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Scheme of Evaluation and solution IAT 4 – Feb. 2022

Sub:	Fluid Power Engineering					Sub Code:	18ME55	Branch:	ME
Date:	01/02/2022	Duration:	90 min's	Max Marks:	50	Sem / Sec:	5th sem A & B		

Note: 01. Answer any THREE full questions, choosing at least ONE question from each MODULE.
02. Draw neat sketches wherever necessary.

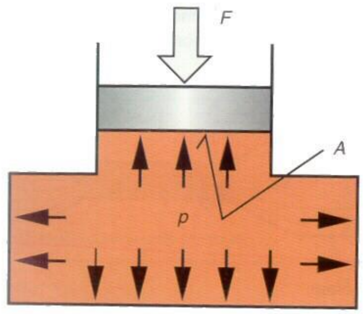
Q.N.	**Module 1**	**Marks**
1.a)	State Pascal's law and explain the working of hydraulic jack using Pascal's law.	**8**
b)	What are the advantages and limitations of hydraulic system?	**6**
c)	List the types of hydraulic fluids used in a hydraulic systems stating its advantages	**6**
	OR	
2.a)	Differentiate between strainers and filters. Discuss the basic methods of filtering used in hydraulic circuits.	**8**
b)	List and explain the desirable properties of fluid used in the hydraulic system.	**6**
c)	List and explain different types of sealing materials commonly used.	**6**
	Module 2	
3.a)	With neat sketch explain the working of variable displacement vane pump.	**6**
b)	List and explain various pump performance parameters.	**4**
c)	A pump having 96% of volumetric efficiency drives of 0.030 m^3/min of oil at 1000rpm. Calculate the volumetric displacement of pump.	**10**
	OR	
4.a)	With neat sketch explain the construction and working of gear motor.	**5**
b)	With the neat sketch explain the function of shuttle valve.	**5**
c)	A hydraulic motor has a displacement of 164 cm^3 and operates with a pressure of 70 bars and a speed of 20000 rpm. If the actual flow a rate consumed by the motor is 0.0006m^3/sec and the actual torque delivered by the motor is 170NM, find i. Volumetric efficiency ii. Mechanical efficiency iii. Overall efficiency iv. The actual kW delivered by the motor	**10**
	Module 3	
5.a)	With neat hydraulic sketch explain the working and control of single and double acting cylinders.	**10**
	OR	
6.a)	With neat hydraulic circuit explain the working of counter balance valve application.	**10**

CI **CCI** **HOD**

State Pascal’s law. Explain Pascal’s law applied for hand operated jack.

Pascal’s Law is the most fundamental principle in fluid power. It deals with hydrostatics, the transmission of force through a confined fluid under pressure.

Pascal’s law reveals the basic principle of how fluid power systems perform useful work. This law can be stated as follows: “Pressure applied to a confined fluid is transmitted undiminished in all directions throughout the fluid and acts perpendicular to the surfaces in contact with the fluid”.



Pressure in an enclosed fluid can be considered uniform throughout a practical system. There may be small differences arising from head pressures at different heights, but these will generally be negligible compared with the system operating pressure. This equality of pressure is known as *Pascal’s law,* and is illustrated in figure above.

The applied force develops a pressure, given by the expression:

$$p = f/a$$

The force on the base is:

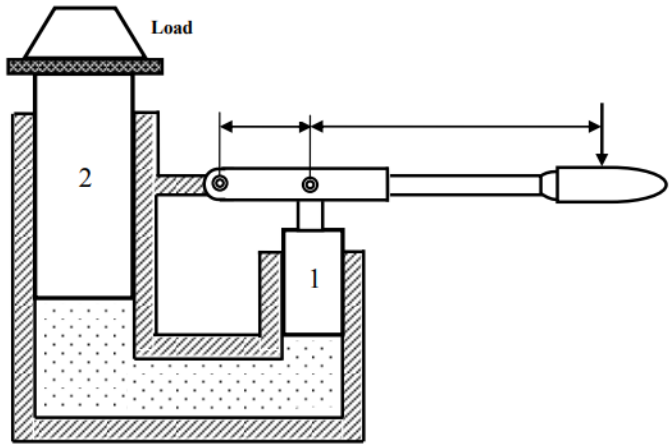
$$F = p \times A$$

from which F can be derived as:

$$F = f \times A/a$$

The above expression shows an enclosed fluid may be used to magnify a force.

