speed Control of a Hydraulic Cylinder

The speed control of a hydraulic cylinder circuit can be done during the extension stroke using a flow-control valve (FCV). This is done on a meter-in circuit and meter-out circuit as shown in Fig. 1.11. Refer to Fig. 1.11(a).

When the DCV is actuated, oil flows through the FCV to extend the cylinder. The extending speed of the cylinder depends on the FCV setting.

When the DCV is deactivated, the cylinder retracts as oil from the cylinder passes through the check valve. Thus, the retraction speed of a cylinder is not controlled. Figure 1.11(b) shows meter-out circuit; when DCV is actuated, oil flows through the rod end to retract the cylinder.

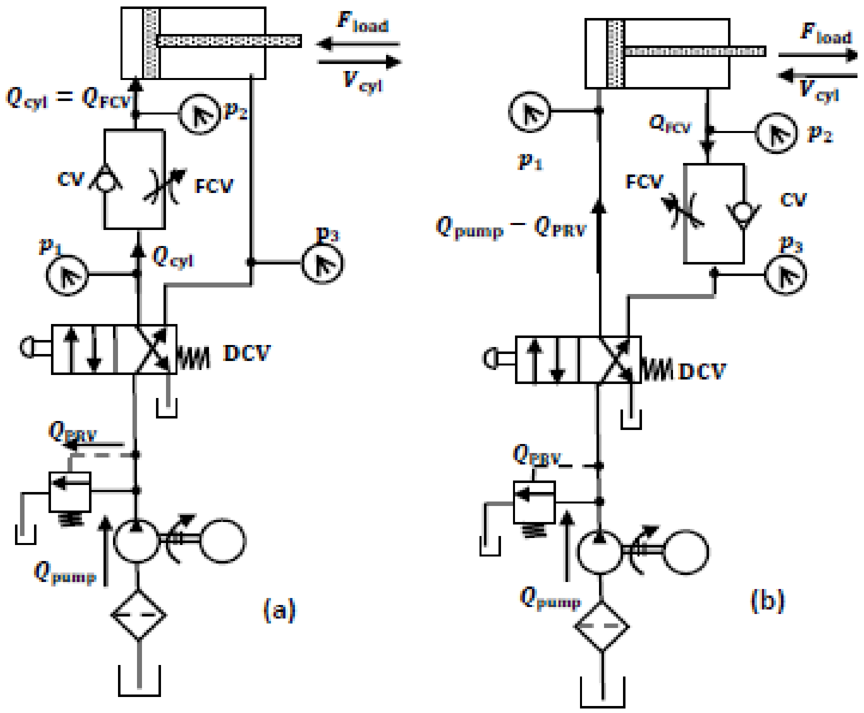


Figure 1.11 Speed control of cylinders :(a) Meter in and (b) meter out.

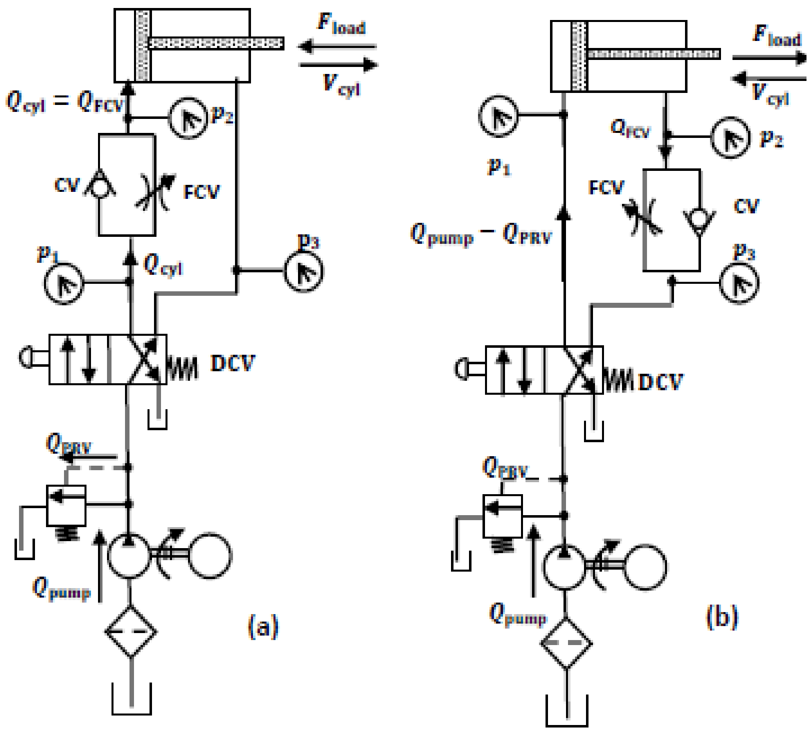
8. Write and explain the working principle of Meter-In Versus Meter-Out Flow-Control Valve Systems

In Meter in circuit, the FCV is placed in the line leading to the inlet port of the cylinder. Thus, it is called the meter-in control of speed. Meter-in flow controls the oil flow rate into the cylinder.

A meter-out flow control system is one in which the FCV is placed in the outlet line of the hydraulic cylinder. Thus, a meter-out flow control system controls the oil flow rate out of the cylinder.

Meter-in systems are used primarily when the external load opposes the direction of motion of the hydraulic cylinder. When a load is pulled downward due to gravity, a meter-out system is preferred. If a meter-in system is used in this case, the load would drop by pulling the piston rod, even if the FCV is completely closed.

One drawback of a meter-out system is the excessive pressure build-up in the rod end of the cylinder while it is extending. In addition, an excessive pressure in the rod end results in a large pressure drop across the FCV. This produces an undesirable effect of a high heat generation rate with a resulting increase in oil temperature.



(a) Meter in and (b)meter out.

9. Write and explain the working principle of Fail-Safe Circuits

Explain the fail-safe circuit with suitable sketches (AU Nov/Dec 2021)

Fail-safe circuits are those designed to prevent injury to the operator or damage to the equipment. In general, they prevent the system from accidentally falling on an operator and also prevent overloading of the system. In following sections, we shall discuss two fail-safe circuits: One is protection from inadvertent cylinder extension and other is fail-safe overload protection.

1. Protection from inadvertent cylinder extension:

Figure 1.13 shows a fail-safe circuit that is designed to prevent the cylinder from accidentally falling in the event when a hydraulic line ruptures or a person inadvertently operates the manual override on the pilot-actuated DCV when the pump is not working. To lower the cylinder, pilot pressure from the blank end of piston must pilot open the check valve to allow oil to return through the DCV to the tank. This happens when the push button is actuated to permit the pilot pressure actuation of DCV or when the DCV is directly manually actuated when the pump operates. The pilot-operated DCV allows free flow in the opposite direction to retract the cylinder when this DCV returns to its offset mode.

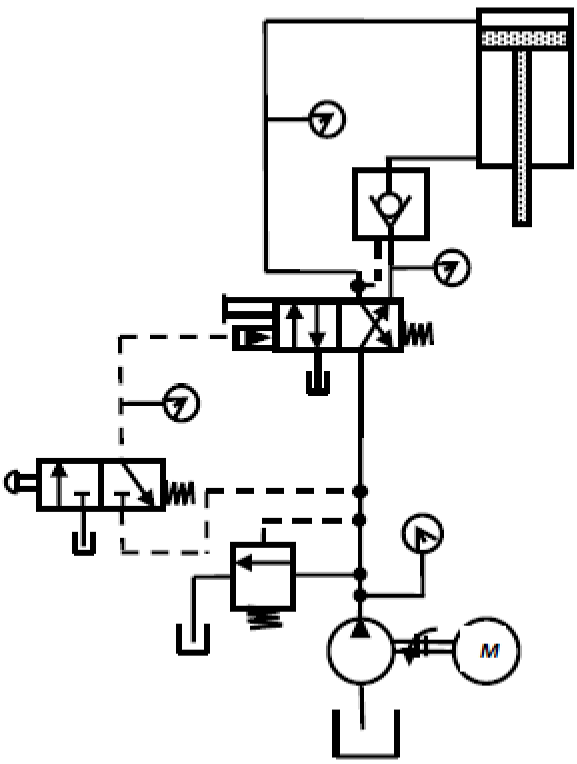


Figure 1.13 Fail-safe circuits – inadvertent cylinder extension.

2. Fail-Safe System with Overload Protection:

Figure 1.14 shows a fail-safe system that provides overload protection for system components. The DCV V1 is controlled by the push-button three-way valve V2. When the overload valve V3 is in its spring offset mode, it drains the pilot line of valve V1. If the cylinder experiences excessive resistance during the extension stroke, sequence valve V4 pilot-actuates overload valve V3. This drains the pilot line of valve V1 causing it to return to its spring offset mode. If a person then operates the push-button valve V2 nothing happens unless overload valve V3 is manually shifted into its blocked-port configuration. Thus, the system components are protected against excessive pressure due to an excessive cylinder load during its extension stroke.

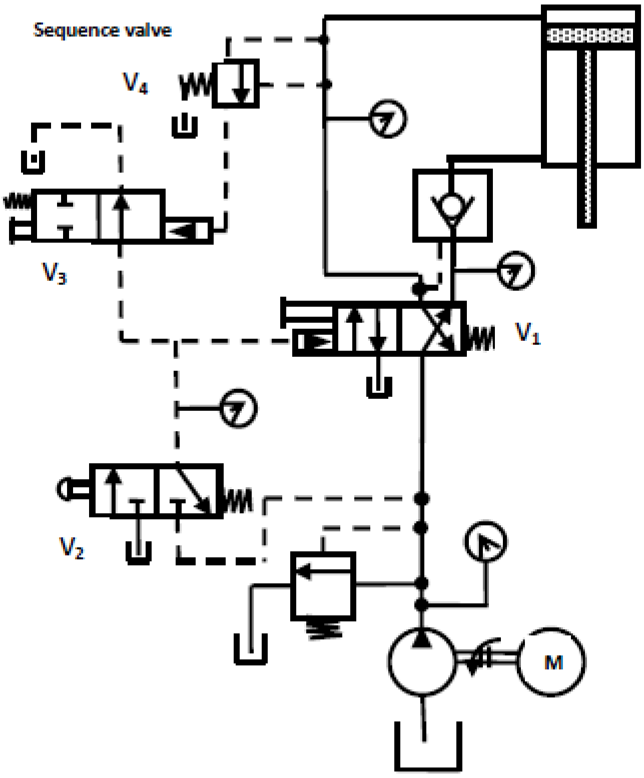


Figure 1.14 Fail-safe circuits –overload protection.

10. Explain different types accumulators with neat diagram.

1. Weight-loaded or gravity accumulator: Schematic diagram of weight loaded accumulator is shown in Fig. 1.1. It is a vertically mounted cylinder with a large weight. When the hydraulic fluid is pumped into it, the weight is raised. The weight applies a force on the piston that generates a pressure on the fluid side of piston. The advantage of this type of accumulator over other types is that it applies a constant pressure on the fluid throughout its range of motion. The main disadvantage is its extremely large size and heavy weight. This makes it unsuitable for mobile application.

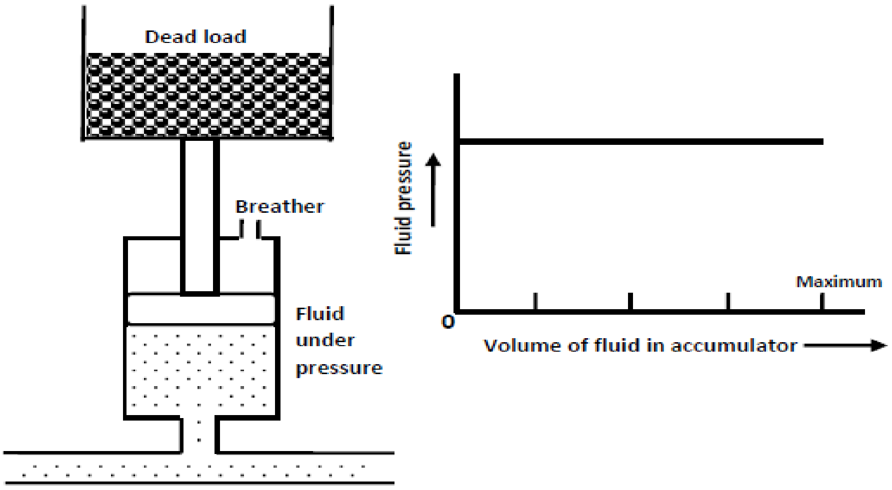


Figure 1.1 Dead weight accumulator.

2. Spring-loaded accumulator:

A spring-loaded accumulator stores energy in the form of a compressed spring. A hydraulic fluid is pumped into the accumulator, causing the piston to move up and compress the spring as shown in Fig. 1.2. The compressed spring then applies a force on the piston that exerts a pressure on the hydraulic fluid.

This type of accumulator delivers only a small volume of oil at relatively low pressure. Furthermore, the pressure exerted on the oil is not constant as in the dead-weight-type accumulator. As the springs are compressed, the accumulator pressure reaches its peak, and as the springs approach their free lengths, the accumulator pressure drops to a minimum.

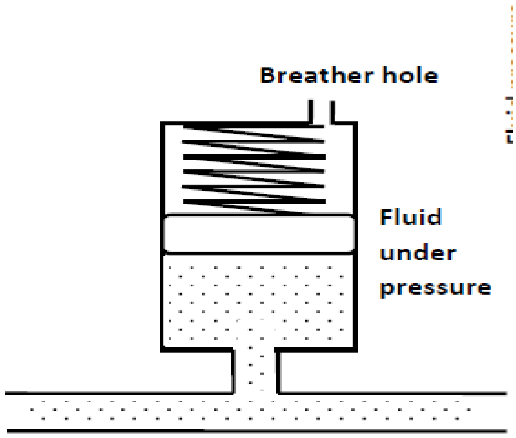


Figure 1.2 Spring-loaded accumulator.

3. Gas-loaded accumulator:

A gas-loaded accumulator is popularly used in industries. Here the force is applied to the oil using compressed air. Schematic diagram of a gas loaded accumulator is shown in Fig. 1.3.A gas accumulator can be very large and is often used with water or high water-based fluids using air as a gas charge. Typical application is on water turbines to absorb pressure surges owing to valve closure and on ram pumps to smooth out the delivery flow. The exact shape of the accumulator characteristic curve depends on pressure–volume relations:

Isothermal (constant temperature): This occurs when the expansion or compression of the gas is very slow. The relationship between absolute pressure p and volume V of the gas is constant:

pV = constant (1.1)

- **Isentropic (adiabatic processes):** This is where there is no flow of energy into or out of the fluid. The law that the gas obeys is given by pV^{γ} = constant, where γ is ratio of specific heat and is approximately equal to 1.4.
- **Polytropic:** This is somewhere between isothermal and isentropic. This gas change is governed by the law pV^{n} = constant, where n is somewhere between 1 and 1.4 and is known as the polytropic coefficient.

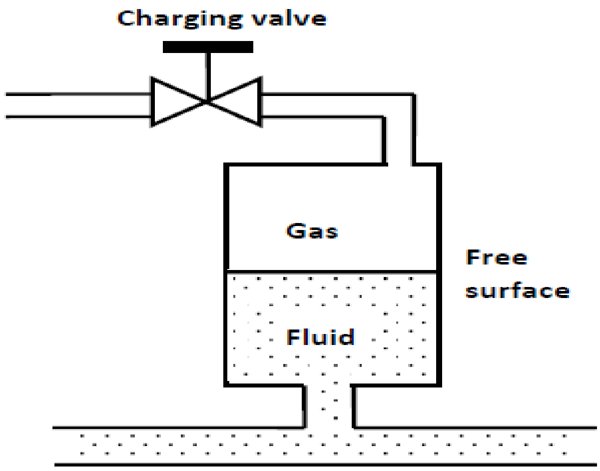


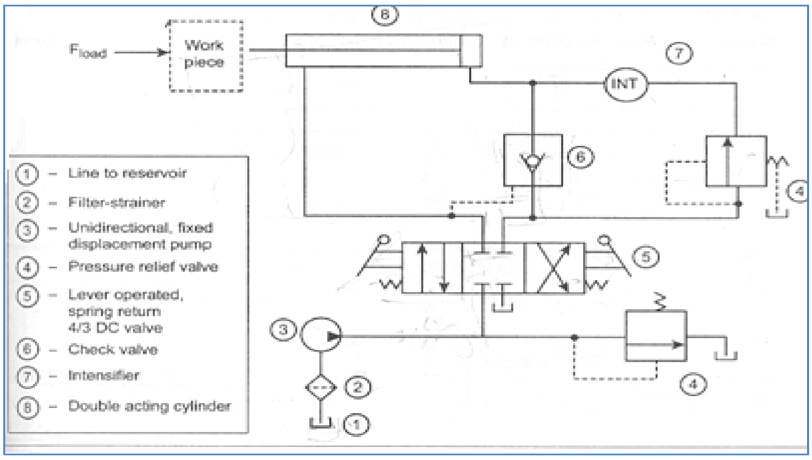
Figure 1.3 Gas-loaded accumulator

11. Make a circuit showing in an intensifier in a punching press application. (A/M-08)

OPERATION:

First operator places work pieces the fixture and shifts handle of 4/2 DC valve. When the 4/2 DC valve is fitted to the right-side position. The oil flows in blind end of the cylinder through the check valve. When the pressure in the cylinder reaches the sequence value pressure setting

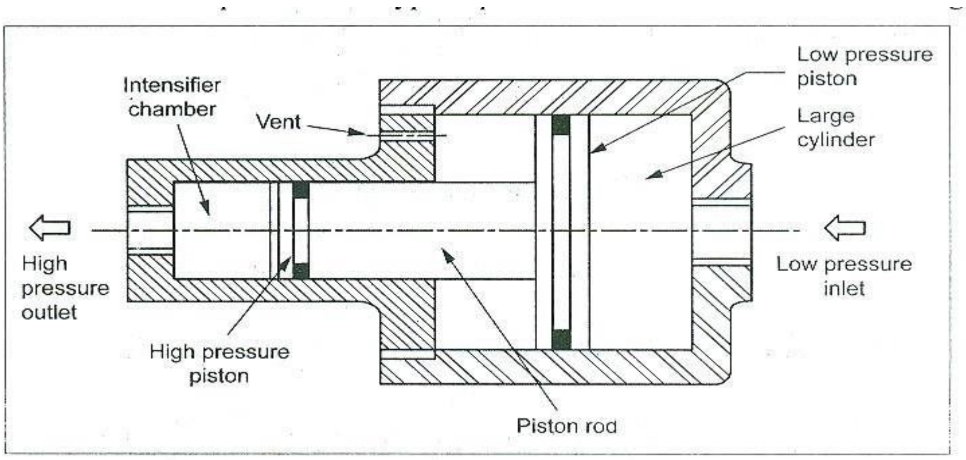
The sequence valve happens and setting the flow to the intensifier. Now it is start to operate and gives high pressure output. This high-pressure output of the intensifier closes the pilot check valve and pressurizes the blind end of the cylinder.



When the 4/2 DC valve 3 is shifted to the left side position. The oil flows to the rod end of the cylinder. When it builds up the pressure, the pilot signal opens the check valve. Thus the cylinder is retracted to the starting position.

12. **Write and explain the working principle of pressure intensifier with neat diagram. (N/D- 08)**

As shown in fig. the unit consists of two pistons – low pressure and high pressure, having a common piston rod. The larger piston is exposed to pressure from a low-pressure pump. The low pressure fluid is introduced to the larger piston side and thus it force the piston is moved. Neglecting the losses due to the friction. The smaller end of the piston exerts the same force on the fluid is intensifier chamber or smaller cylinder.



Pressure intensifier

INTENSIFIER RATIO:

PI/PO=AO/AI

High outlet pressure/ low inlet pressure=area of large piston/area of small piston.

High inlet flow rate/ low inlet flow rate

ADVANTAGES:

Low volume or high-pressure flow over the short period.
More compact and simple than adding another power unit.
Low power input can be used to maintain high pressure at a period of time.
Power requirement remains constant.
High pressure is produced at small volume of oil, heat generated is minimum.

13. Explain hydrostatic transmission?

A hydrostatic transmission (HST) exists any time a hydraulic pump is connected to and dedicated to one or more hydraulic motors. Versatility is achieved by making either or both the pump and motor(s) variable displacement. The result is a continuously variable transmission (CVT)

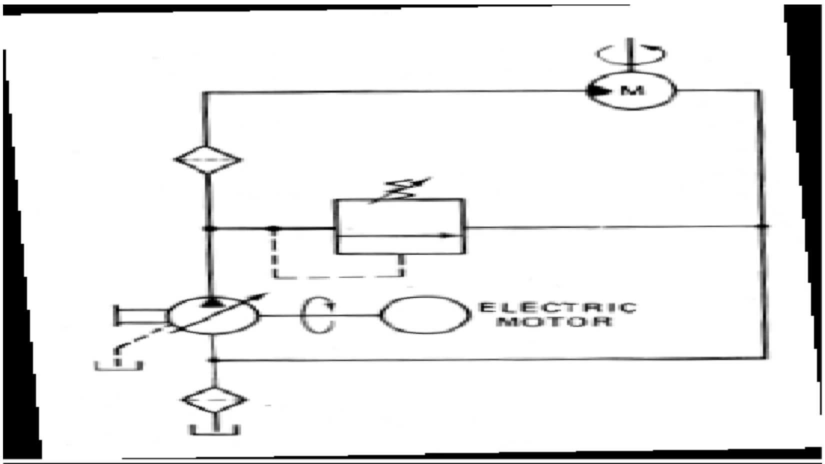
Hydrostatic Transmission

- Open Circuit Drives
- Pump draws fluid from reservoir
- Pump output directed to Hydraulic Motor
- Discharge from Motor into reservoir
- Closed Circuit Drive
- Exhaust oil from the motor returned directly to pump inlet.

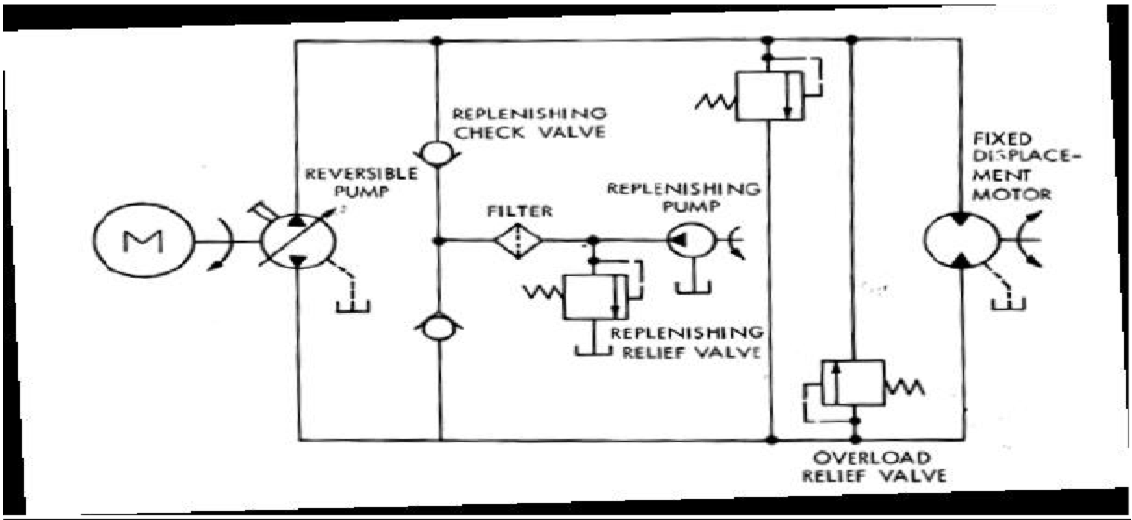
Closed Circuit One-Direction Hydrostatic Transmission

Closed Circuit that allows only one direction of motor rotation.

- Motor speed varied by changing pump displacement.
- Torque capacity of motor adjusted by pressure setting of the relief valve.



Closed Circuit Reversible Direction Hydrostatic Transmission



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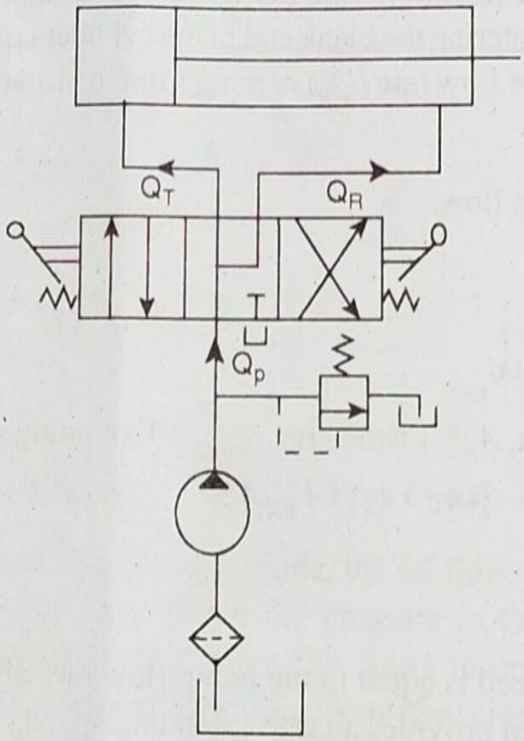
14. An industry is interested in developing a hydraulic drilling machine to drill 10mm thick steel plates. Since, the cycle time of the process has to be minimum, faster approach and retraction strokes are essential. A power pack with a single pump system is available with the industry and hence the same is proposed to be used. As an automation Develop an appropriate circuit to achieve the above objectives

Justify that the extension velocity is faster than the conventional (AU Nov/Dec 2021) .

A drilling machine requires rapid spindle advance (extension), slow feed during drilling (extension) and retraction of the spindle. This is achieved by a regenerative circuit, with a three position four way valve having a center condition with tank port closed and pressure port open to both cylinder ports. The circuit shown in figure is used as a regenerative circuit for drilling machine application.



This circuit consists of a reservoir, filter, and a fixed displacement unidirectional pump. Pressure reliefvalve, 4/3 DCV and a double acting single rod cylinder. The direction control valve used in this circuit is a three position four way manually operated spring centered valve.

Operation: The hydraulic pump draws fluid from the reservoir through filter and then send it to the direction control valve

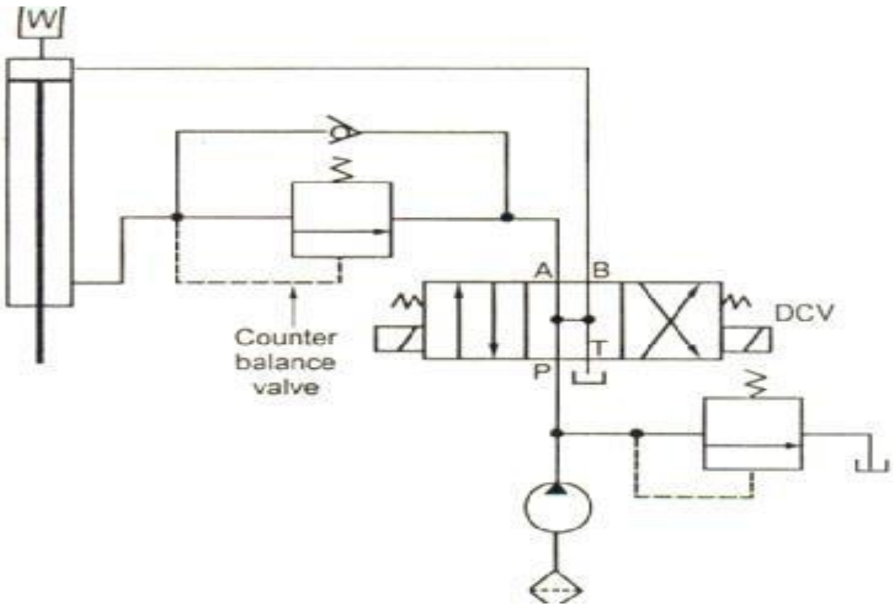
The direction control valve directs the oil to the hydraulic cylinder according to the valve position selected.

15. Draw and explain the Counter balance valve circuit.

The following circuit shows the use of a counter balance valve to keep a vertical cylinder in the upward position while the pump is stopped.

The cylinder supports a load „W‟ and the load is held in that position.

This is done by the counter balance valve set for a force slightly above the external



Load W. When the load is to be lowered, the fluid is forced to the blank end of the piston through DCV.

The increased pressure causes the counter balance valve to open in order to lower the load. Acheck valve is provided in the circuit to allow free flow for raising the load.

UNIT - IV
PNEUMATIC AND ELECTRO PNEUMATIC SYSTEMS

Properties of air – Perfect Gas Laws – Compressor – Filters, Regulator, Lubricator, Muffler, Air control Valves, Quick Exhaust Valves, Pneumatic actuators, Design of Pneumatic circuit – Cascade method – Electro Pneumatic System – Elements – Ladder diagram – Problems, Introduction to fluidics and pneumatic logic circuits.

PART-A

1. Define 'pneumatics'.

The pneumatics may be defined as that branch of engineering-science which deals with the study of the behavior and application of compressed air.

2. Discuss air used as the fluid medium in all pneumatic systems?

The air is popularly used as the fluid-medium in pneumatic systems due to the following reasons:

(i) Air is abundantly available.
(ii) It is safe to use (as it has the fire-proof characteristics).
(iii) It is very cheaper in cost.
(iv) Easier maintenance and easily handling.
(v) It can be exhausted easily to the atmosphere after use.

3. What is the use of lubricators applied in pneumatic systems?

The function of an air lubricator is to add a controlled amount of oil with air to ensure proper lubrication of internal moving parts of pneumatic components.

4. Mention the applications of a 2-way, 3 way, and 4 way D.C valves.

Generally, two-way DC valves are used as on-off type valves; three-way DC valves are used to control single-acting linear actuators; and four-way DC valves are used to control double-acting actuators.

5. What is the function of an air pressure regulator?

The air pressure regulator is used to supply a prescribed reduced outlet pressure in a pneumatic circuit and to maintain it at a constant value.

6. What is the function of a pneumatic cylinder?

Pneumatic cylinders are the devices used for converting the air pressure into linear mechanical force and motion.

7. What are the four important factors that should be considered while designing a fluid power circuit?

1. Safety of operation,
2. Performance of desired function,
3. Efficiency of operation, and
4. Cost.

8. What is the use of a regenerative circuit?

A regenerative circuit is used to speed up the extending speed of the double-acting cylinder.

9. Name the various methods by which synchronization of cylinders can be achieved.

1. By using double-end cylinders connected in series,
2. By using mechanically linked pistons,
3. By using hydraulic motors as metering devices.
4. By using flow control valves, and
5. By using air-hydraulic cylinders in series.
6.

10. Differentiate between meter-in and meter-out circuits with respect to speed control circuits

In meter-in circuit, the flow control valve is located in the line leading to the inlet port of the cylinder.

- In meter-out circuit, the flow control valve is located in the outlet line of the hydraulic cylinder.

11. What are hydro-pneumatic circuits?

In some applications, the hydraulic and pneumatic circuits are coupled to get best use of the advantages of both oil and air mediums. These combination circuits are known as hydro-pneumatic or pneumo-hydraulic circuits.

12. Why are electrical controls of fluid power systems preferred than the manual controls?

Because electrical controls offer the following features:

(i) They can be easily controlled.
(ii) They improve the overall control flexibility offluid power systems.
(iii) They provide quick and accurate control operations.
(iv) They require less maintenance.

13. Name any four basic electrical devices commonly used in the control of fluid power systems.

1. Push-button switches,
2. Limit switches,
3. Solenoids, and
4. Relays.

14. Draw the graphic symbols for the following:

(a) Solenoid, and (b) Indicator lamp.

(a) Solenoid *(b) Indicator lamp*

15. What are fluidics? (AU Nov/Dec2021)

Fluidics is the technology that utilizes fluid flow phenomena in components and circuits to perform a wide variety of control functions.

16. What advantages does fluidics offer? State its significance in logic circuits **(AU Nov/Dec2021)**

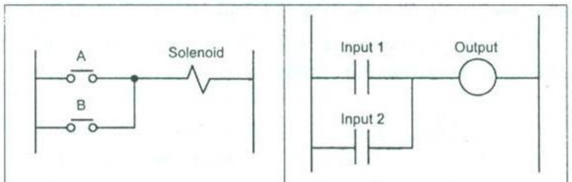
1. Fluidic devices offer exceptional thermal and physical stability and ruggedness.
2. They are completely insensitive to radiation, even of extremely high loads.
3. They are not affected by severe vibration and shock.
4. They are not susceptible to wear and tear.

17. Name four fluidic devices.

1. Bistable flip-flop,
2. Flip-flop with start-up preference,
3. SRT flip-flop,
4. OR/NOR gate

18. Give the symbol and truth table for fluidic OR/NOR gate. (AU Nov/Dec2021)

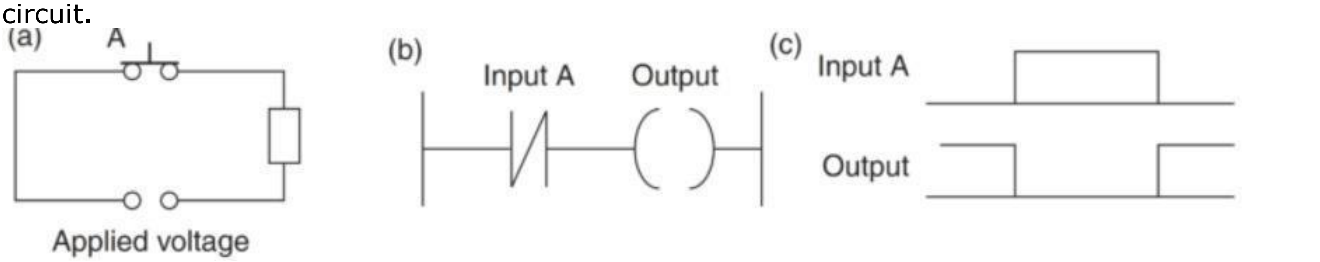
It shows a situation where a coil is not energized until either, normally open, switch A or B is closed. This situation is an OR logic gate.



(a) OR logic situation (b) PLC ladder diagram

NOT Logic Function:

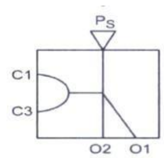
Figure 4.2(a) shows an electrical circuit controlled by a switch that is normally closed. When there is an input to the switch, it opens and there is then no current in the circuit.



(a) NOT Circuit (b) NOT Logic with a ladder rung (c) High Output when no input to A

Fig.4.2 NOT Logic Function

19. Give the symbol and truth table for the fluidic AND/NAND gate.



Symbol

		AND	NAND
C1	C3	O1	O2
0	0	0	1
1	0	0	1
0	1	0	1
1	1	1	0

Truth table

AND/NAND gate

20. Draw the equivalent electrical and pneumatic symbols for AND gate function.

(a) Electrical equivalent (b) Pneumatic equivalent

21. What is Boolean algebra? Write its two functions relative to fluid power systems.

- Boolean algebra is' a l g e b r a of logic'. This is the algebra of proportions where only two possibilities - true or false - are allowed.
- Boolean algebra provides the following two functions:
  - It provides a means by which a logic circuit can be reduced to its simplest form.
  - It allows for the quick synthesis of a circuit that is to perform desired logic operations.

22. Name four fluid sensors that are used in fluid power systems.

1. Back-pressure sensor,
2. Cone-jet proximity sensor,
3. Interruptible-jet sensor, and
4. Contact sensing.

23. What is meant by the term 'contact sensing'?

Contact sensing is nothing but the sensing of objects by physical contact. It can be achieved by using a device called a limit valve or limit switch.

24. Name three ways in which MPL devices can be actuated.

The MPL devices can be actuated by means of (i) mechanical displacement, (ii) electric voltage, or (iii) Fluid pressure.

25. What is a PLC?

A programmable logic controller (PLC) is a user-friendly electronic computer designed to perform logic functions such as AND, OR, or NOT for controlling the operation of industrial equipment and processes.

26. How does a PLC differ from a general-purpose computer?

1. PLCs are rugged and designed to withstand vibrations, temperature, humidity, and noise.
2. The interfacing for inputs and outputs is inside the controller.
3. They are easily programmed and have an easily understood programming language. Programming is primarily concerned with logic and switching operations.

27. List any four advantages that PLCs provide over electromechanical relay control systems.

1. PLCs are more reliable and faster in operation.
2. They are smaller in size and can be more readily expanded.
3. They require less electrical power.
4. They have very few hardware failures when compared to electromechanical relays.

28. List three major units of a PLC.

1. Central processing unit (CPU).
2. Programmer/monitor (PM), and
3. Input/output module (I/O).

29. What is the function of the CPU in a PLC?

(i) Receives input data from various sensing devices,
(ii) Executes the stored program, and
(iii) Delivers corresponding output signals to various load control devices.

PART-B & C

1. What is the Composition of Air? Explain the relationship with pressure?

- Air is a mixture of gases. Air is invisible, colourless, odourless, and tasteless.
- **Composition:** The main constituents of air by volume are 78% nitrogen, 21% oxygen, and 1% other gases such as argon and carbon dioxide.
- The gaseous layer of air around the earth is known as atmosphere.

Pressure Relationship

- **Atmospheric pressure:** The air surrounding the earth exerts a pressure on the earth's surface. The pressure prevailing directly on the earth's surface is known as atmospheric pressure.
- The atmospheric pressure is also referred to as reference pressure. Normally it considers the sea level as its reference point.
- The atmospheric pressure may be calculated from the fundamental principle of barometer which states that the barometer reads the pressure due to the height of mercury (Hg) in the tube and its weight.

  Atmospheric pressure = ρ g h

  Where ρ = Density of Hg = 13600 kg/m^3,

  g = Acceleration due to gravity = 9.81 m/s^2, and

  h = Height of Hg column = 760 mm of Hg at normal sea level.

  Substituting the above values in the equation, we get

  Atmospheric pressure = 13600 x 9.81 x 0.76

  = 1,01,396 N/m^2 = 1.013 bar

  But for easy and simple calculation, we take the atmospheric pressure as 1 bar.

- **Absolute and gauge pressure:** The relationship between atmospheric, absolute, and gauge pressures can be given as below:

  Absolute pressure = Gauge pressure + Atmospheric pressure

  $P_{abs} = P_g + 1.013$ bar

- **Pressure variation with altitude:** The atmospheric pressure decreases with the increase in altitude, as shown in Fig.4.1. From Fig.4.1, it may be noted that the pressure varies linearly upto an altitude of 6 km and after that the pressure drops about 11 kPa per km change in altitude.

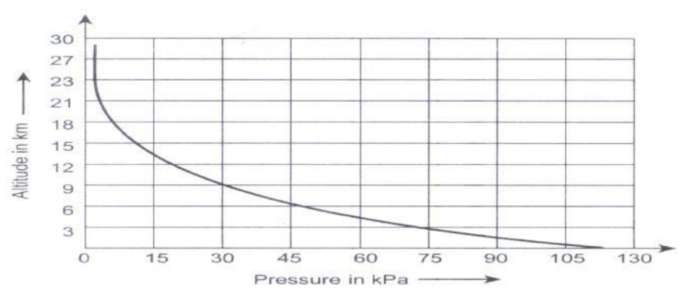


Fig.4.1. Pressure variation in the atmosphere

- **Standard air:** Standard air is sea-level air having a temperature of 20°C, pressure of 1.013 bar, and a relative humidity' of 36%. Usually the above valves of standard air are used while making pneumatic system calculations.

2. Write a short note on perfect gas laws. Explain in detail

Perfect Gas Laws:

We know that, Boyle's law, Charles law, Gay-Lussac's law and the general gas law are called the 'perfect gas laws' because they were derived on the basis of a perfect gas. The air behaves like a perfect gas or an ideal gas with very insignificant deviation from the perfect gas. Therefore all the perfect gas laws are equally applicable to air.

1. Boyle's Law

- Boyle's law states that if temperature remains constant, the pressure of a confined mass of gas will vary inversely with its volume.
- Mathematically, $P \propto \frac{1}{V}$ when T = constant (or) PV = Constant (or)
- $P_1V_1 = P_2V_2 = P_3V_3 = ... = P_nV_n$

2. Charles' Law

- Charles' law states that pressure remaining constant, the volume of a given mass of gas will vary directly as its absolute temperature.
- Mathematically, $V \propto T$ when P = constant (or) $\frac{V}{T}$ = Constant (or)

$$\frac{V_1}{T_1} = \frac{V_2}{T_2} = \frac{V_3}{T_3} = \cdots = \frac{V_n}{T_n}$$

3. Gay-Lussac's Law

- Gay-Lussac 's law states that volume remaining constant, the pressure of a confined mass of gas will vary directly as its absolute temperature.
- Mathematically, $P \propto T$ when V = constant (or) $\frac{P}{T}$ = Constant (or)

$$\frac{P_1}{T_1} = \frac{P_2}{T_2} = \frac{P_3}{T_3} = \cdots = \frac{P_n}{T_n}$$

4. General Gas Law

- Boyle's, Charles', and Gas-Lussac's laws can be combined to obtain the general gas law and is given by,

$$\frac{PV}{T} = \text{Constant (or)} \frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2} = \frac{P_3V_3}{T_3} = \cdots = \frac{P_nV_n}{T_n}$$

3. Discuss the working principle of an air compressor (Nov /Dec 2007)

Construction:

A typical piston type reciprocating compressor consists of cylinder, cylinder head piston with piston rings, inlet and outlet valves, connecting rod, crank, crankshaft, bearings etc. the arrangement of basic single cylinder compressor is illustrated in fig.4.2.

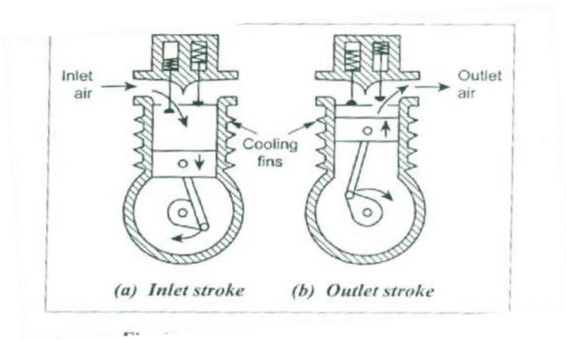


Fig.4.2 Single cylinder Compressor

Operation:

Inlet stroke:

During the downward motion in piston the pressure inside the cylinder falls below the atom pressure and the inlet valve is opened due to pressure difference. The air is drawn into the cylinder until the piston reaches the bottom of the stroke.

Out stroke:

As the piston start moving upwards the inlet valve is closed and the pressure starts increasing continuously until the pressure inside the cylinder is above the pressure of the delivery side with is connected to the receiver then the outlet valve opens and air is delivered during the remaining upward motion of the piston to the receiver.

4. With a neat sketch explain the working of piston compressor. [NOV-2012]

Piston compressors are the most commonly used compressors in the fluid power industry.

Construction:

First a prime mover mostly an electric motor is used to drive the compressor unit. The electric motor supplies the rotary motion to the crank shaft which in turn converted into reciprocating motion of piston through the crank and connecting rod arrangement.

Operation:

Inlet stroke: During the downward motion of the piston the pressure inside the cylinder falls below the atmospheric pressure and thee inlet valve is opened due to the pressure difference. The air is drawn into the cylinder until the piston reaches the bottom of the stroke.

Outlet stroke: As the piston starts moving upwards the inlet valve is closed and the pressure of the delivery side which is connected to the receiver. Then the outlet valve opens and air is delivered during the remaining upward motion of the piston to the receiver.

Multicylinder piston compressors:

Though a single cylinder compressor can provide pressure up to about 10 bars usually a multi cylinder compressors are used for increasing compression capacity and also due to many practical reasons.

- **Single stage compressor:** The compression of the air from the initial pressure to the final pressure is carried out in one cylinder only as shown in fig.4.3

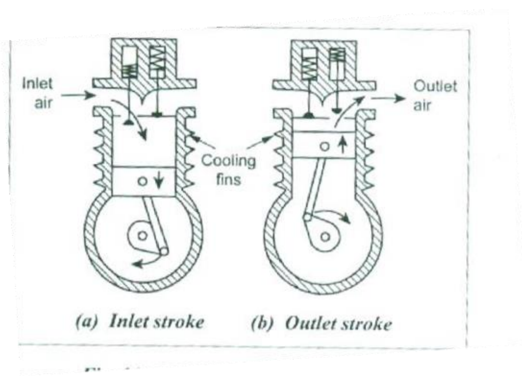


Fig.4.3. single cylinder compressor

- **Multi stage cylinder:** When the compression of air from the initial pressure to the final pressure is carried out in more than one cylinder then the compressor is known as multi stage compressor as shown in fig.4.4.

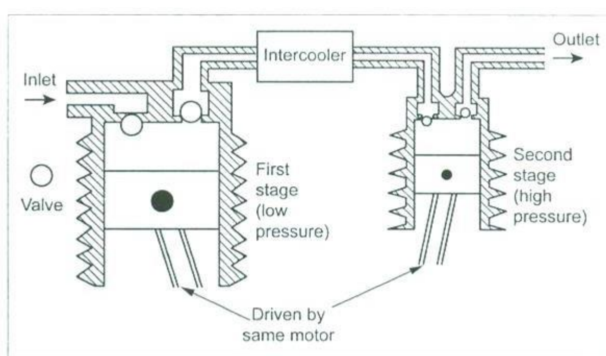


Fig.4.4 Two stage Compressor

Staging: Staging means dividing the total pressure among two or more cylinders by allowing the outlet from one cylinder into the inlet of the next cylinder and so on.

Advantages:

- Piston type compressors are available in wide range of capacity and pressure
- The overall efficiency of piston compressor are high when compared to other compressors.
- Very high air pressure and air volume flow rate can be obtained by using the multistage compressors.
- Better mechanical balance can be achieved with multi-stage compressors

5. Explain with its symbol, diagram and functioning of filter, regulator and lubricator.Illustrate the working of a lubricator in a pneumatic system. (Nov/Dec 2021)

AIR FILTERS:

Functions:

The function of air filters is to remove all foreign matter and allow dry, clean air to flow without restriction to the regulator and then on to the lubricator.

Filters are available in wide ranges starting from a fine mesh wire cloth(which only strains out heavier foreign particles) to elements made of synthetic materials (which are designed to remove very small particles).

Usually in line filter elements can remove contaminants in the 5 to 50 µm range.

Factors affecting selection of filters:

1. Size of particles to be filtered from the system.
2. Capacity of the filter.
3. Accessibility and maintainability.
4. Life of the filter.
5. Ability to drain the condensate

Construction:

- The construction and operation of a typical cartridge type filter system is illustrated in fig.4.5.
- It consists of filter cartridge, deflector, plastic bowl, baffle, water drain valve, etc..,

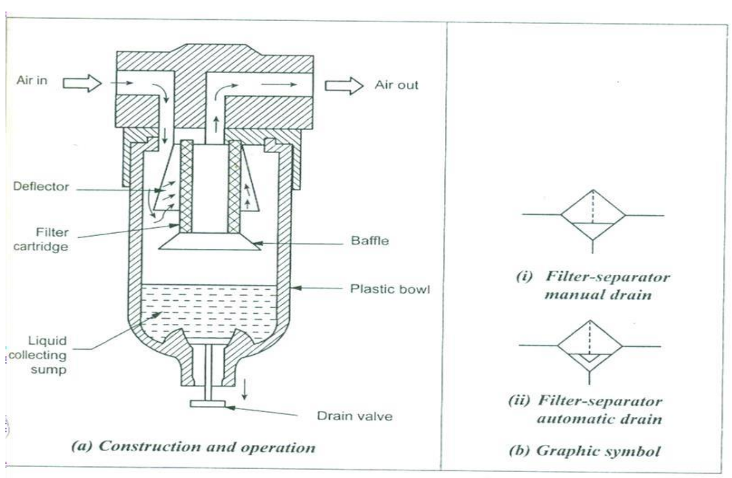


Fig.4.5 Air Filter

Operation:

The air to be filtered is allowed downward with a swirling motion that forces the moisture and the heavier particles to fall down. The deflector used in the filter mechanically separates the contaminants before they pass through the cartridge filter. The filter cartridge provides a random zigzag passage for the air flow. This type of air flow arrests the solid particles in the cartridge passage.

The water vapour gets condensed inside the filter and is collected at the bottom of the filter bowl. Also heavier foreign particles that are separated from the air are collected at the bottom of the bowl. Then the accumulated water and other solid particles at the bottom of the filter bowl are drained off with the use of an on-off drain valve located at the bottom of the filter bowl.

AIR PRESSURE REGULATOR:

Function:

The function of the air pressure regulator is to regulate the pressure of the incoming compressed air so as to achieve the desired air pressure at a steady condition.

The compressed air leaving the compressor should be properly prepared before it goes into the circuit. The air should have the proper operating pressure for the circuit. Improper fluctuating pressure level in the piping system can adversely affect the operating characteristics of the system components such as valves, cylinders, etc.. Therefore air pressure regulators are fitted to ensure the constant supply pressure irrespective of the pressure fluctuations in the compressor unit.

For example, the line from the compressor may carry a pressure of 10 bars, the air pressure regulator can reduce this pressure to 0 bar to any point between the full line pressure and zero pressure.

Thus the air pressure regulators act as pressure guards by preventing pressure surges or drops from entering the air circuits

The two types of air pressure regulators are

1. Diaphragm-type regulator
2. Piston type regulator

Construction:

The construction and operation of a typical diaphragm type air pressure regulator is shown in Fig.

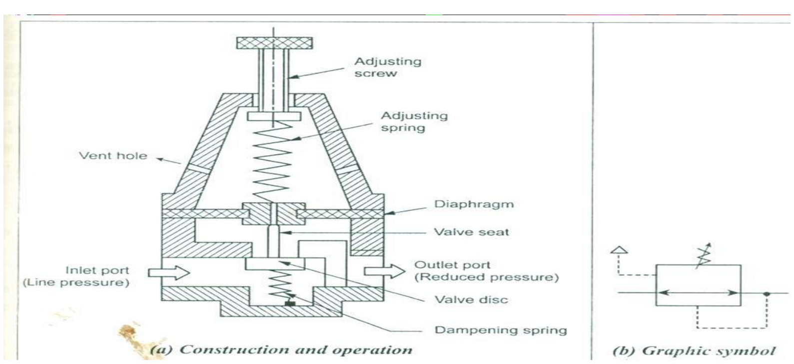


Fig.4.6 air pressure regulator

It consists of diaphragm, valve, main and dampening springs, etc. Usually the diaphragm is made of oil-resistant synthetic rubber with nylon cloth reinforcements.

Operation:

The diaphragm allows the proper amount of movement for opening and closing at the valve seat. When the adjusting screw is turned to compress the adjusting and dampening springs, the valve is opened. Thus the air is allowed from inlet port to the outlet port.

The pressure of the outlet air depends upon the size of the valve opening that is maintained. This is determined by the compression of the adjustable spring. Higher the spring compression, more will be the amount of opening and hence more the pressure and vice versa.

The vent holes are provided to let out the undesirable excessive outlet pressure, if any into the atmosphere. The dampening spring is provided to act as a dampening device needed to stabilize the pressure.

6. Illustrate the working of a lubricator in a pneumatic system(AUDec2021)

Function:

The function of an air lubricator is to add a controlled amount of oil with air to ensure proper lubrication of internal moving parts of pneumatic components.

The lubricator adds the lubrication oil in the form of a fine mist to reduce the friction and wear of the moving parts of pneumatic components such as valves, packings used in air cylinders, etc.

Construction and Operation:

The construction and operation of a typical force-feed type air lubricator is shown in fig.4.7. Its operation is similar to the principle of simple carburetor used in the petrol engines to obtain air-fuel mixture.

As the air to be lubricated enters into the inlet pipe, the venture ring located in the pipe increases its velocity of low. It causes a local reduction in the upper chamber. This pressure differential between upper and lower chambers causes suction of lubrication oil from the oil reservoir to the upper chamber. Now the oil in the form of mist is sprayed in the air stream and the air-oil mixture is obtained. This air oil mixture is forced to swirl as it leaves the central cylinder causing more oil particles to be spread out of the air stream. The amount of oil dropping into the upper chamber can be controlled by a needle valve.

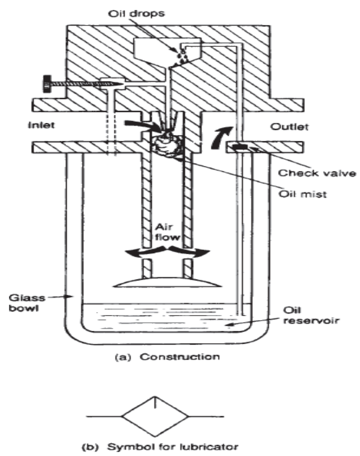


Fig.4.7 Air Lubricator

7. Explain the operation of air pressure regulator construction (April/may2008)

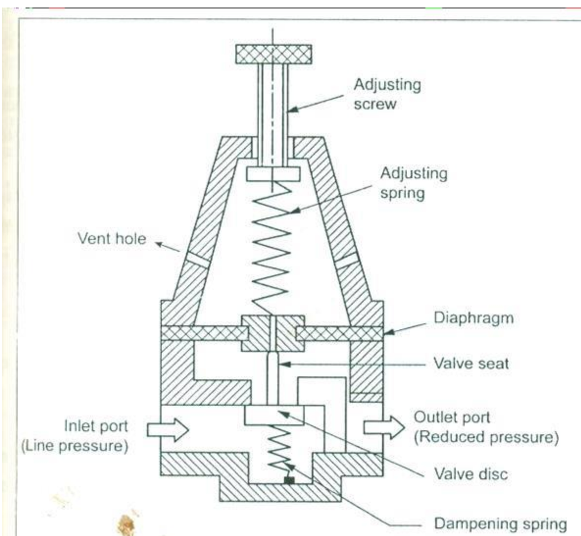
It consists of diaphragm valve, main and dampening springs etc. usually the diaphragm is made of oil-resistant synthetic rubber with nylon cloth reinforcements shown in fig.4.8.

Operation:

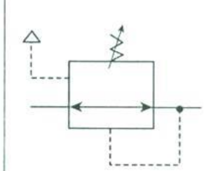
The diaphragm allows the proper amount of movement for opening and closing at the valve seat. When the adjusting screw is fully in the retracted position the valve is closed when the adjusting screw is turned to compress the adjusting and dampening springs the valve is opened. Thus the air is allowed from the inlet to the outlet port.

The pressure of the outlet air depends upon the size of the valve opening that is maintained. This is determined by the compression of the adjustable spring. Higher the spring compression, more will be the amount of opening and hence more the pressure and vice versa.

The vent holes are provided to let out the undesirable excessive outlet pressure if any into the atmosphere. The dampening spring is provided to act as a dampening device needed to stabilize the pressure.



(a) Construction and operation



(b) Graphic symbol

Fig.4.8 air pressure regulator

8. Discuss the function of FRL unit (Nov/Dec-2007)

In most pneumatic systems the compressed air is first filtered and then regulated to the specific pressure and made to pass through a lubricator for lubricating the oil. Thus usually a filter, regulator, and lubricator are placed in the inlet line to each air circuit. These may be installed as separate units. But most often used in the form of a combined unit.

The combination of filter regulator and lubricator is often labeled as FRL unit or service unit as shown in fig.4.9.

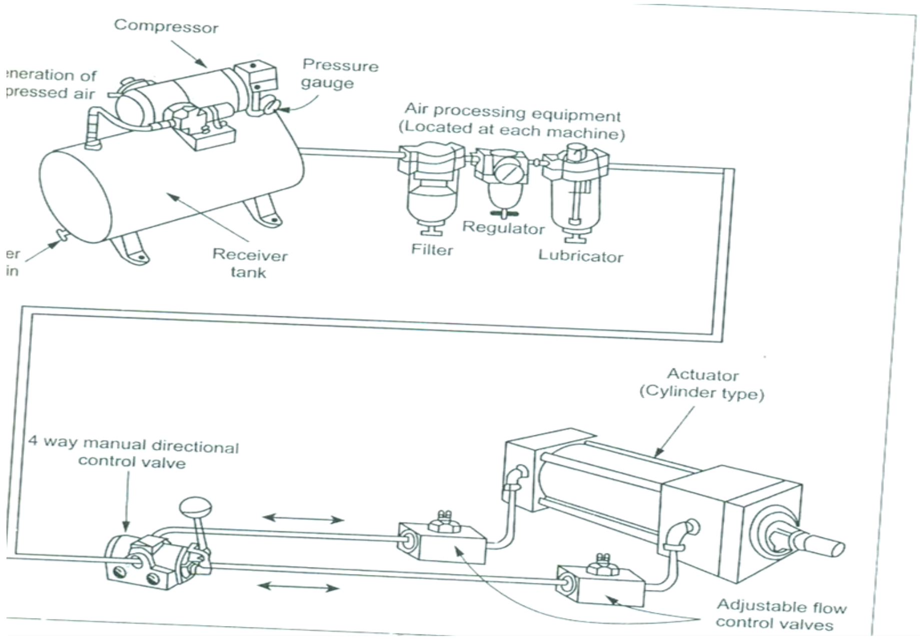


Fig.4.9. FRL unit

9. Write a short note on mufflers. [MAY-2013]

Function:

The function of muffler also known as pneumatic exhaust silencer is to control the noise caused by a rapidly exhausting air-stream flowing into the atmosphere.

Noise created by air exhausting from an air system not only cause nervous tension and dissatisfaction among the operators but also results in fatigue, lack of concentration and inefficiency. The exhaust noises can be greatly reduced by installing a muffler at each pneumatic exhaust port.

Construction and working:

The construction and operation of a typical pneumatic silencer is shown in fig.4.10

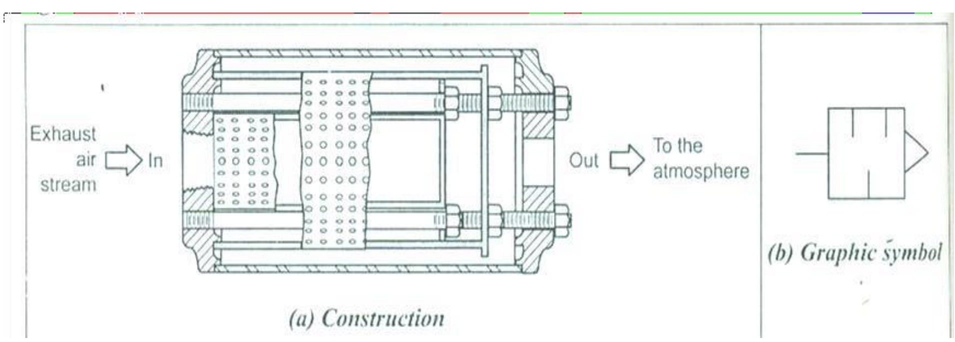


Fig.4.10 Muffler

The exhaust air stream enters one end and passes out another end after passing through a series of baffles. The baffle tubes are perforated with a large number of small holes. The outer shell acts as a barrier and helps guide the stream toward the exit to the atmosphere.

10. Draw and explain the function of pneumatic check valve (May/June 2009)

Check valves are the most commonly used and the simplest type of directional control valves.

FUNCTIONS:

- To allow free flow of compressed air in only one direction.
- To prevent any flow of compressed air in opposite direction.
- Since check valves block the reserve flow of the fluid, they are also known as non-return values.

Construction and operations:

The sectional view and ANSI symbol of pneumatic check value are shown in fig.4.11. when flow is in the forward direction the compressed air pressure pushes the disk seal and thus the valve allows free flow. Instead if flow is attempted in the opposite direction as shown if fig. the compressed air pulse the disk seals in the closed position. Hence no flow is permitted in opposite direction.

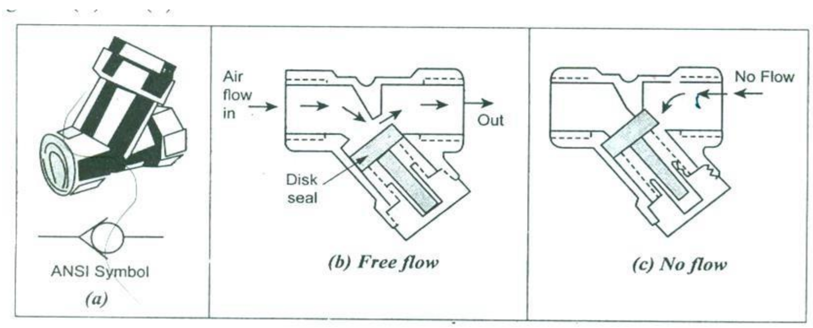


Fig.4.11 Pneumatic check valve

11. Describe the construction and operation of a valve-seat type four-way, two position directional control valve.

Construction and Operation:

The construction and operation of a typical valve-seat type four-way two-position (i.e., 4/2) pneumatic valve is illustrated in Fig.4.12(a). Fig.4.12. (b) shows the graphic symbol of the 4/2 way valve.

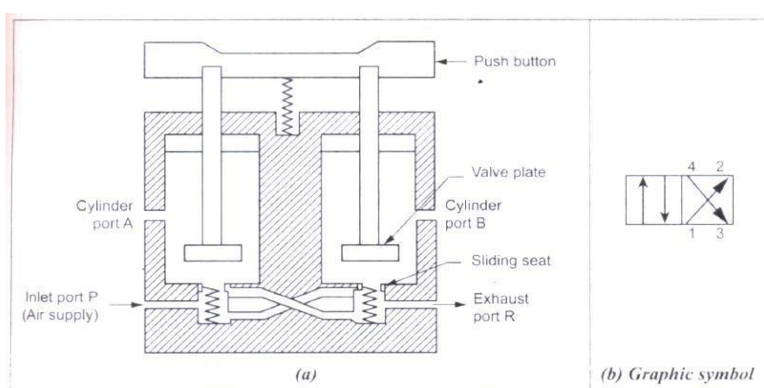


Fig.4.12 4/2 way DC valve

As shown in Fig.4.12, the inlet port P connects to cylinder ports A and B to exhaust port R. When the valve elements are actuated by means of the push button, they are unseated and port P connects to cylinder ports B and A to exhaust port R.

12. Describe with the help of neat sketch the construction and operation of a shuttle valve in a pneumatic circuit.

Shuttle Valves:

- Shuttle valves, also known as double check valves, are used when control is required from more than one power source.
- In other words, shuttle valves are used to select the higher of the two input pressures automatically and connect to output port. This valve is also known as 'OR GATE'.

Construction and Operation:

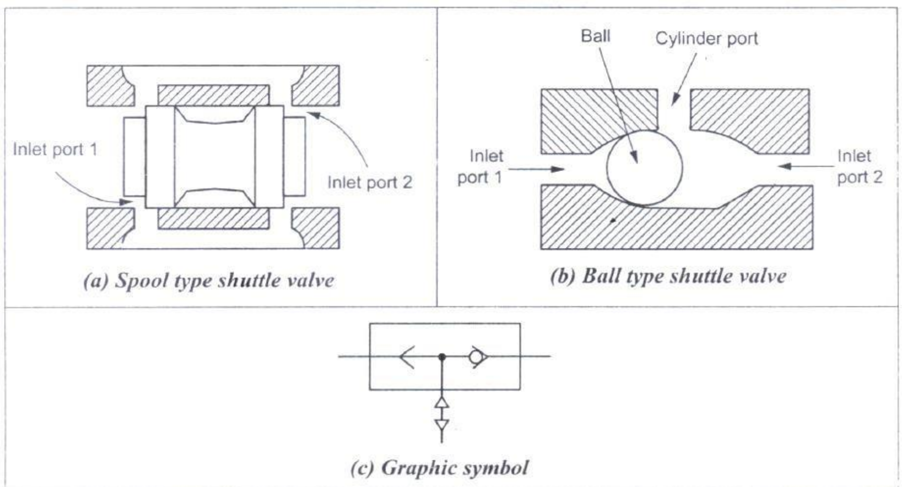


Fig.4.13. Shuttle valve

The construction and operation of a typical three port spool-type shuttle valve is illustrated in Fig.4.13(a). The alternative ball-type shuttle valve for the same purpose is shown in Fig.4.13(b).

As shown in Figs.4.13(a) and (b), this valve consists oftwo inlet ports and one outlet port. As long as pressure in the right inlet port is greater than the left, the spool (or ball) closes the left port. When pressure at the left port becomes greater than at the right, the spool (or ball) moves to the right, closing the right port and opening the left.

13. What do you mean by Flow Control Valve? Explain its working principle with a sketch.

FLOW CONTROL VALVE:

Flow control valves, also known as volume-control valves, are used to regulate the volumetric flow of the compressed air to different parts of a pneumatic system.

Construction and Operation:

The construction and operation of a typical spring-loaded disk-type flow control valve is illustrated in Fig.4.14.

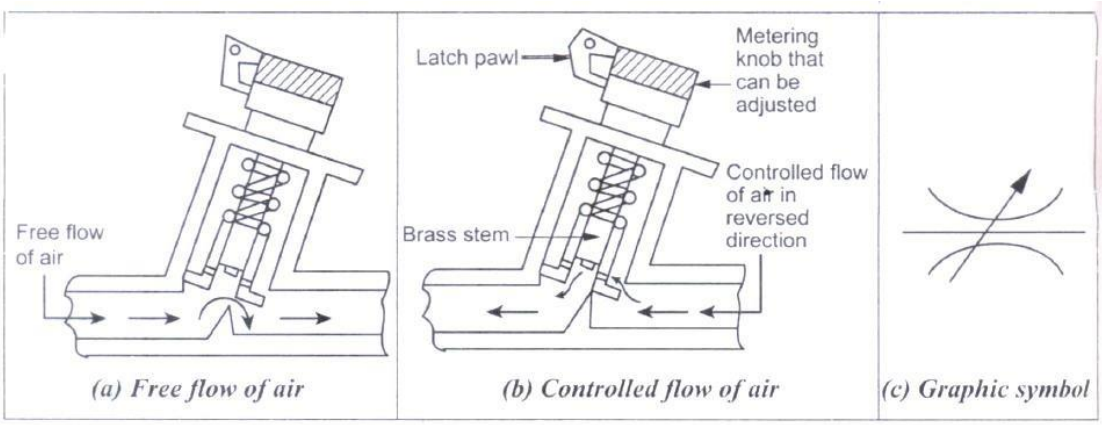


Fig.4.14. Flow control valve

As shown in Figs.4.14(a) and (b), the spring loaded disk allows free flow in one direction and an adjustable or controlled flow in the opposite direction. A tapered brass stem controls the flow adjustment by controlling the flow through the cross hole in the disk.

14. What do you mean by quick exhaust valve? Explain its working principle with a sketch. [MAY-2012] (AU Nov/Dec 2021)

Quick Exhaust Valve:

- A quick exhaust valve is a typical shuttle valve. The quick (or fast) exhaust valve is used fa exhaust the cylinder air to the atmosphere quickly.
- It is basically used with spring return single-acting pneumatic cylinders to increase the piston speed of cylinders .
- The higher speed of piston in a cylinder is possible by reducing the resistance to flow of the exhausting air during motion of the cylinder. The resistance can be .reduced by expelling the exhausting air to the atmosphere quickly by using a special valve. That's why this valve is known as a quick exhaust valve.

Construction and Operation:

The construction and operation of a typical quick exhaust valve is shown in Fig.4.15. It consists of a movable disc and three ports-an inlet port (P), and exhaust port (R), and a cylinder port (A). Its working principle is very much similar to that of a shuttle valve.

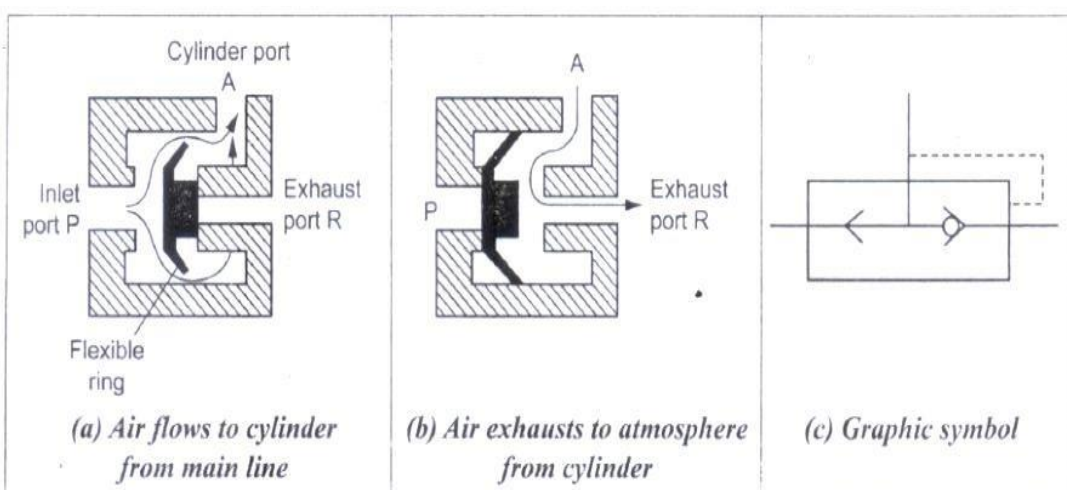


Fig.4.15. Quick Exhaust valve

When the air flowing to the cylinder from the DC valve is applied at port P, then the flexible ring covers the exhaust port R, whereby the compressed air passes from port P to the cylinder through port A as shown in Fig.4.15(a). But the return air from the cylinder pushes the flexible ring to cover the inlet port P, whereby the exhaust air immediately expelled to the atmosphere as shown in Fig.4.15(b).

Thus, the resistance to piston movement is reduced considerably and the speed of the piston in the cylinder is accelerated proportionately.

15. With a neat diagram explain the semi-automatic material handling pneumatic circuit.
SEMI-AUTOMATIC CONTROL OF A DOUBLE-ACTING PNEUMATIC CYLINDER:
(Semi-Automatic Material Handling Circuit)
Circuit:

Fig.4.23 illustrates a circuit that provides semi-automatic operation by using pressure operated pilot controls.

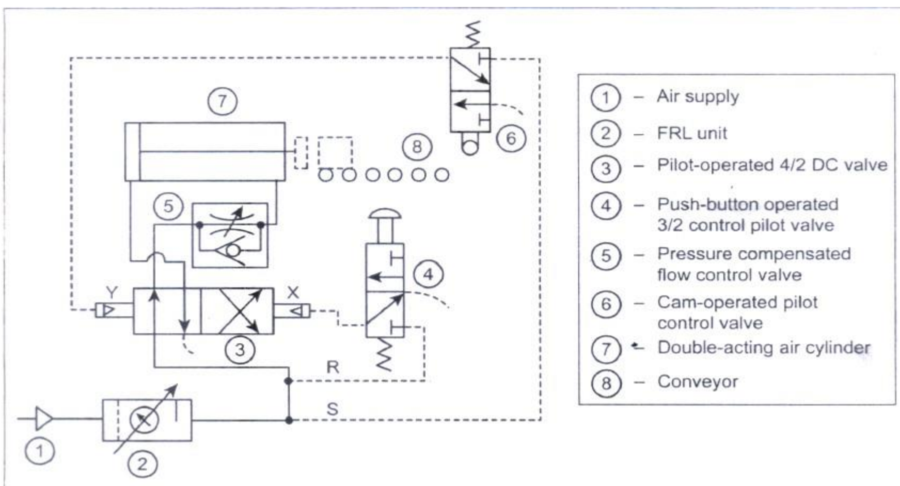


Fig.4.23 Semi-automatic control of a double-acting air cylinder

Extension:

When operator momentarily presses the push-button of 3/2 pilot control valve, the compressed air flows through this valve and enters pilot chamber X shifting the 4/2 DC valve to its right envelope flow path configuration. When the 4/2 DC valve is shifted to its right mode, the compressed air flows to blind end of the cylinder and thus the cylinder extends. At the same time, the air at the rod end of the cylinder is exhausted into the atmosphere directly. It may be noted that the piston out speed of the cylinder is controlled by flow control valve.

Retraction:

Once the extension stroke of the cylinder completes, the cam-operated pilot control valve is tripped and air flows to pilot chamber Y of 4/2 DC valve shifting its position.

When the 4/2 DC valve is shifted to its left mode, the compressed air flows to the rod end of the cylinder and thus the cylinder retracts. At the same time, the air at the blind end of cylinder is exhausted to the atmosphere.

For the next cycle, again the operator only needs to momentarily press the push-button. Thus in this semi-automatic circuit, once the operator momentarily presses the push-button the circuit completes its cycle automatically. This circuit may be used as serni-automa material handling circuit for pushing the large boxes from transfer table onto conveyor, shown in Fig.4.23.

16. Explain the sequencing of four double-acting air cylinders with a neat circuit.

<u>Sequencing of Four Double-Acting Air Cylinders:</u>

Circuit:

Fig.4.24 illustrates a circuit that provides sequencing control of four double-acting pneumatic cylinders. This circuit uses four earn-operated 3/2 pilot control valves, two pilot operated 4/3 DC valves, and four double-acting air cylinders. These valves are spring centered so that when rollers ride off the cams, the valves return to neutral position with all ports closed.

Operation:

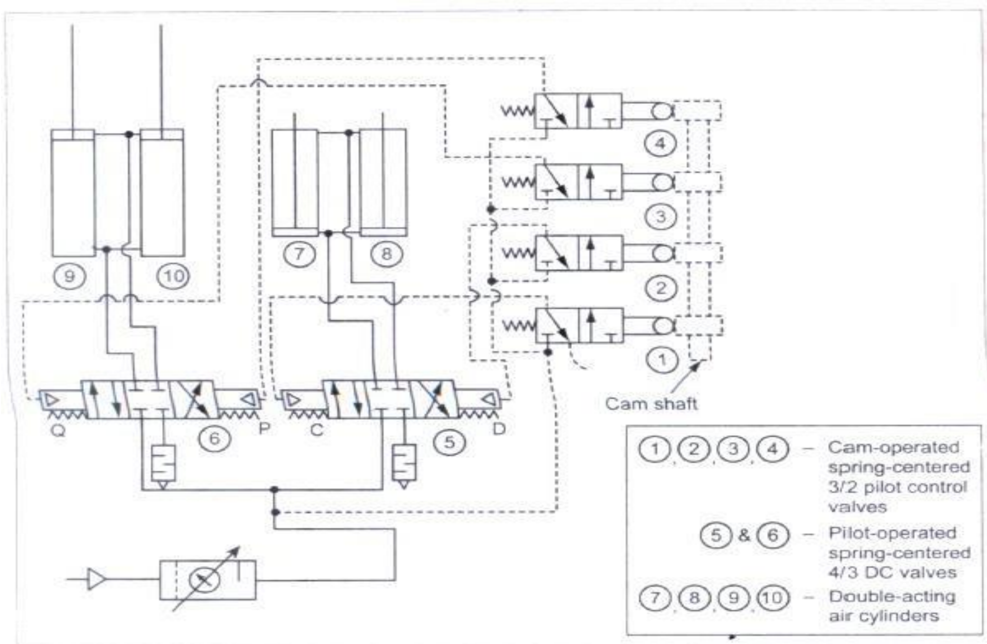


Fig.4.24. Sequencing of four double-acting air cylinders

First operator engages camshaft drive. As camshaft rotates, cams (1) and (4) depress rollers on 3/2 pilot control valves (1) and (4). From pilot valve (1), air is directed to chamber Cof 4/3 DC; valve (5). This pilot pressure shifts the position of the 4/3 DC valve (5) to its left mode. When the 4/3 DC valve (5) is shifted to its left envelope flow path configuration, the compressed air flows into blind ends of cylinders (7) and (8), and hence both cylinders (7) and (8) extend. At the same time, air flows through 3/2 pilot control valve (4) to pilot chamber P of 4/3 DC valve (6). This pilot pressure shifts the position of the 4/3 DC valve (6) to its right mode. When the 4/3 DC valve (6) is shifted to its right mode, the air is directed to rod ends of cylinders (9) and (10), and hence both cylinders (9) and (10) retract.

As the camshaft rotates 180^0 angle, cams (1) and (4) release the rollers on 3/2 pilot control valves (1) and (4). Now cams (2) and (3) contact and depress rollers on 3/2 pilot control valves (2) and (3). From pilot valve (2), air is directed to chamber D of 4/3 DC valve (5).

This pilot pressure shifts the position of the 4/3 DC valve (5) to its right mode. When the 4/3 DC valve (5) is shifted to its right mode, the compressed air flows into rod ends of cylinders (7) and (8), and hence both cylinders (7) and (8) retract.

At the same time air flows through 3/2 pilot control valve (3) to pilot chamber Q of 4/3 DC valve (6). This pilot pressure shifts the position of the 4/3 DC valve (6) to its left mode. When the 4/3 DC valve (6) is shifted to its left mode, the air is directed to blind ends of cylinders (9) and (10), and hence both cylinders (9) and (10) extends.

The cylinder will continue to cycle until the operator disengages the camshaft drive.

17. With the help of a diagram explain the air-over-oil circuit.

<u>AIR-OVER-OIL CIRCUIT:</u>

Circuit:

Fig.4.25 illustrates a typical air-over-oil circuit to make best use of advantages of both fluid mediums for counterbalancing application. This circuit uses an air-oil surge tank, a manually operated 3/3 DC valve, a FRL unit, a flow control valve, a pressure relief valve, and a cylinder. In the surge tank, oil is filled at the bottom and the air at the top.

<u>Operation:</u>

Extension:

When the 3/3 DC valve is shifted to its upper envelope flow path configuration, the compressed air flows via FRL unit and the valve to the surge tank. So the surge tank is pressurized by the compressed air. This pushes the oil (out of the bottom of the surge tank) to the blind end of the cylinder through the flow control valve.

Thus, the cylinder extends to lift a load. Here the flow control valve can be used to regulate the extension speed of the cylinder.

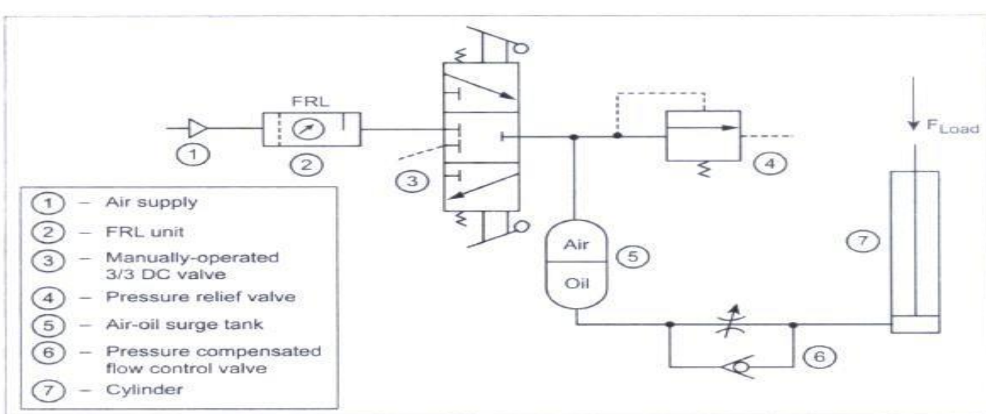


Fig.4.25. Air-over-oil circuit

Retraction:

When the 3/3 DC valve is shifted to its lower envelope flow path configuration, the air leaves the surge tank and exhausts into the atmosphere via the DC valve. So the oil at the blind end of the cylinder returns back steadily through the flow control valve and thus the cylinder retracts.

The load (F_{load}) can be stopped at any intermediated position by shifting the 3/3 DC valve to its spring-centered position. This circuit eliminates the use of a costly hydraulic pump and an oil reservoir. Also this circuit uses the oil for the advantage of generating high force and precision control of the cylinder.

18. A double-acting cylinder is hooked lip in the regenerative circuit. The relief valve setting is 100 bars. The piston area is 180 cm² and the rod area is 60 cm².If the pump flow is 0.0015 m³/s. Find the cylinder speed and load-carrying capacity for the (i) extending stroke, and (ii) retracting stroke.

Given Data : $P = 100 \text{ bars} = 100 \times 10^5 \text{ N/m}^2$; $A_p = 180 \text{ cm}^2$; $A_r = 60 \text{ cm}^2$; $Q_P = 0.0015 \text{ m}^3/\text{s}$.

☺ ***Solution :***

(a) For extending stroke :

$$\text{Cylinder speed, } v_{p_{ext}} = \frac{Q_P}{A_r} = \frac{0.0015}{60 \times 10^{-4}} = \mathbf{0.25 \text{ m/s}} \quad \textbf{Ans.}$$

$$\text{Load-carrying capacity, } F_{load_{ext}} = P \times A_r = (100 \times 10^5)(60 \times 10^{-4})$$

$$= \mathbf{60 \text{ kN}} \quad \textbf{Ans.}$$

(b) For retracting stroke :

$$\text{Cylinder speed, } v_{p_{ret}} = \frac{Q_P}{A_p - A_r} = \frac{0.0015}{(180 \times 10^{-4} - 60 \times 10^{-4})}$$

$$= \mathbf{0.125 \text{ m/s}} \quad \textbf{Ans.}$$

$$\text{Load-carrying capacity, } F_{load_{ret}} = P(A_p - A_r)$$

$$= (100 \times 10^5)(180 - 10^{-4} - 60 \times 10^{-4})$$

$$= \mathbf{120 \text{ kN}} \quad \textbf{Ans.}$$

19. Coanda effect (or) wall attachment effect (NOV /DEC 2007)

The coanda effect also known as wall attachment effect is the basic for functioning of many fluids components and the fluid technology itself.

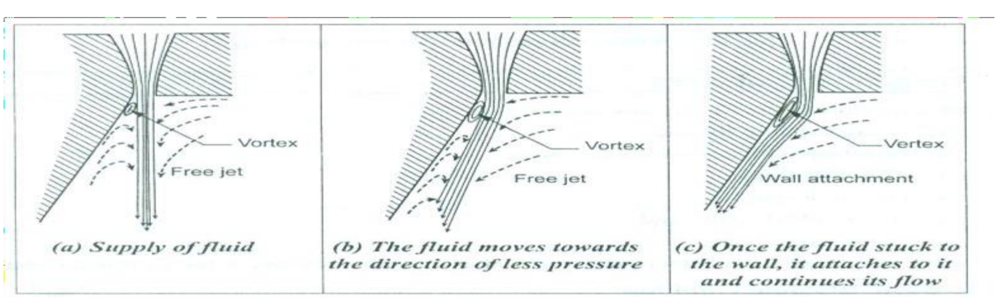


Fig.4.33. Coanda effect

Visual demonstration of coanda effect:

A simple self explanatory visual demonstration of coanda effect when a finger is held near the stream of water flowing at from the water tap then one can see that the water attaches itself to the figure.4.34 as shown.

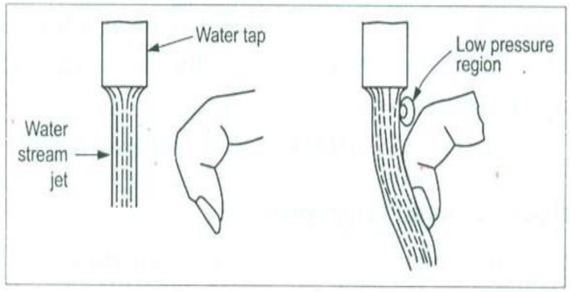


Fig.4.34. Visual demonstration of coanda effect

20. Proportional Pressure Reducing Valve (N/D-2010)

The construction and operation of a typical proportional pressure reducing valve is shown in fig.4.35.

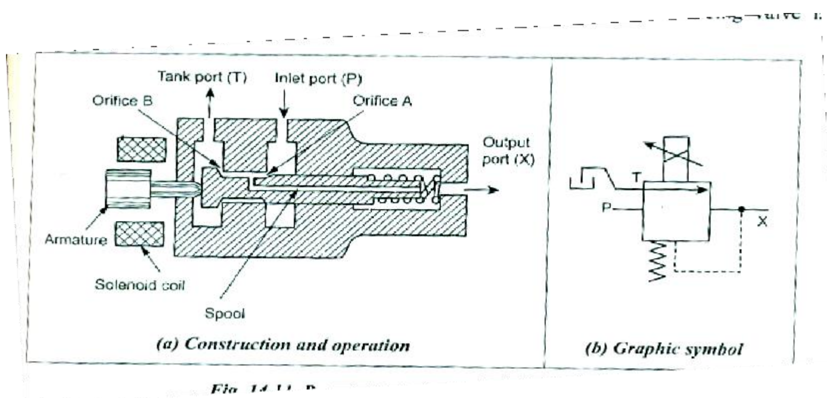


Fig.4.35. proportional pressure reducing valve

Operation

The proportional pressure reducing valve works on exactly the same principle as the conventional pressure reducing valve, except that the control spring is replaced by a proportional solenoid. Also unlike the conventional pressure reducing valve, this valve is normally closed when the solenoid is not energized.

When the solenoid is energized, its corresponding armature deflection will move the spool to the right. This opens the control orifice A and allows the fluid to flow to the output port X. The outlet

pressure of this valve is dependent upon the openings of control orifices A and B. which in turn depends on the input current supplied to solenoid. Thus by proportionately varying the input current to the solenoid, the operating pressures of the valves can be varied.

21. Explain various locations at which filters and strainers are fined giving reasons. (A/M-2010)

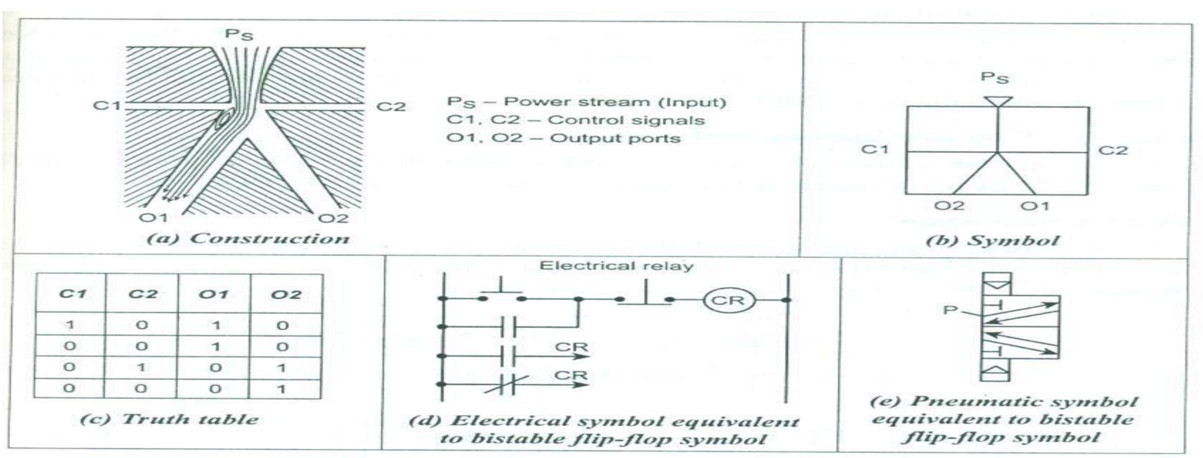
The various filter and strainer locations are as below:

1. Pressure filtration: Locating filters/strainers in pressure lines provide maximum protection for components located immediately downstream.
2. Return filtration: The reason for locating filters/strainers in the return line is: if the reservoir and returning fluid is adequately filtered, then the fluid cleanliness will be maintained.
3. Off-line filtration: Off-line filtration enables continuous, multi-pass filtration at a controlled flow velocity and pressure drop, which results in high filtration efficiency.
4. Suction filtration: From a filtration perspective, the pump intake is an ideal location for filtering media. The filter efficiency is increased by the absence of both high fluid velocity and high pressure drop across the element.

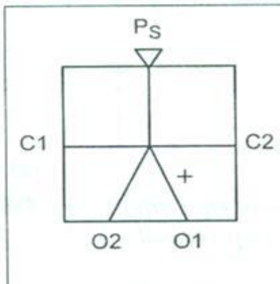
22. Write a short notes on basic fluids device. (MAY/JUNE 2009)

- Bistable flip flop
- Flip flop with startup preference
- SRT flip flop
- OR/NOR gate
- AND/NAND gate
- Exclusive OR gate

(i) Truth table



(ii) Flip flop with startup preference



(a) Symbol

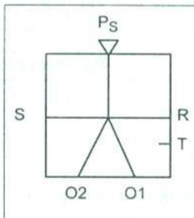
C1	C2	O1	O2
0	0	1	0
0	1	0	1
0	0	0	1
1	0	1	0
0	0	1	0

(b) Truth table

Operation:

The (+) sign indicates that the output 01 is preferred over 02. this can be accumulated by building the splitter slightly off center that's why when the flip flop first receives it power supply (and control signals are OFF) the wall attachment is preferred to the 01 output.

(iii) SRT flips flop

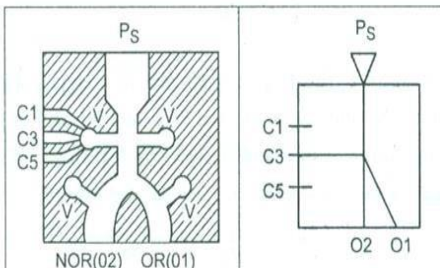


(a) Symbol

T	S	R	O1	O2
0	1	0	1	0
0	0	0	1	0
0	0	1	0	1
0	0	0	0	1
1	0	0	1	0
0	0	0	1	0
1	0	0	0	1
0	0	0	0	1

(b) Truth table

(iv) ON/NOR gate



(a) Construction (b) Symbol

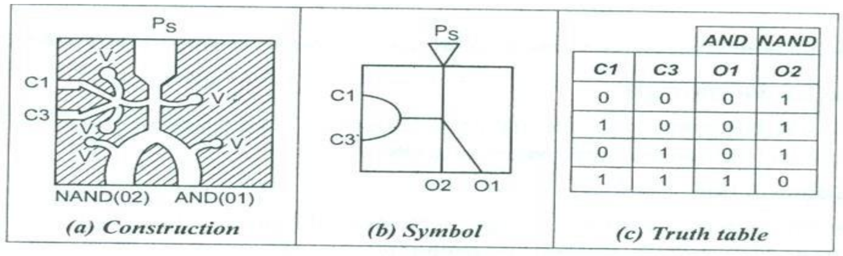
		OR	NOR
C1	C3	O1	O2
0	0	0	1
1	0	1	0
0	1	1	0
1	1	1	0

(c) Truth table

(i) OR (01) ----→ pressure at one (or) any combination of the control parts.

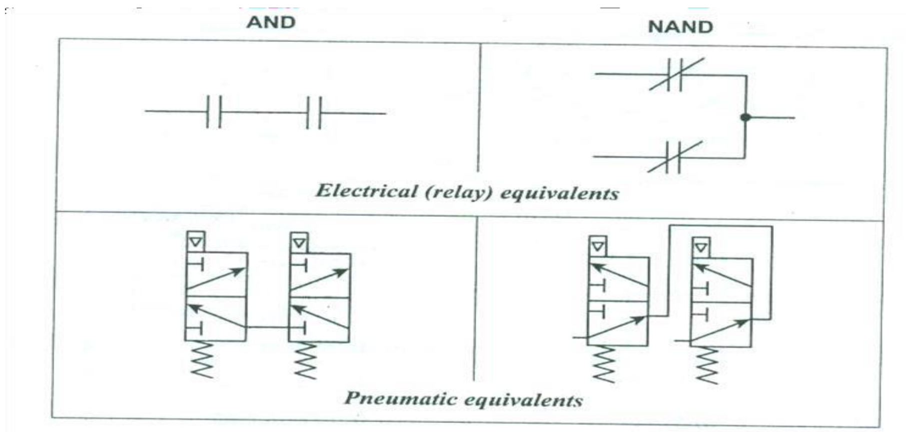
(ii) NOR (02) pressure at none of the control parts.

(V) AND / NAND:



		AND	NAND
C1	C3	O1	O2
0	0	0	1
1	0	0	1
0	1	0	1
1	1	1	0

Fig. 15.7. AND/NAND gate



23. Write a short note on PLC application in fluid power control.

A programmable logic controllers (PLC) can be defined as a digital electronic device that uses a programmable memory to store instruction and to implement function such as logic, sequencing timing, counti9ng and authentic in order to control machine and processer.

Advantage:

- PLC are more reliable and faster operation
- They are smaller in size can more readily expanded
- They requires less electrical power
- They are less expensive when compared electro mechanical relays for the same number ofcontrol function
- Hard wired electromechanical relays lack flexibility for instance when system operation requirement change then the relay have to be rewired
- PLCs have very few hardware failure when compared to electro mechanical relay
- Special function such as time delay actions and counters and easily performed.

24. What are the Major units of PLC (Nov/ Dec 2008)

(i) Central processing unit

(ii) Programme/ monitor (PM)

(iii) input/output (I/O)

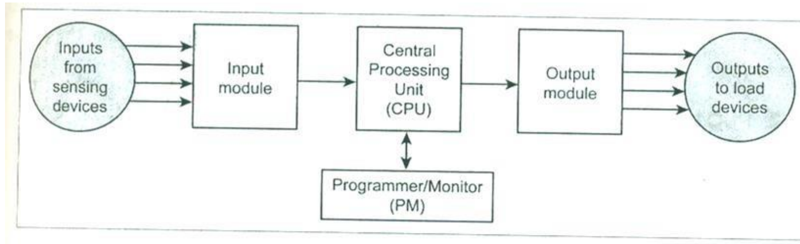


Fig 4.36: Block diagram of a PLC

Operation:

(I) CPU: (i) receives input data from various sensing device such that switches

(ii) Executes the stored program

(iii) Delivers corresponding output signals to various load control devices such as relay coils and solenoids.

(II) PM:

User to enter the desired programmed into the RAM.

The programme which is entered in relay logic (in RAM) determines the sequence of operation of the system to be controlled.

(III) Input / output:

The purpose of the I/O module is to transform the various signals received from or sent to the fluid power interface devices such as push button switches pressure switches unit switches solenoid coil motor relay and indicator lights.

25. Write a short note on selection of hydraulic and pneumatic system.

- If the application requires a very high pressure or an extremely accurate feed then an oilhydraulic system can be used.
- If the application requires speed, a medium amount of pressure and only a faulty accurate feedthen an air pneumatic system can be used.
- If the application requires only a medium amount of pressure and a feed of greater accuracythen a combination of air and hydraulic system can be used.

26. What is the Advantage of the using fluid system? (NOV / DEC 2007)

- Fluidic devices offer exceptional thermal and physical stability and ruggedness when compared to electronic control system.
- Fluidic devices are completely insensitive to radiation even extremely high levels
- It is not affected by serves vibration and shock
- Highly reliable functionality
- Relatively low cost
- Interfacing capability can be easily accomplished with fluids. Fluidic component can be interfaced to control pneumatic, electrical (or) other system
- Since air is normally used as the working fluid within these device there are no problems of electrical noise, vibration fatigue and contact contamination
- Since there is no affecting of switching element. Circuit empolying fluidic devices can be operated quite safely in highly explosive (or) other dangerous environment

27. What is meant by ladder programming? And discuss the Logic functions.Ladder programming:

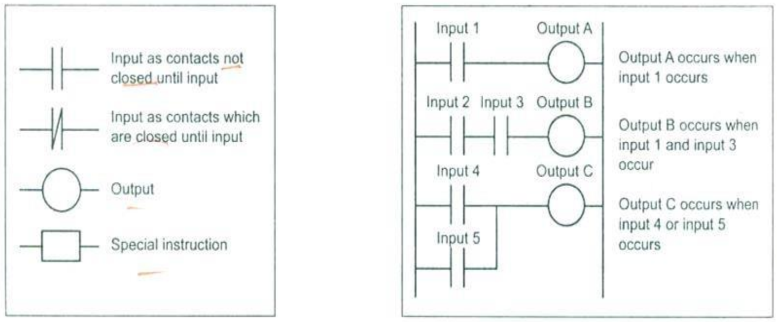


Fig.4.39. Ladder programming

The basic form of programming commonly used with PLCs is ladder programming. PLC programming based on the use of ladder diagrams involves writing a program in a similar manner to drawing a switching circuit

The ladder diagram consists of two vertical lines representing the power lines. Circuits are connected as horizontal lines. I.e. the rungs of the ladder, between these two verticals.

LOGIC FUNCTIONS:

AND Logic Function:

It shows a situation where a coil is not energized unless two normally open switches are both closed. Switch A and switch B have both to be closed, which thus gives an AND logic situation.

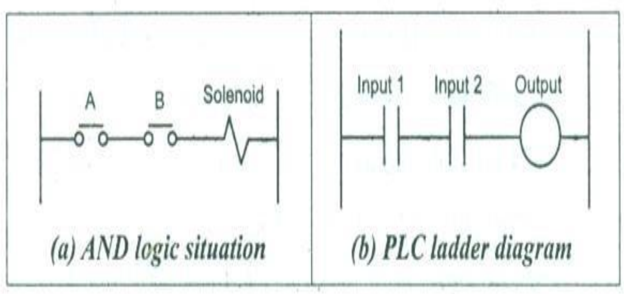


Fig.4.40. AND System

It shows the PLC ladder diagram for the AND logic function. The ladder diagram starts with ll labeled input 1,to represent switch A and in series with it ll labeled input 2 to represent switch B. The line then terminates with O to represent the output.

OR Logic Function:

It shows a situation where a coil is not energized until either, normally open, switch A or B is closed. This situation is an OR logic gate.

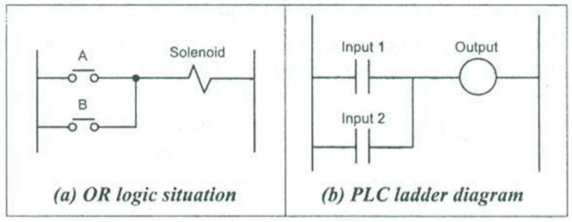


Fig.4.41 OR Logic Function

It shows the PLC ladder diagram for the OR logic gate. The ladder diagram starts with ll labeled input 1, to represent switch A and in parallel with it ll labeled input 2 to represent switch B. The line then terminates with O to represent the output.

NOR Logic Function:

It shows a NOR logic gate situation. It shows the PLC ladder program for the NOR gate. Since there has to be an output when neither A nor B have an input to A or B the output stops, the ladder program shows input 1 in parallel with Input 2,with both being represented by normally closed contacts.

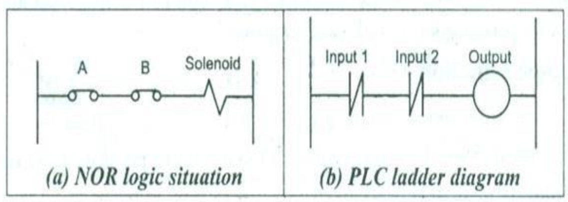


Fig.4.42. NOR Logic Function

NAND Logic Function:

It shows a NAND logic gate situation. The PLC ladder program for the NAND gate. There is no output when both A and B have an input. Thus for the ladder program line to obtain we require no inputs to input 1 and to input 2.

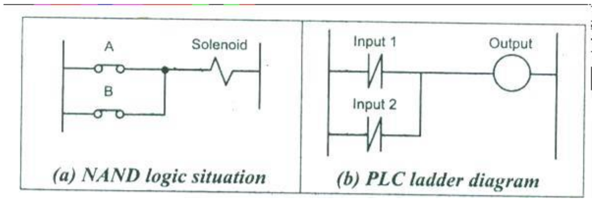
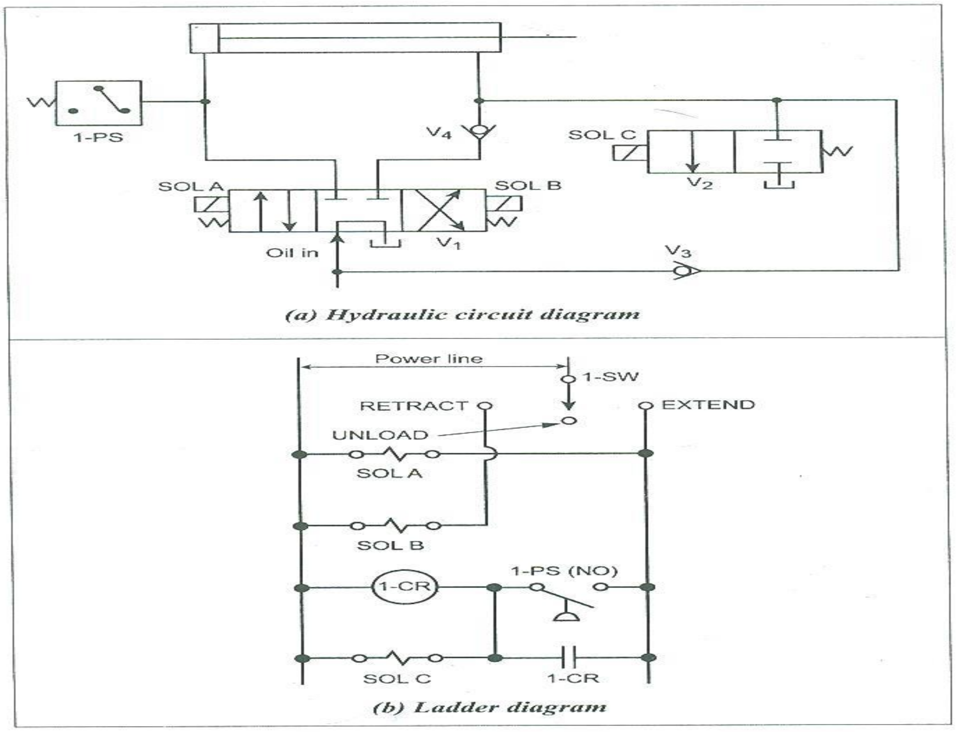


Fig.4.43. NAND Logic Function

38. Electrical control of regenerative circuit (N/D-2012)

A regenerative circuit speeds up the extending operation of a hydraulic cylinder.

When switch 1-SW is manually placed into the extend position, solenoid A gets energized and extends the cylinder. When extending oil from the cylinder rod pass joins to the incoming oil from the pump through check valve V_3 to provide rapid extension of cylinder. On extending oil pressure builds up to close the pressure switch 1-PS and thus blocks the flow until the desired pressure is reached. This energizes the coil 1-CR and solenoid C to vent the oil from rod end directly back to the reservoir through valve V_2.



(a) Hydraulic circuit diagram

(b) Ladder diagram

Fig.4.44. Electrical control of regenerative circuit

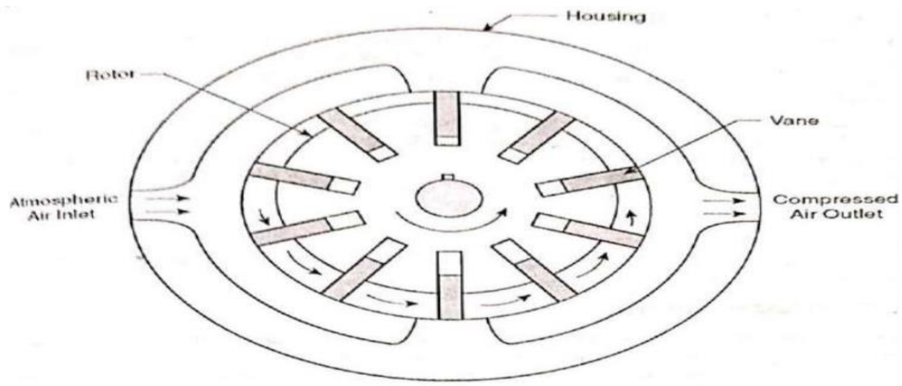
Thus, the cylinder extends slowly as it drives the load. Relay coil 1-CR holds the solenoid C as energized during the slow extension of the cylinder to prevent any fluttering of the pressure switch. This would occur because fluid pressure drops at the cylinder blank end at the completion of regenerative cycle and switch the pressure switch 1-PS to energies and de-energies continuously.

When the switch 1-SW is placed in the retract position solenoid b becomes energized and de energizing 1-CR and solenoid C. Thus cylinder is retracted in the normal fashion. When the switch 1-SW is put into the unload position, all the solenoids and the relay coils are reenergized and returns the valve V_1 in its spring centered position to unload the pump.

28. Brief on the working of any one type of positive displacement compressor (AU Nov/Dec 2021)

Vane compressors

The compressor consists of a rotor with radial slots, mounted eccentrically to a casing. The vanes are inserted in the slots of the rotor. As the rotor turns, the negative pressure created by the vanes causes air to be drawn through the inlet of the compressor. As the rotor continues to turn, the vanes compress the air in a space that gets progressively smaller. The air is compressed to the required pressure, as the vanes approach the discharge portion of the casing and the air is discharged through the discharge port.



(b) Vane Compressor

29. Brief on the working of 3/2 solenoid operated spring return valve.(Nov/Dec2021)

3/2-way valve have three connection ports and two positions that can be driven via a solenoid valve. They are used to control a single-action cylinder, for driving pneumatic actuators, used as a blow-off valve, as pressure release valve and in vacuum applications.

A valve is used to fill the cylinder, and also to exhaust it afterwards, so that a new working stroke can be realized. Therefore, a valve with two ports would not be adequate. Venting requires a third port. There are two kinds of 3/2 valves: mono-stable and bi-stable. Mono-stable 3/2-way valves can also be normally closed or normally open, just like 2/2-way valves.

Function of 3 way air valves

The 3/2-way pneumatic valve has three connection ports and two states. The three ports are:

• inlet (P, 1),
• outlet (A, 2)
• exhaust (R, 3)

The two states of the valve are open and closed. When the valve is open, air flows From the inlet (P, 1) to the outlet (A, 2). When the valve is closed, air flows from the outlet(A, 2) to the exhaust (R, 3). A valve that is closed in non-actuated state is normally closed (N.C.), the opposite is called normally open (N.O.).

Most valves are mono-stable and return to their default position when not actuated, This is achieved with a spring mechanism. Bi-stable 3/2-way valves retain their positionduring power loss, and require a separate action to switch the valve state.

Therefore, they cannot be designated as Normally Closed or Normally Open. Bi-stable pneumatic solenoid valves typically have a coil at each position and are pulse operated. Summarized, the different functions of the 3/2-way valve are:

• 3/2-way mono-stable NC
• 3/2-way mono-stable NO
•3/2-way bi-stable

The circuit functions can be shown with valve symbols. For the three above mentioned

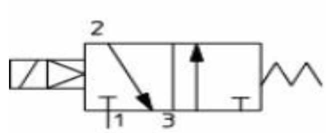


Figure.4.17.C. 3/2-way pneumatic solenoid valves.

Functions, the symbol of an indirect operated solenoid valve is shown in fig.4.17.c.

Design

3/2-way valves are available in several designs. The sealing mechanism of the valves can be a poppet or a spool. The valve's main parts are the following: housing, seals, poppet (or spool) and an actuator

With direct operated valves, the spool or poppet is moved directly by the actuator.

Several types of actuators are possible:

- Solenoid (coil)
- Push button
- Lever
- Foot pedal, etc.

The valve closes or opens by moving the spool or poppet. Mono-stable valves return to their default position, which is accomplished by spring force. In case of indirect operation, the spool is not directly actuated by the solenoid.

The valve uses the system pressure to move the spool. In order to do this an additional pilot valve is used.

This pilot valve is a small direct operated 3/2-way valve. The pilot valve delivers compressed air to a small air cylinder inside the valve.

The compressed air in this cylinder pushes against the piston and actuates the solenoid to switch the valve. This way, a relatively small solenoid can be used to switch the valve.

Mono-stable valves are built with one coil, bi-stable valves with two coils. The valve can be fixed directly to an actuator. Manifolds can be used to save space and to group valves. Not only can several 3/2-way valves be built up into one manifold, there is a possibility to mix valves.

For example, you can mount a 5/2-way valve next to a 3/2-way valve.

The possible combinations depend on the type and design of the manifold. A 5/2-way valve can be used as a 3/2-way valve by only using only one inlet and the corresponding outlet port. With two 2/2-way valves the function of a 3/2-way valve can be mimicked.

Applications

3/2-Way valves are suitable for several tasks: driving pneumatic actuators, blow-off, pressure release and vacuum applications.

Controlling a single acting cylinder

Operating a single acting cylinder is a typical application of 3/2-way valves. A single acting cylinder has one pneumatic port to fill and empty the air chamber.

The cylinder moves in one direction by filling the air chamber, and returns by spring force. The 3/2-way valve either fills the air chamber or vents the chamber to the atmosphere.

A basic pneumatic circuit for a single acting cylinder valve either fills the air chamber or vents the chamber to the atmosphere. A basic pneumatic circuit for a single acting cylinder can found on the picture shown in Fig.4.17.D

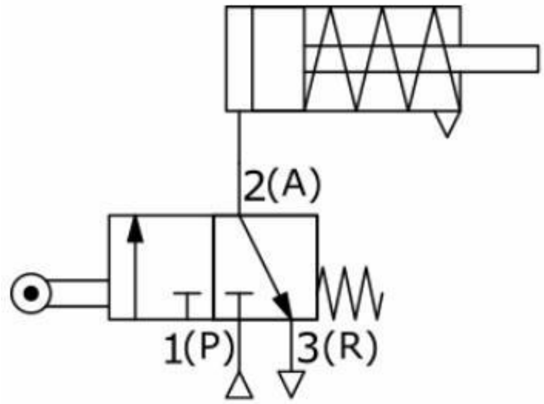


Figure 4.17.D. single single-acting cylinder drive with a 3/2-way valve

30. Develop an electro pneumatic circuit by cascade method for the following sequence: A +B+B-A- where A and B stand for cylinders, (+) indicates extension and (-) retraction of cylinders. (or) Grooves are to be cut in wooden frames on a shaper (Fig). The wooden frame is to be clamped with a pneumatic cylinder-A as shown in Fig. The feed of the shaper table is carried out by a pneumatic feed the shaper table retracts b cylinders are confirmed by circuit for the above sequence of operations using Cascade method. The cycle has to start only if a start button is pressed b table is carried out by a pneumatic feed unit (cylinder-B). After the groove is cut, the shaper table retracts back, and is followed by unclamping. The strokes of B). After the groove is cut, and is followed by unclamping. The strokes of limit switches a0, a1, b0 and b1. Design a pneumatic sequence of operations using Cascade method. The cycle has limit switches a0, a1, b0 and b1. Design a pneumatic sequence of operations using Cascade method. The cycle hast to start only if a start button is pressed by an operator (Nov/Dec 2021)

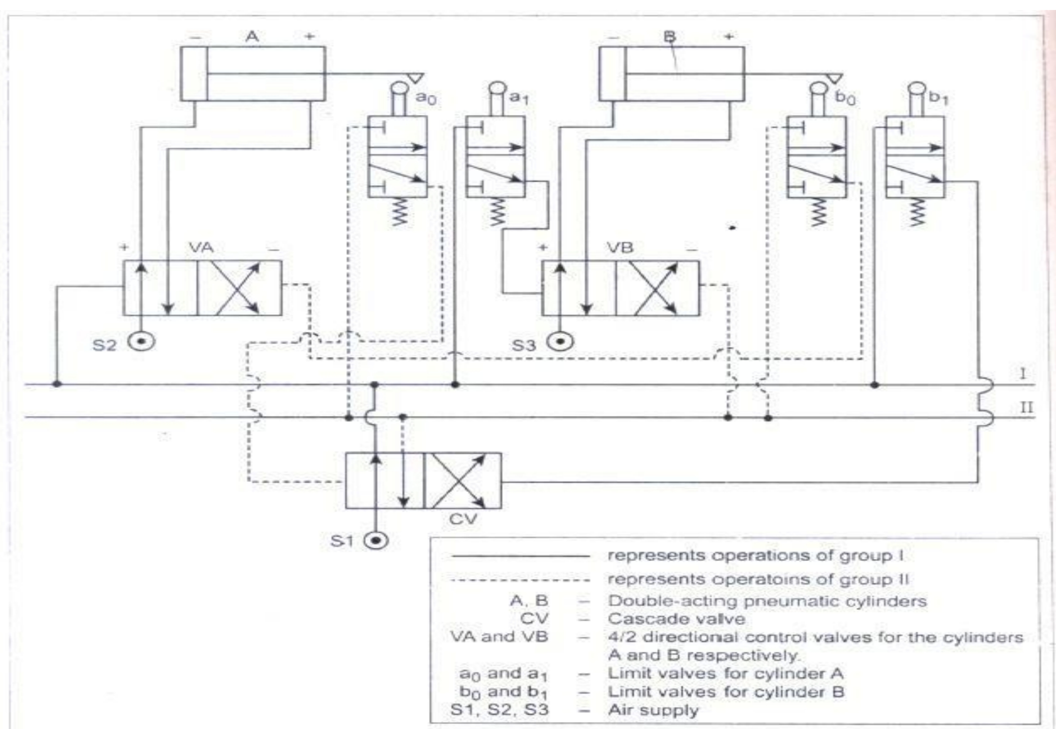


Fig. 13.23. Cascade circuit for A+B+B- A- sequence

☺ ***Solution :*** The solution to this design problem is very much similar to that of the previous problem. So the same procedure may also be followed for this problem.

Step 1 : Given sequence : $A^+ B^+ B^- A^-$

Step 2 : Grouping : $\frac{A^+ B^+}{I}, \frac{B^- A^-}{II}$

Step 3 : Number of pressure lines = Number of groups = 2

Step 4 : (*i*) Number of pilot operated 4/2 DC valve = Number of cylinders = 2

(*ii*) Number of limit valves = 2 × Number of cylinders = 2 × 2 = 4

(*iii*) Number of cascade valves = Number of groups – 1 = 2 – 1 = 1

Step 5 : The cascade circuit and their valve connections for the sequence $A^+ B^+ B^- A^-$ is drawn as shown in Fig.13.23.

UNIT - V
TROUBLE SHOOTING AND APPLICATIONS

Installation, Selection, Maintenance, Trouble Shooting and Remedies in Hydraulic and Pneumatic systems, Design of hydraulic circuits for Drilling, Planning, Shaping, Surface grinding, Press and Forklift applications. Design of Pneumatic circuits for Pick and Place applications and tool handling in CNC Machine tools – Low cost Automation – Hydraulic and Pneumatic power packs.

PART-A

1. List any four common types of faults that can be found in hydraulic systems.

1. Reduced speed of travel of machine tool elements.
2. Slow response to control.
3. Excessive loss of system pressure.
4. Excessive leakage in the system.

3. List any four common causes of hydraulic system breakdown.

1. Inadequate supply of oil in the reservoir.
2. Clogged or dirty oil filters.
3. Leaking seals.
4. Loose inlet lines that cause the pump to take in air.

4. What is the purpose of a tree-branching chart?

A tree-branching chart is a fault finding chart which can be used to simplify the complex fault finding process in a fluid power circuit. This chart helps the maintenance personnel in developing a logical and rapid approach to fault diagnosis.

5. List any four common types of pump faults.

1. Pump may deliver insufficient or no oil.
2. Pump may make more noise.
3. Pump may develop unstable or zero pressure.
4. Pump oil may get overheated.

6. If a pump is delivering insufficient or no oil, what are all the possible causes and also give remedies for them. A pump is delivering insufficient oil to the system. State any three possible causes and remedial actions **(AU Nov/Dec2021**)

Probable Causes	Remedies
1. Wrong direction of shaft.	Must be reversed immediately to prevent seizure.
2.Pump shaft turning too slowly to prime itself.	Check minimum speed recommendation and momentarily increase rpm, to rectify.
3.Clogged strainer or suction pipeline.	Clean strainer or suction pipeline. Remove foreign matter.
4. Air leak in suction line.	Add oil and check oil level in reservoir. Check for leaks and repair.

7. List any two types of faults that can be found in each of the components of a FRC unit.

Faults in a filter:

a. Excessive pressure drop through filter.

b. Contaminants carried through the filter.

Faults in a regulator:

1. Air often escaping from vent hole.
2. Chatter and vibration.

Faults in a lubricator:

1. Oil not delivered from the lubricator.
2. Delayed oil delivery.

8. If an air cylinder produces erratic cylinder action, identify the probable causes and also give remedies for them.

Probable Causes	Remedies
1. Valve sticking or binding.	a) Check for dirt or gummy deposits. b) Check for worn parts.
2. Cylinder sticking or binding.	a) Check for over tightened packing on rod seal or piston. b) Check for misalignment or worn parts.

9. List the probable causes for the problem of leakage of compressed air in pneumatic systems.

a. Loose joints, fittings or glands.

b. Ruptured pipes and hoses.

10. What do you mean by sequencing of cylinders? Name some applications where it would be desirable to have sequencing of two cylinders.

In many applications, the operation of two hydraulic cylinders is required to be performed in sequence one after the another. This is known as sequencing of cylinders.

Applications:

- In a drilling machine, clamping and drilling operations should be performed in a sequence.
- In a punching machine, clamping and punching operations should be performed in a sequence.

11. List any four advantages of employing hydro-pneumatic circuits.

- Using the combination circuit, the quick action of air and smooth, high-pressure action of oil can be blended.
- The hydro pneumatic circuits will reduce space requirements.
- These circuits increase the performance of the equipment.
- These circuits will reduce initial and maintenance cost of original equipment.

12. What is meant by an air-over-oil system?

The air-over-oil system was both air and oil to obtain the advantages of each medium. By the use of these two media, the quick action of air and the smooth high-pressure action of oil can be blended.

13. Why is the load-carrying capacity of a regenerative cylinder small when the piston rod area is small?

We know that,

Regenerative cylinder extending load-carrying capacity, $F_{load} = P. Ar$

Therefore, when piston area (Ar) is small, then the load-carrying capacity of the regenerative cylinder will also be small.

14. Why is extension stroke faster than retraction stroke in a regenerative circuit?

This is because oil flow from the rod end regenerates with the pump flow to provide a total flow rate, which is greater than the pump flow rate to the blank end of the cylinder.

15. What do you mean by synchronization of cylinders? Name some applications where it would be desirable to have two cylinders synchronized in movement.

Synchronization of cylinders is the process of making cylinders to perform identical task at same rate.

Application:

The application of synchronizing of two cylinders can be found in material handling equipment to push heavy components. Also, they are widely used in packing industries.

16. What do you meant by bleed-off circuit control?

In the bleed-off circuit, the flow control valve is connected with its outlet port which is connected to the reservoir. The flow control valve controls flow to the cylinder by diverting an adjustable amount of pump's flow to the reservoir. Since oil delivered to the cylinder does not have to flow through the flow control valve, this circuit avoids the need of dumping excess oil through the relief valve.

17. What is the purpose of a fail-safe circuit?

Fail safe circuit is designed to safeguard the operator, the machine, and the workpiece. It prevents any possible injury to the operator or damage to the machine and the workpiece.

18. What are the axes of a pick and place robot?

The robot has three axes about which motion can occur. They are:

a. Rotation in a clockwise or counter clockwise direction of the unit on its base.

b. Arm extension or contraction and arm up or down.

c. Gripper can open or close.

19. What is an engine management?

An electronic engine management system is made up of sensors, actuators, and related wiring that is tied into a central processor called microprocessor or microcomputer (a small version of a computer).

20. What are the uses of sensors?

They detect a mechanical condition (movement or position), chemical state, or temperature conditioning and change it into electrical signals that can be used by the microcomputer which makes decisions based on information it receives from sensors.

21. Write about the engine speed sensor? [Apr/May-17]

The engine speed sensor is an inductive sensor and consists of a coil for which the inductance changes as the teeth of the sensor wheel pass it and so results in an oscillating voltage.

22. How is the voltage produced by the oxygen sensor?

The oxygen sensor is generally a closed – end tube made of zirconium oxide with porous platinum electrodes on the inner and outer surfaces. Above about 3000C, the sensor becomes permeable to oxygen ions with the result that a voltage is produced between the electrodes.

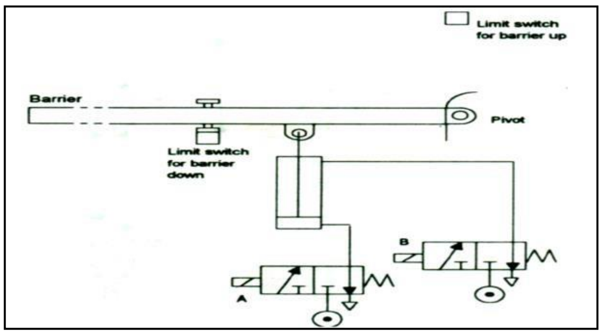
23. List out the various sensors used in engine management system. [Nov-11]

The various sensors used in engine management system are:

- ✓ Throttle-position sensor
- ✓ Exhaust gas oxygen sensor
- ✓ Temperature sensor
- ✓ Speed / timing sensor
- ✓ Engine position sensor
- ✓ EGR value position sensor

24. How does a car park barrier works? [Nov/Dec-16]

When current flows through the solenoid valve A, the piston in the cylinder will move upward and cause the barrier to turn about its pivot and also rise to let a car through. When the barrier hits the limit switch, it will turn on the timer to give a required time delay. After that time delay, the solenoid valve B is activated which brings the barrier downward by operating piston in the cylinder.



25. Name the two barriers used in automatic car parking system and state its uses.

There are two barriers used namely in barriers and out barriers. In barriers is used to open when the correct money is inserted while out barrier opens when the car is detected in front of it.

26. What are the requirements satisfied before starting the timer?

The requirements satisfied before starting the timer are:

- ✓ Start the pulse applied.
- ✓ Check the timer whether it is PN or OFF condition.
- ✓ The timer should be OFF before triggering.

27. What is the use of PLC in automatic car park system?

An illustration of the use of a PLC in the coin operated barriers for a car park. The in-barrier is to open when the correct money is inserted in the collection box and the out – barrier is to open when a car is detected at the car park side of the barrier.

28. Define numerical control machine

Numerical control machine can be defined as a form of programmable machine in which the processes are controlled by a program of numbers, letters, and symbols.

29. What is NC part programming?

NC part programming is the step by procedure of by which the sequence of processing steps to be performed on the NC machine is controlled by a program of numbers, letters, and symbols.

30. What is meant by machining centre?

The machining centre is CNC system with automatic tool changing arrangement that is designed to perform a verity of machining operations, with large number of cutting tools.

31. What is part program?

Part program is a high-level language containing the instructions for machining a part to various standard words, codes and symbols.

32. What is post processing?

Post processing is a computer program that takes a generalized part program output and adopts it to a particular machine control unit and machine tool combination. It is the basic intelligence required to change the program into computer language.

33. What are the major areas to be considered in the design of NC machine tools?

- Machine structure and frame
- Location of transducer
- Slide ways
- Elements of transmission and positioning of sliders

34. Why are pneumatic systems preferred for tool handing in machine tools? (AU Nov/Dec2021)

The main reasons for preferring pneumatic system in tool handling of machine tools are lower upfront and maintenance costs.

35. State the importance of proper trouble shooting of hydraulic systems (AU Nov/Dec2021

The importance of trouble shooting of hydraulic systems is to preserve the nominal conditions ie to take precaution in order to reduce wear during the useful life of the equipment.

PART-B

1. What do you mean by tree-branching chart? Illustrate how it can help in fault finding and fault diagnosis for a hydraulic system.

Fault Finding Using Troubleshooting Charts:

The term troubleshooting refers to an organized and systematic study of the problem and a logical approach to the difficulty faced in a system.

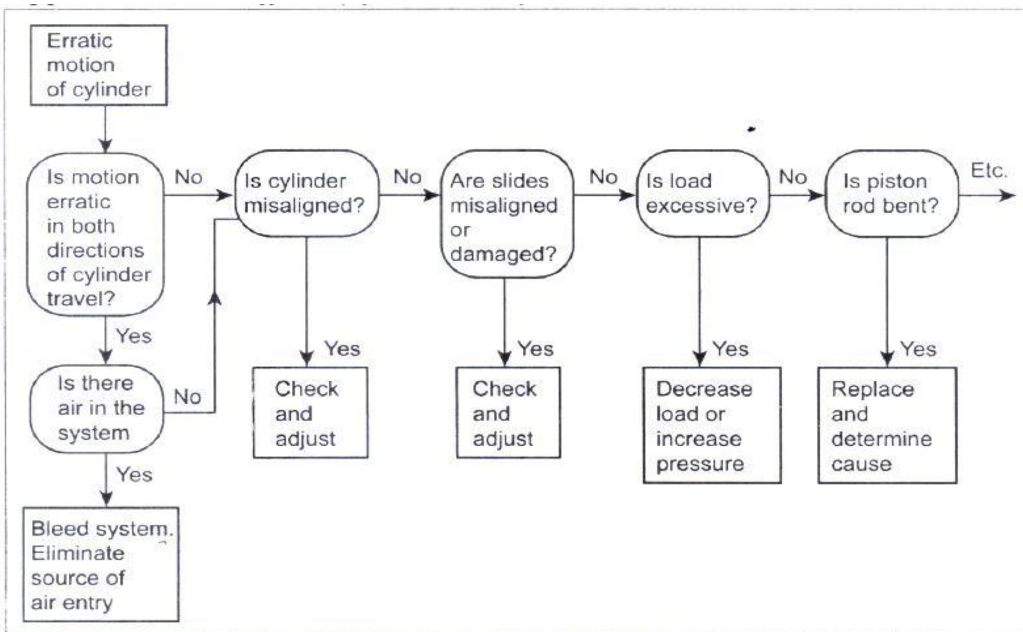


Fig. 5.1. Tree-branching chart for a hydraulic system

Maintenance engineers often use a fault-finding chart, also known as tree-branching chart, to simplify the complex fault-finding process in a hydraulic circuit.

A typical tree branching chart is illustrated in Fig.5.1.

As could be seen from the chart, it asks a question which has answers only in the 'yes' or 'no' type. This answer will determine the next step to be taken. Thus, this tree-branching chart technique helps the maintenance personnel in developing a logical and rapid approach to fault diagnosis.

2. Draw and explain a tree-branching chart for a pneumatic system.

Fault Finding using Troubleshooting Charts:

Similar to hydraulic systems, a tree branching chart shown in Fig.5.2 can be used to find the faults in pneumatic systems.

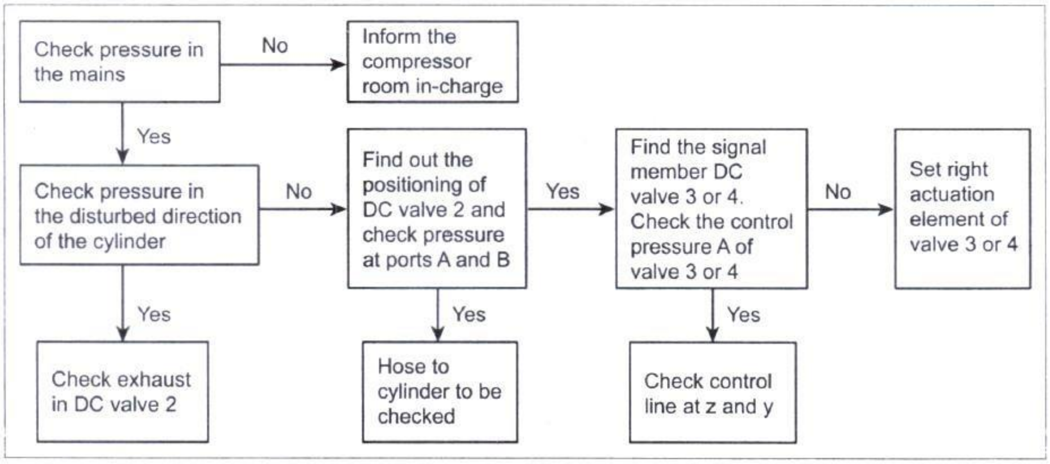


Fig. 5.2. Tree-branching chart for a pneumatic system

3. Explain the detail with Design and Selection of Hydraulic / Pneumatic Circuit Components.

Design and Selection of Hydraulic / Pneumatic Circuit Components:

The primary objective of any system design is to obtain system with higher efficiency. This efficiency of system depends upon careful selection and proper assembly of several components to perform a specific function. So designing and selecting of components for hydraulic or pneumatic systems plays a very important role in it's actual performance. There are basically three important considerations in designing a hydraulic or pneumatic circuits.

(1) **Safety:** The system should be designed in such a way that it will take care of safety of both man and machine.

(2) **Efficient performance:** The system should work efficiently and perform specific task as designed and intended.

(3) **Cost:** The system should be affordable for the particular applications. Pneumatic systems are usually used for the low cost automations.

Other Design Considerations:

Any hydraulic or pneumatic circuit design should be able to fulfill following requirements.

(1) Execute the desired function.

(2) Simple to maintain.

(3) Longer life.

(4) Less running cost.

(5) Proper integration etc.

Pre-requisite for Design:

The designer of the hydraulic/pneumatic system should have knowledge of various aspects of applications. For example, he must design the system according to maximum load requirement that may encounter in the operation. In general, the designer must have information regarding following,

(1) System pressure:

It is the maximum operating pressure that is necessary for the system operation. Usually system is designed to provide higher pressure than maximum operating pressure.

(2) Type of end user/consumer:

There are various types of actuators available for utilizing fluid energy. The selection of particular actuator depends upon application requirements. With a particular actuator, the parameters need to be considered are as follows,

- **Linear actuators:** Need to know the force and speed during the extension as well as retraction stroke. Also, one has to select the cushioning (if needed), sealing etc.

- **Semi-rotary actuators:** The parameters like angle of rotation, speed, torque required, cushioning, sealing etc. must be known.
- **Rotary actuators:** Some parameters required to know are acceleration and deceleration requirements, speed, torque, sealing requirements etc.

(3) Type of controls:

There are various control methods available to choose from, like manual, mechanical, hydraulic, pneumatic, electrical or combination. Apart from this control valve logic can differ from application to application.

(4) Sequence of operation:

There are various operations which includes in a system. These operations are interdependent and can be controlled by either,

a) Event based sequence, or b) Time based sequence.

(5) Operating conditions:

Following are few operating condition parameters that affects the design as well as component selection.

a) Location: The system must be designed by considering it's location. Heavy systems must be having good foundation or stability. The system must be fire proof if the system need to be used in fire hazardous environment.

b) Surrounding/Ambient conditions: The system should sustain various ambient conditions. For example, in cooler region the hydraulic oil should be selected in such a way that it has cloud point very low.

If the environment is dusty and corrosive, proper care must be taken in preventing components from dust and corrosive media.

c) Noise level: Some of the requirements may be having lower noise and clean operation etc. These can be achieved by adding various measures.

(6) Other requirements:

The other requirements which may need to considered are,

a) Type of operation: continuous or intermittent.

b) Level of automation

c) Daily hours of operations.

4. Tabulate the various faults, probable causes, and also the remedial actions for the following hydraulic system components:

(i) Pump, (ii) DC valve, (iii) Hydraulic motors, and (iv) Hydraulic cylinders.

<u>Fault Diagnosis of Hydraulic System:</u>

Table 5.1 presents the various faults, their symptoms, probable causes, and also the remedial actions that can be taken to prevent them in hydraulic systems.

Table 5.1. Various faults, possible causes and remedies of a hydraulic system and its components

Trouble/Fault	**Probable causes**	**Remedial actions**
I. PUMP		
1.Pump delivering insufficient or no oil	Wrong direction of shaft	Must be reversed immediately to prevent seizure and breakage of parts due to lack of oil
	Pump shaft turning too slowly to prime itself	Check minimum speed recommendation and momentarily increase rpm, to rectify

	Clogged strainer or suction pipe line	Clean strainer or suction pipe line. Remove foreign matter
	Strainer capacity insufficient	Replace with a strainer whose capacity is more than twice the maximum flow rate.
	Air leak in suction line	Add oil and check oil level in reservoir. Check for leaks and repair
	Oil leak in pump casing due to seizure or wear of pump sliding parts	Check the sliding parts
	Low level of oil in the reservoir	Add the oil recommended as per the indicator line
	Oil viscosity too heavy to pick up prime or too light causing excessive slippage	Use oil as per recommendation
2.Internal leakage around pump	Shaft packing worn out	Replace
	Top cover packing damaged	Change the packing and apply clamping torque on the cover as per manufacturer's recommendation
3.Excessive wear	Viscosity of oil very low at working conditions	Check pump manufacturer's recommendations or consult your hydraulic engineer
	Sustained high pressure above the maximum pump rating	Check maximum setting of the relief valve
4.Pump oil over-heated	Faulty oil cooler	Repair
	Pump pressure too high	Readjust relief valve setting
	Excessive flow velocity	Replace piping
	Insufficient size of oil reservoir	Increase capacity or install an , oil cooler

II. DIRECTIONAL CONTROL VALVES		
1. Faulty or incomplete shifting	Worn out control linkage, shift pin, etc.	Check and repair
	Insufficient pilot pressure	Check and replace
	Burned out solenoid	Check and replace
	Worn spring centering mechanism	Check and replace
2.Cylinder creeping or drifting	Valve spool not centering properly	Check and rectify
	Valve spool not shifting completely	Check and replace
	Valve spool or body worn out	Check and rectify
	Leakage past the piston in the	Check and overhaul the cylinder
III. HYDRAULIC MOTORS		

1. Motor turning in wrong direction	Incorrect piping between control valve and fluid motor	Check circuits to determine correct piping
2.Absence of proper speed and torque	Relief valve sticking open	Inspect and overhaul relief valve, set correctly
	Free recirculation of oil to reservoir	Identify the exact point of fault and rectify
	Pump not delivering sufficient volume or pressure	Check pump delivery and pressure
3.External oil leakage from fluid motor	Gasket leaking (may be due to drain not connected to the reservoir when required)	Replace gasket. If drain line is required, it must be connected directly to reservoir.
IV.HYDRAULIC CYLINDERS		
1. Piston packing failing too often	Defective or poor quality of packing	Check and consult a hydraulic engineer for the correct solution
	Packing retainer bent	Check and rectify
	Piston bearing worn out	Check and replace
	Design defects in mounting	Consult hydraulic engineer
	Defective rod wiper	Check and change rod wiper
	Getting damaged during assembling	Check and take care during assembling
2.Reduced speed	Oil bypassing the piston	Check and overhaul cylinder. Replace defective parts
	Wrong setting of the control valve	Adjust properly
	Less delivery from pump	Check and rectify
	Directional valve not shifting fully	Check directional valve as discussed before
3.Insufficient force available or no	Defective or very low set relief valve	Check and correctly set as mentioned before
	Oil bypassing the piston	Check and overhaul the

5. Enlist the various faults, probable causes, and also the remedial actions for the following pneumatic system components:

(i) Compressor, (ii) FRL unit, (iii) Air cylinder, and (iv) Pipelines and hoses.

Fault Diagnosis of Pneumatic System:

Table 5.2 presents the various faults, their symptoms, probable causes, and also the remedial actions that can be taken to prevent them in pneumatic systems.

Table 5.2. Various faults, possible causes, and remedies of a pneumatic system and its components

Trouble/Fault	Probable causes	Remedial actions
I. COMPRESSORS		
1.Unusual noise	Leaking cylinder valve	Adjust and stop leakage

	Loose belt in compressor wheel, motor pulley	Adjust the belt as recommended
	Motor with excessive end play in shaft	Adjust the end play
	Carbon on top of the piston	De-carbonize
	Leaking, broken or worn out constant speed unloader parts	Adjust or replace
	Valve seats worn	Recondition valve seat
	Loose motor fan	Tighten the motor fan
2.Inadequate performance	Dirt in suction filter	Clean filtering plate and filter disc. Do not use gasoline for danger of explosion
	Defective sealing of cylinder head	Mount fresh packing of the cylinder head
	Piston rings broken or not sealed	Replace piston rings as per manufacturer's instructions
	Rough, scratched or excessive end gaps	Replace
II. FILTERS		
1. Excessive pressure drop through filter	Dirty filter element	Replace filter element
	Filter is undersized	Consult manufacturer's flow charts; consider both body, size and port sizes when specifying
2. Contaminants carried through the filter	Elements omitted during servicing	Replace missing elements
	Elements not tightened enough	Tighten elements to prevent bypass
	Broken elements	Replace broken elements
	Element too coarse	Replace with finer graded elements
3. Moisture in downstream air	Sump of filter bowl has collected too much water and water is re-entering the system	Drain bowl or install automatic drain
	Installation is wrong	Correct installation
	Location is incorrect: filter too close to the after cooler or too high in the plant ceiling	Relocate filter or install a dryer
	Dew point of air is too high	Install a dryer
III. REGULATORS		
1. Regulator cannot reach high set point	Pressure gauges are inaccurate	Ensure that gauge calibration is a regular maintenance function
	Insufficient upstream pressure	Measure and compare inlet pressure with outlet pressure
	Incorrect control spring range	Check model number for type used and replace

	Leakage in downstream circuit	Check fittings, valves, cylinders and regulators, correct as required
2. Set point pressure becomes too high	External loads imposing a higher pressure	Use pressure relief valves, circuit changes or a venting regulator
	Leakage from inlet side: worn out poppet seal, seat or balancing seal	Check for leakage and replace parts as necessary
IV. LUBRICATORS		
1. Oil not delivered from the lubricator	Empty reservoir bowl	Institute program of regular refilling, or use an automatic refill system
	Clogged passageways	Disassemble and clean
	Closed needle valve	Check adjustment
	Clogged pick-up tube inlet	Clean away debris
	Non-vertical positioning	Reposition and/ or relocate the lubricator
2. Oil delivery is delayed	Initial start up delays are natural	Allow a few minutes of sustained air flow to fill internal passageway in the lubricator with oil
	Internal leakage in oil passageways	Disassernble and inspect for missing, damaged or improperly assembled parts
	Clogged pick-up tube inlet	Clean away debris
V. PIPELINES AND HOSES		
1. Pressure drop due to leakage of compressed air	Loose joints, fittings or glands	Tighten them
	Ruptured pipes and hoses	Replace the pipes and hoses
2. Pressure rises at specific points	Pipes, hoses are blocked	Clean and remove dirt
	Pipes, hoses are bent	Change them
3. Noise level is high	Silencer stops working	Clean it
VI.AIR CYLINDERS		
1. Cylinder fails to move the load when valve is actuated	Binding in machine linkage	Check linkage to ensure that excessive friction loads are not present
	Pressure too low	Check the pressure at the cylinder to make certain that it is in accordance with circuit requirements
	Cylinder undersized for loads	Re-calculate force needs and install appropriately sized cylinders to carry the load
	Piston rod broken at piston end	Disassembled and replace piston rod

2. Excessive or rapid piston seal wear	Seal installed incorrectly	Check installation instructions and make necessary corrections
3.Rod gland seal leak	Torn or worn seal	Examine the piston rod for dents and nicks. Replace the piston rod if the surface is rough
4.Cylinder body seal leak	Loose tie rods	Tighten the tie rods according to manufacturer's recommendations
	Excessive pressure	Reduce the pressure to the rated limits
	Pinched or extruded seal	Replace the cylinder body seal
	Seal deterioration	Check the compatibility of seal material with the lubricant used

6. Explain with neat circuit. a) Hydraulic circuit for drilling b) Hydraulic circuit for shaping.

<u>Hydraulic Circuit Design for Drilling</u>:

The basic circuit used to achieve drilling operation is regenerative center circuit, wherein central position of direction control valve gives regenerative action. Fig.5.3 shows hydraulic circuit for drilling operation.

List of components:

i) Tank (T_k)
ii) Pump (P_p)
ill) Filter (F)
iv) Pressure relief valve (PRV)
v) Directional control valve (DCV) - 4/3 solenoid operated, spring centered
vi) Consumer (C) : Double acting cylinder.

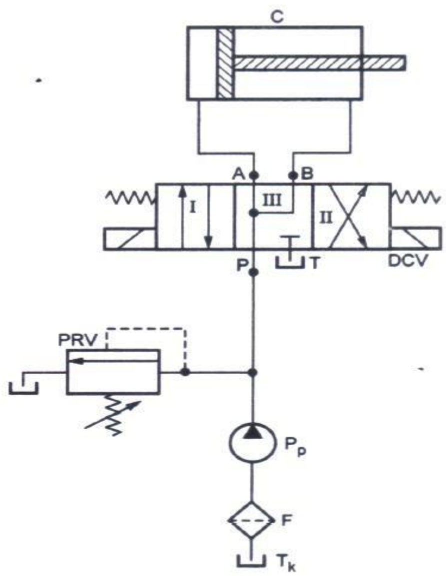


Fig. 5.3 hydraulic circuit for drilling machine

Operation:

1) The system utilizes 4/3 directional control valve which has 3-positions (switching/spool positions) and 4-ways. Most importantly regenerative central position is used.
2) At the spring centered position of the DCV, port 'P' is connected to both port 'A' and 'B' and tank port T is blocked. This is regenerative arrangement, where pump flow goes to 'A' and flow from rod end of the cylinder also joins the pump flow to give rapid spindle advance (no work is done during this period).
3) The reason for rapid extension of cylinder is simple, because oil from the rod end regenerates with the pump flow going to the blank(piston) end. As effective flow rate to blank end increases, the spindle (cylinder) extension speed increases.
4) When the DCV shifts to spool I position. 'P' is connected to 'A' and 'B' is connected to 'T'', which gives slow feed (again extension itself) when the drill starts to cut into the work piece.
5) Similarly, when the DCV shifts to spool n position, 'P' is connected to 'B' and 'A' is connected to 'T', since the ring area is less, the cylinder (spindle) will have fast return motion.

Hydraulic Circuit Design for Shaping Machine:

In hydraulic shaper tool is actuated by using double acting cylinder over the bed carrying workpiece to be machined. Fig. 5.4 shows hydraulic circuit for shaper machine.
The basic circuit used to achieve shaper operation is meter-out circuit.

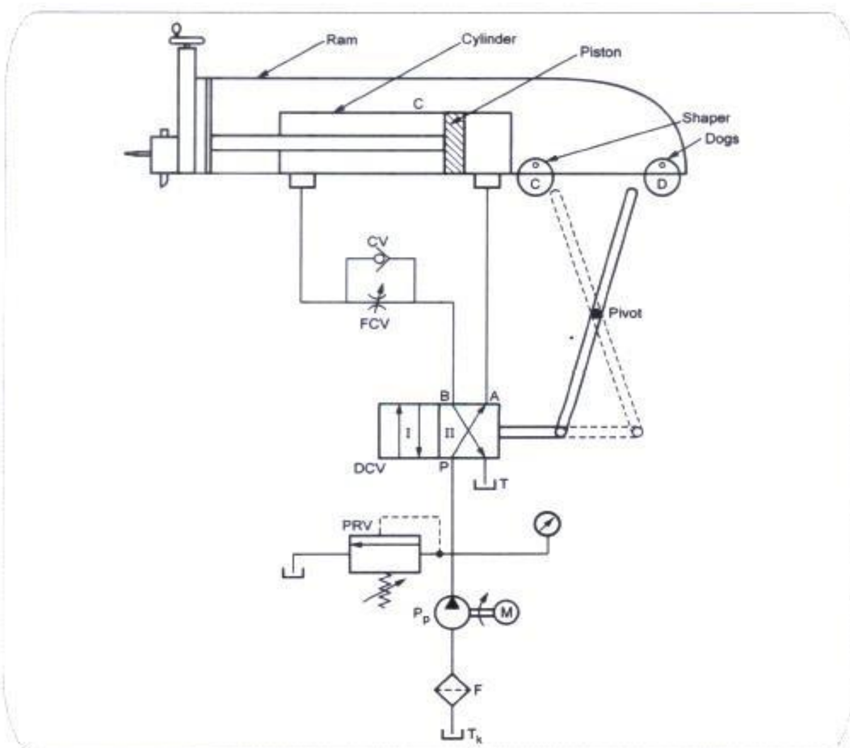


Fig. 5.4 Hydraulic circuit for shape operation

List of components:

i) Tank (T_k)

ii) Filter (F)

ill) Pump (fixed discharge) (Pp)

iv) Pressure Relief Valve (PRV)

v) Directional Control Valve (DCV) - 4/2 mechanically operated

vi) Flow Control Valve (FCV)

vii) Check Valve (CV)

viii) Consumer I Cylinder (C)

Operation:

1) The system uses 4/2 DCV which is operated mechanically. The shaper dogs shown in the Fig. 5.4 marked by 'C' and '0' alters the spool of DCV when being hit by the lever at the end of stroke.
2) When spool-II of DCV is in position port 'P' is connected to port IA' and port 'B' is connected to port 'T'. The fluid from pump (fixed discharge hydraulic pump) enters blank (piston) side and gives forward/extension stroke to carry out shaping operation.
3) The return fluid from rod side will pass through FCV, depending upon opening of FCV valve the speed is being varied i.e. It's a meter out combination.
4) At the end of extension stroke, lever hits the shaper dog '0' and it alters the spool position of DCV to I.
5) Due to spool position I of DCV, 'P' get connected to 'B' and 'A' gets connected to 'T', which allows pump flow to enter the rod side of DCV and shaper changes it's course for retraction still the shaper dog get's hit by lever and again the sequence gets repeated.

7. Draw typical planning hydraulic circuit and explain its working.

Hydraulic Circuit for Plans (Planning Operation):

Often shapes and planes operations are considered similar ones as both are used to make flat surfaces, cut slot and grooves and also to make concave and convex geometry.

However, there is basic and main difference between the both which is in the shaper machine work piece is fixed at the table and tool is in reciprocating motion.

While in planer, machine tool act like a stationary body and work piece move over it. Fig. 5.5shows circuit for typical planning operation(planer circuit).

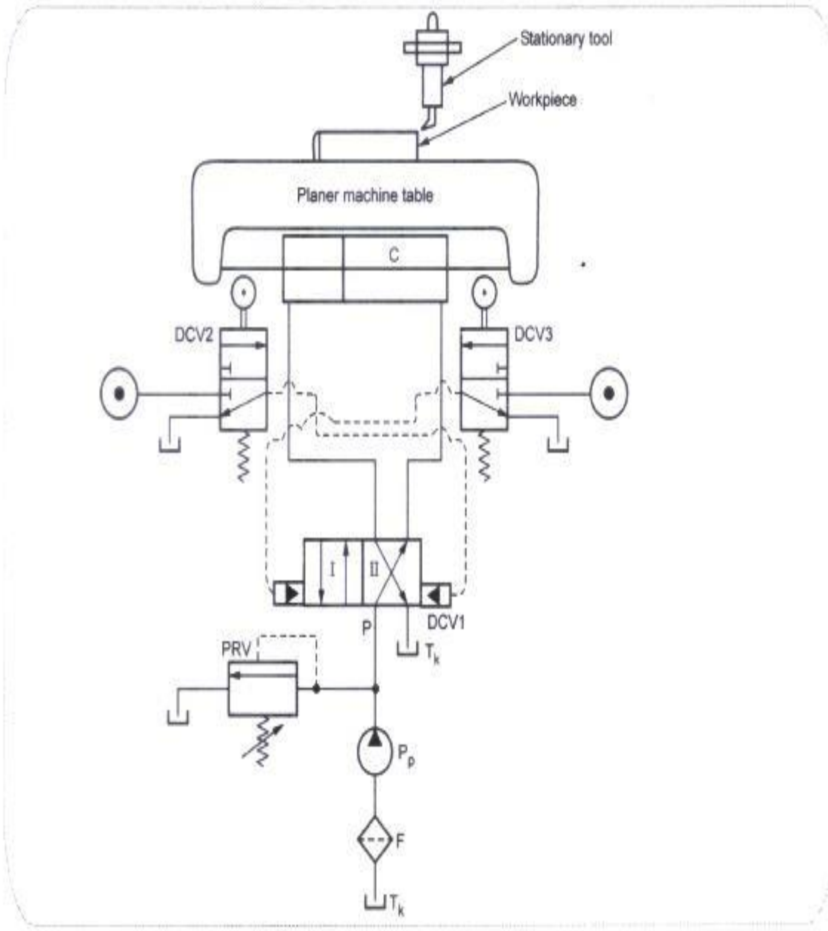


Fig. 5.5 Hydraulic circuit for planer machine tool

List of components:

i) Tank (T_k)
ii) Filter (F)
iii) Pump (Pp)
iv) Pressure relief valve (PRV)
v) Directional control valve (DCV)
  a) 4/2 DCV - Hydraulically operated
  b) Two 3/2 DCV - Roller operated (Mechanically operated)
vi) Cylinder (Double acting non-differential hydraulic cylinder)

Operation:

1) A simple automatic reciprocating circuit is used to reciprocate machine table carrying work piece between the end positions.
2) When DCV1 position is at 1 spools machine table slides rightward allowing workpiece to rub against a stationary tool. At the end of stroke, machine tool itself operates roller actuated DCV2, which generates hydraulic pilot signal to change the DCV1 position to spool II.
3) This in turn moves table leftward causing work piece to rub against tool. At the end of this stroke, machine tool operates roller actuated DCV3, which generates hydraulic signal causing change in spool position of DCV1 from II to 1.
4) This process is continued still pump is not shut off or supply is not cut.

8. Draw typical Hydraulic Circuit Design for Press and explain its working.

<u>**Hydraulic Circuit Design for Press:**</u>

There are various types of applications of the press. They are basically used for doing forging or drawing or pressing applications etc. Every hydraulic press is characterized by the following,

a) Gives large amount of force b) Quantity of fluid flow is large c) The size of lines, cylinders etc. are large Due to above the working presses range of hydraulic pressures is quite high. Fig. 5.6 shows a typical circuit used for hydraulic press.

Circuit for the mentioned conditions is outlined below,

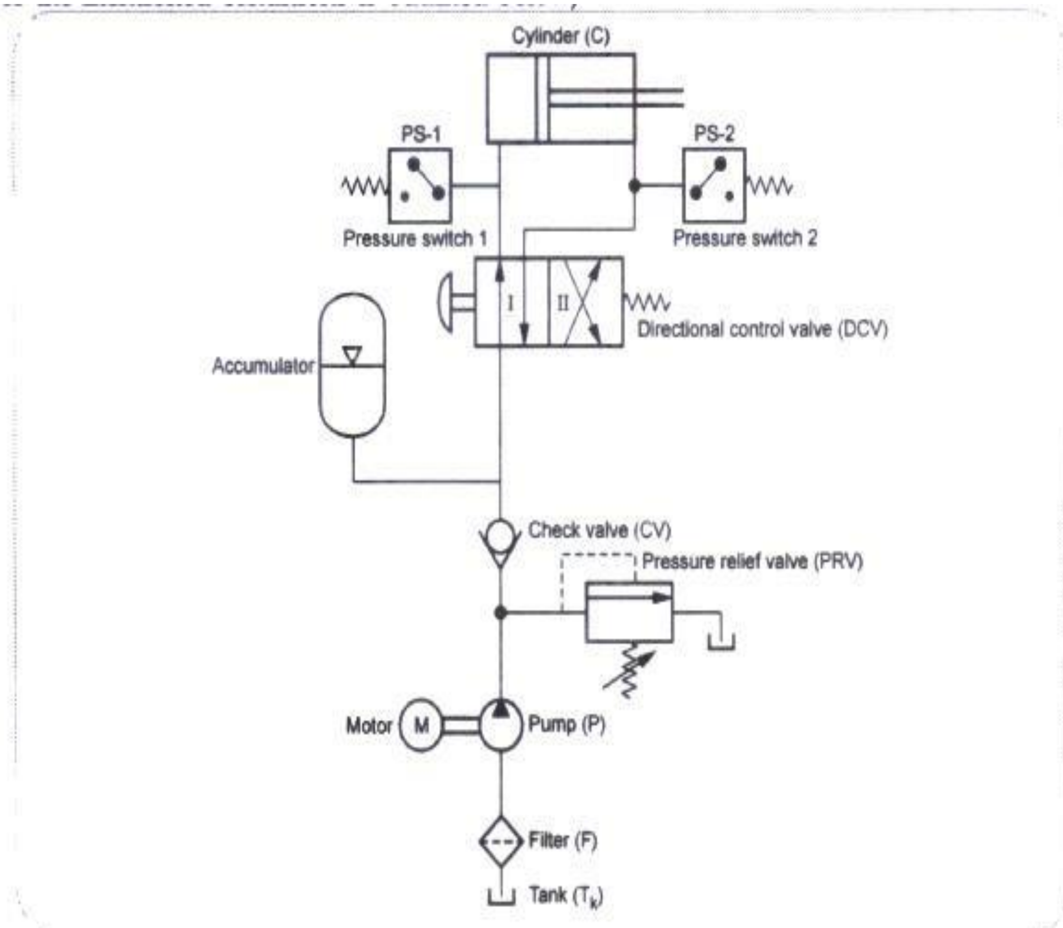


Figure 5.6: Hydraulic Circuit Design for Press:

Operation of the circuit:

1) Default spool position-a of DCV, brings retraction of cylinder (C). In order to execute working stroke of press, one has to push DCV button to activate spool position-I of DCV.
2) The spool-I of DCV connects the pressure line to the piston side of cylinder, hence the working (forward) stroke of press get executed.
3) At the end of forward stroke pressure switch shut off the motor, as it senses the increase in pressure in the pressure line.
4) Due to stoppage of pump supply and release of push button of DCV, which brings, spool position-I in action, the pressurized fluid from accumulator flows towards the rod side of the cylinder to execute return stroke.
5) Note here check valve (CV) restricts the pressurized flow of accumulator fluid from entering towards pump side.

9. Draw typical Hydraulic Circuit Design for Forklift Pressure System and explain its working.

<u>Hydraulic Circuit Design for Forklift Pressure System:</u>

Forklift hydraulic system has numerous applications in heavy job lifting in industrial domain. It provides platform to lift and shift various goods across industry floor with ease. Fig. 5.7 shows a typical hydraulic forklift pressure circuit.

List of components :

i) Tank (T_K)

ii) Filter (F)

ill) Pump (Pp)

iv) Pressure relief valve (PRV)

v) Directional Control Valve (DCV) - Proportional Control Valve

vi) Cylinder (Single acting vertical cylinder)

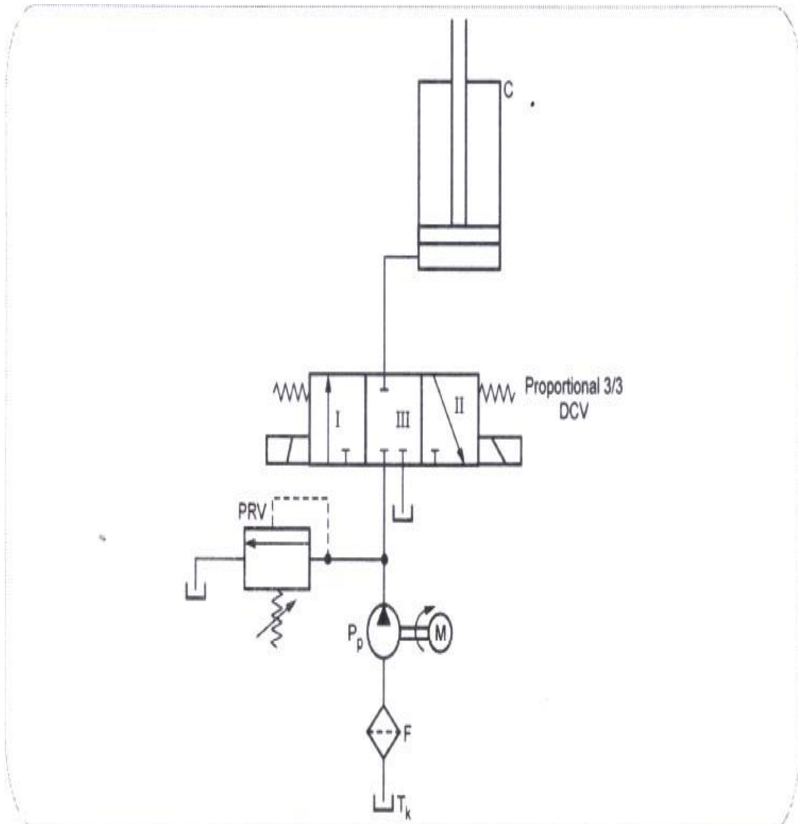


Fig. 5.7 Forklift hydraulic circuit

Operation :

1) Single acting vertical cylinder is used to lift or lower the goods according to the will of it's operator.
2) Proportional type 3/3 directional control valve is used to control the fluid flow either towards actuator or towards tank.
3) For lifting operation fluid flow is connected to the piston side of cylinder, the DCV position 1 is maintained during this period. It can be raised to any height between stroke length and maintained at that height by using proportion DCV position ill.
4) To lower the load, proportion DCV position II is used to allow the flow towards tank due to gravitational force (pressure) on a fluid.
5) Proportional DCV helps to achieve precise raising or lowering of weight.

10. Draw typical surface grinding hydraulic circuit and explain its working. (AU Nov/Dec21)

Sketch a hydraulic circuit used for the operation of a surface grinder and explain the same

Hydraulic Circuit Design for Surface Grinding:

In surface grinding, machine table movement is achieved through automatic reciprocating circuit. One such a circuit is shown in Fig. 5.8. Automatic reciprocating circuit can be developed in number of ways. In this case limit switches are used to control 4/2 DCV and it's actuation.

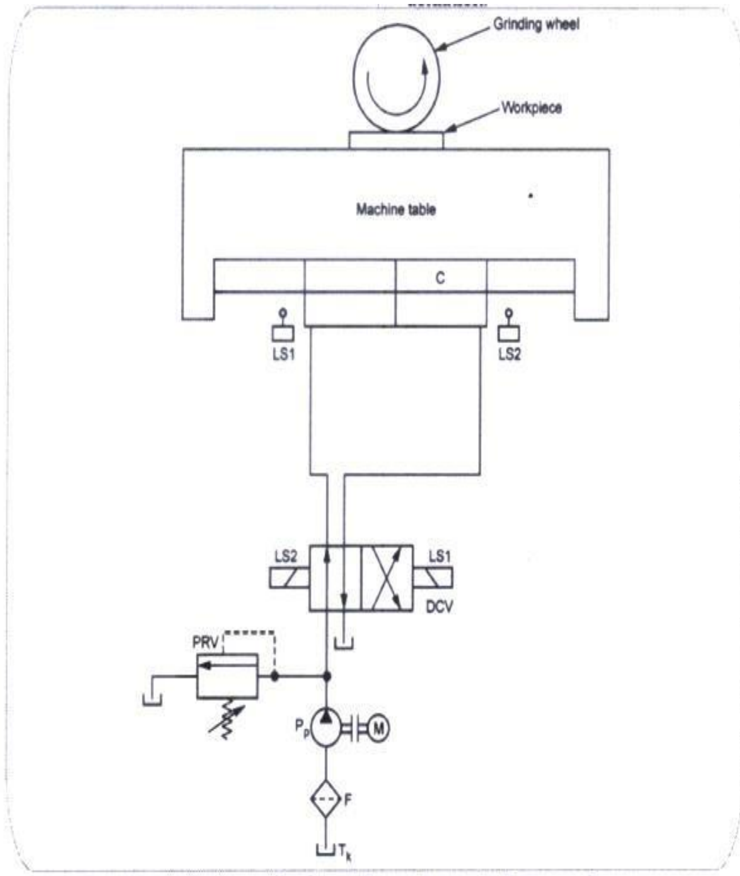


Fig. 5.8 Hydraulic circuit for surface grinding operation

List of components:

i) Tank (T_k)

ii) Filter (F)

ill) Pump (Pp)

iv) Pressure Relief Valve (PRV)

v) Directional Control Valve (DCV) - 4/2 solenoid operated.

vi) Unit switches (LS1 and LS2)

viii) Cylinder (C) Double acting non-differential type

Operation :

1) In surface grinding machine, the workpiece is clamped on the table. The machine table is made to reciprocate using a double rod end (non-differential) type hydraulic cylinder.
2) Continuous reciprocation of ram can be obtained by using limit switches, which actuates 4/2 DCV when hit by the machine ram.
3) During rightward journey of table, the limit switch LS1 is actuated which sends solenoid signal to the 4/2 DCV to change it's position and vice-versa for the leftward journey of piston.
4) Continuous actuation of DCV and reciprocation of cylinder takes place unless pump stops the flow.

11. What is Low cost Automation? Explain the Scope of Low Cost and Automation and Automatic Operation Control.

Low Cost Automation:

Automation is a part of modem working. Every industry try to make their processes automatic due to various reasons discussed below,

1) It reduces human efforts
2) It makes processing cost low.
3) It can work restless.
4) It keeps the industry in competition as it ensures the quality of product.
5) It reduces problem of skilled labour, etc.

Hence industries which were working manually and completely depended on labour, now shifting to the semi-automatic or automatic operations.

Pneumatic system plays a vital role in making processes or operations of industries automatic. It is a very good source of low-cost automation. The advantages of such a pneumatic automated system are,

1) Saving valuable time of workers as well as of industry
2) Improvement in performance efficiency
3) Avoids fatigue of labours
4) Produces components/goods at lower cost etc.

It utilizes pneumatic, hydraulic, electrical and mechanical components to produce a effective automatic system.

The components like pressure dependent valves, time dependent valves, limit switches; solenoids etc. are used to produce automatic system.

Scope of Low Cost Automation:

There is huge scope available for low-cost automation in the industry today. From pushing the component to finally packing it, from conveying component (from one location to other) to holding it etc. can be automated systematically.

Following are the few areas where low-cost automation can be effectively used. These are,

- Pushing or pulling of components
- Clamping
- Conveying components
- Painting of vehicles or other objects
- Manufacturing process like drilling, broaching, riveting etc.
- Assembly operations like bolting, components inserting etc.
- Welding operation etc.
- Measurement and inspection.

Automatic Operation Control:

Position sensors can be used to operate valves, hence the automatic processes can be operated by using such sensors, where different steps can be initiated depending upon position sensors and their actuations. A simple example of such circuit where automatic return of the cylinder is facilitated at the end of forward stroke is shown in Fig. 5.13 below

When the extend switch i.e. DCV1 is pressed, the compressed air acts as a pilot signal to shift the position of DCV3 from spool-Il to spool-I ; which allows compressed air to flow towards piston side for forward stroke.

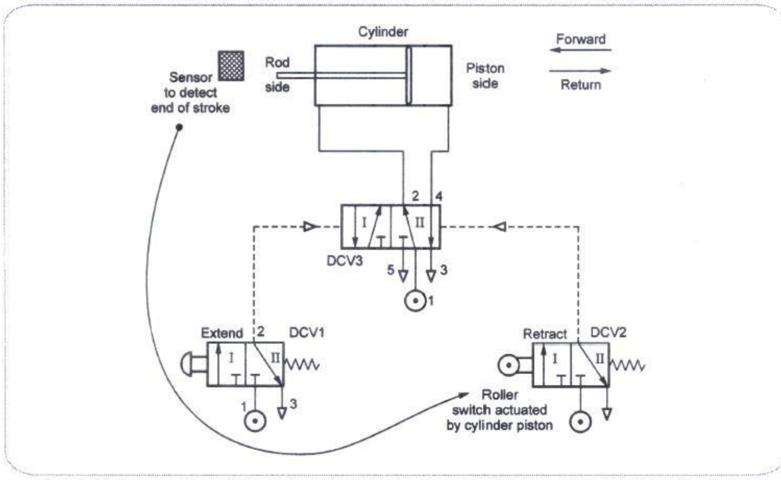


Fig. 5.13 Automatic return circuit

When the piston rod reaches end of it's stroke, it trips a roller limit switch with then switches the retract valve so that piston then retract, because pilot signal from DCV2 forces the DCV3 to change position from spool-I to spool-no The controls can be of two types

1) Time dependent controls
2) Pressure dependent controls.

1) Time dependent controls:

The above example of automatic return circuit is example of position sensed control events; happening at a particular position.

Another situation that can be a case of time control events happening after a particular time. In such cases time delay valves can be used to delay pilot signals.

The principle of operation of time delay valves, involves the use of an orifice to slow down the flow of air and control the time of pneumatic operation.

Time delay functions can be divided as

a) ON-signal delay b) OFF-signal delay.

These are also called as pneumatic timers. They are available as normally closed timers and normally open timers. Normally open pneumatic timers are also used in signal elimination and used as a safety device in two hand blocks.

Time delay valve is basically a combination of

- 3/2 DCV pneumatically actuated,
- An air reservoir and
- Throttle relief valve.

a) ON delay timer: The ON delay signal circuit is shown in the Fig. 5.14 which delays the output of the next control valve. When control valve DCV1 is operated, the one-way flow control valve will slow down the flow of air, thus delaying the signal output of control valve

i.e. DCV2 and output 'A', resulting in a persistent ON signal. The time when control valve DCV2 will be restored to it's original position is not affected.

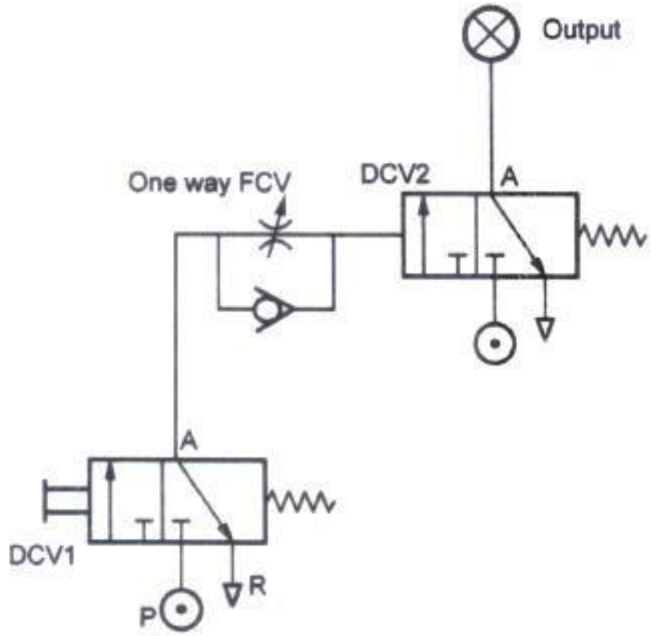


Fig. 5.14 Circuit diagram of an ON signal delay circuit

b) OFF delay timer:

Fig. 5.15 shows a circuit diagram of an off-signal delay circuit, which delays the output of the next control valve. It is similar to that of ON delay circuit. The only difference is that the one-way flow control valve (check valve) is connected in the opposite direction.

Therefore, when control valve DCV1 is operated, the outlet of control valve DCV2 (A) will continue to output signals.

However, when control valve DCV2 is restored to it's original position, the release of air is slowed down by the one way flow control valve, resulting in a persistent OFF signal.

Fig.5.16 shows the construction of an ON-delay timer (NC - Normally Closed) type in the normal and actuated position.

However, the valve can be operated in the OFF-delay mode by connecting check valve in reverse direction. For this purpose, the ports of the throttle check valve should be brought out.

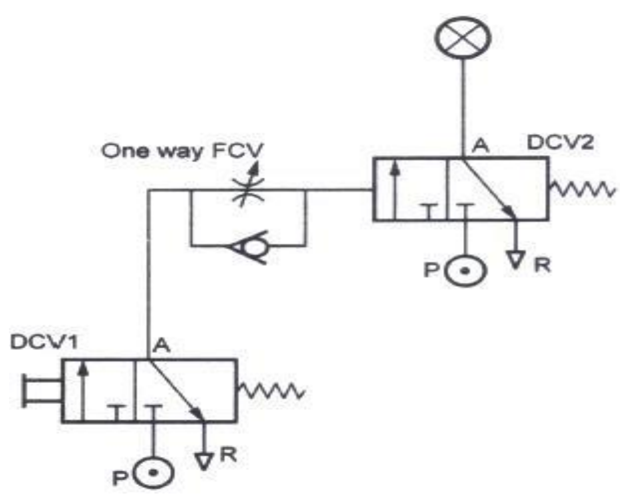


Fig. 5.15 Circuit diagram of an OFF signal delay circuit

2) Pressure dependent control :

In pressure dependent control, the pressure sequence valve is used, which is essentially switch on or off valve. Sequence valve generates pneumatic signal if the sensing pressure (signal input) is more than the desired set pressure.

The generated output signal is used to control the movement of cylinder by using it as a set signal or reset signal to the final control valve to obtain forward or return motion respectively.

Used for the applications such as bonding cylinders, clamping cylinders etc. to ensure desired minimum pressure in the cylinder. This is the combination valve, having two sections.

One of the sections is a 3/2 directional control and the other a pressure control valve. Fig. 5.17 shows the symbol of pressure sequence valve.

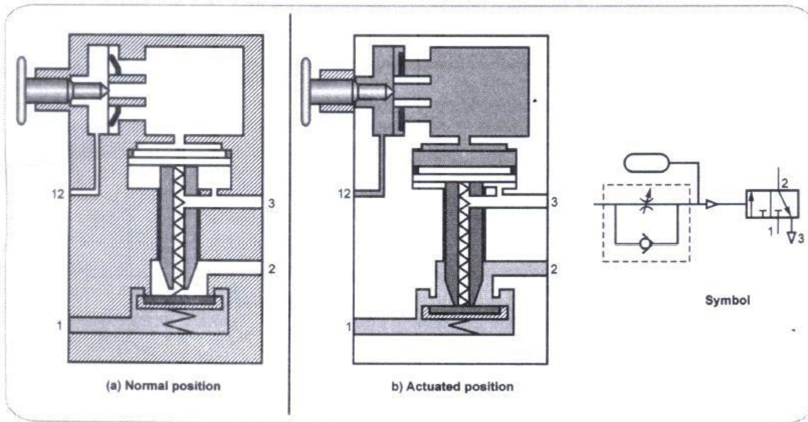


Fig. 5.16 ON delay valve

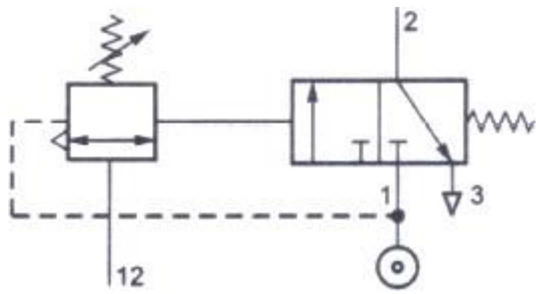


Fig. 5.17 Pressure sequence valve

The construction details of sequence valves is already seen in pneumatic valves. Fig. 5.18 shows the simplified sketch of pressure dependent control valve in normal and actuated position.

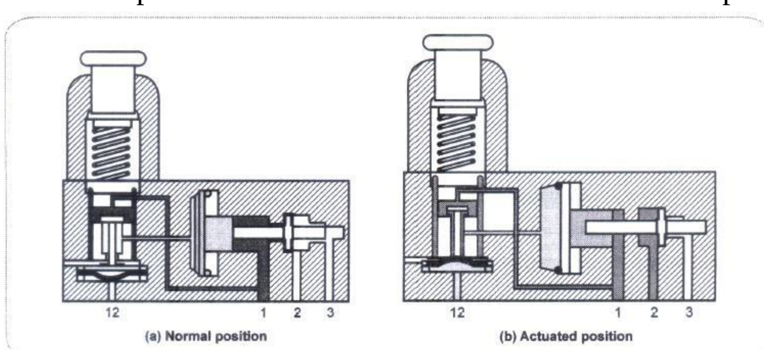
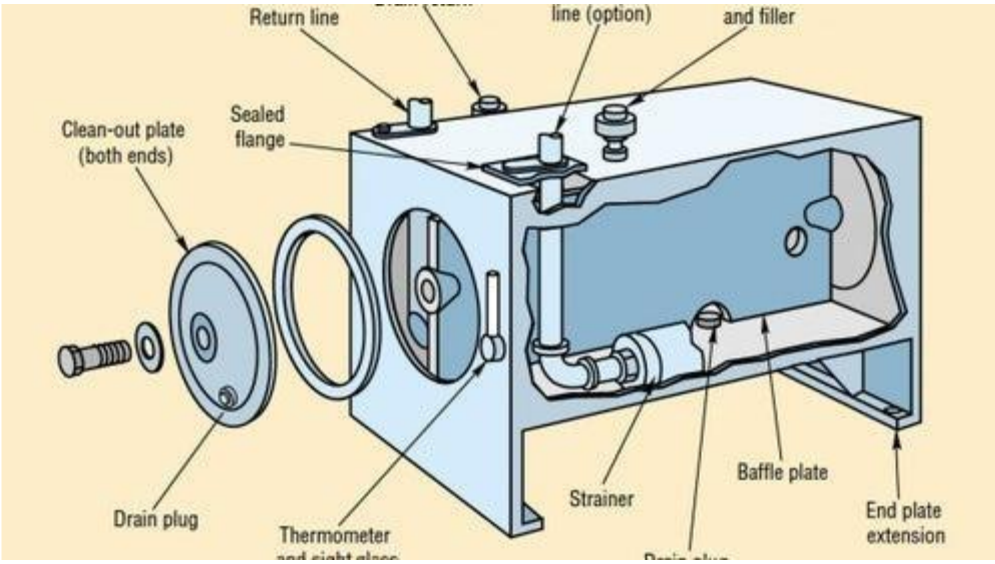


Fig. 5.18 Pressure dependent control valve

12. Sketch a typical reservoir used in a stationary hydraulic machine and discuss the functions of reservoir in the system (AU Nov/Dec2021)



The main function of a reservoir is to hold system hydraulic fluid in a convenient location for the pump inlet. In addition to system requirements, the reservoir also holds excess fluid needed when the hydraulic system is in operation.

This excess fluid is needed when an accumulator is being charged or a cylinder is being extended.

The reservoir performs many roles in the operation of the hydraulic system.

One of its primary jobs is for heat dissipation (cooling the hydraulic fluid) and fluid conditioning (dissipation of contaminants and aeration).

Most hydraulic reservoirs incorporate an internal baffle that is used to circulate turbulent fluid that is hot, dirty and aerated from the system return side of the reservoir to the quiet and cooler pump inlet side.

This movement of the fluid around and through the baffle creates time for fluid contaminants to settle out to the bottom of the tank and for air entrapped in the fluid to separate and rise to the fluid surface.

With most industrial hydraulic systems, the reservoir also serves as the mounting surface for system components such as pump/motor assemblies, filters, accumulators, manifolds and electrical control panels.