The principle of Pascal’s law was successfully applied by an English engineer, Mr. Joseph Bramah, to develop a hydraulic press in which by applying a small input force a large output force was generated.



The above figure shows a hand operated hydraulic jack which works on the principles of Pascal's law.

2. What is the purpose of seals in fluid power system? List the various types of seals used in fluid power system.

Leakage from a hydraulic or pneumatic system can be a major problem, leading to loss of efficiency, increased power usage, temperature rise, environmental damage and safety hazards. Minor internal leakage (Example: Round the piston in a double-acting cylinder) can be of little consequence and may even be deliberately introduced to provide lubrication of the moving parts. External leakage, on the other hand, is always serious. In pneumatic systems, external leakage is noisy; with hydraulic systems, external loss of oil is expensive as lost oil has to be replaced, and the resulting pools of oil are dangerous and unsightly.

Functions of Seals

Seals are used in hydraulic systems to prevent excessive internal and external leakage and to keep out contamination. Various functions of seals include the following:

1. They prevent leakage – both internal and external.

2. They prevent dust and other particles from entering into the system.

3. They maintain pressure.

4. They enhance the service life and reliability of the hydraulic system.

The following represents the most widely used types of seal configurations.

1. O-rings
2. Compression packings (V- and U- shapes)
3. Piston cup packings
4. Piston rings

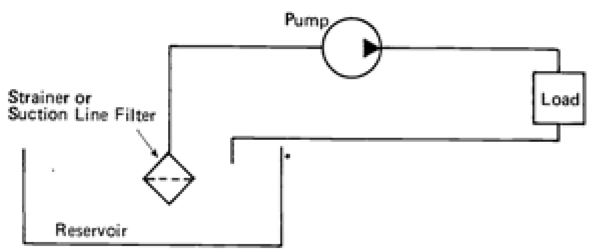
5. Wiper rings

3. Explain types of filtering methods and filters. **(08 Marks)**

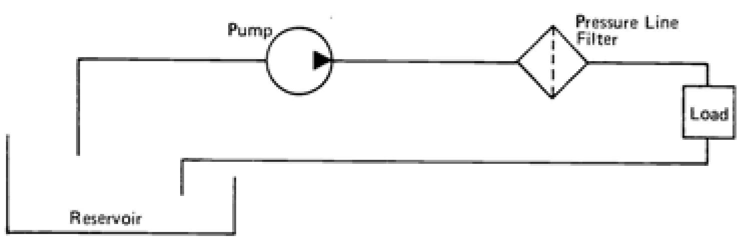
According to the filtering methods:
Mechanical filters: This type normally contains a metal or cloth screen or a series of metal disks separated by thin spacers. Mechanical filters are capable of removing only relatively coarse particles from the fluid.

Absorption filters: These filters are porous and permeable materials such as paper, wood pulp, diatomaceous earth, cloth, cellulose and asbestos. Paper filters are impregnated with a resin to provide added strength. In this type of filters, the particles are actually absorbed as the fluid permeates the material. Hence, these filters are used for extremely small particle filtration.
Adsorbent filters: Adsorption is a surface phenomenon and refers to the tendency of particles to cling to the surface of the filters. Thus, the capacity of such a filter depends on the amount of surface area available. Adsorbent materials used include activated clay and chemically treated paper.

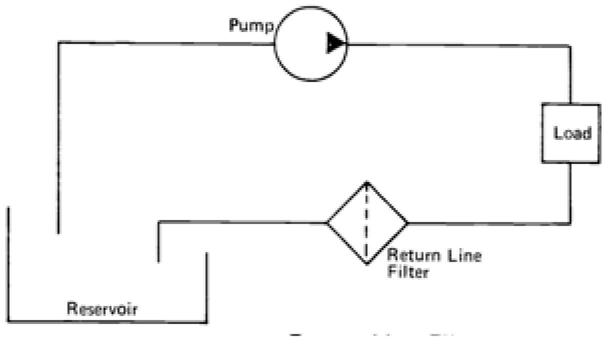
According to the location of filters:
Intake or inline filters (suction strainers): These are provided first before the pump to protect the pump against contaminations in the oil as shown in Fig. These filters are designed to give a low pressure drop, otherwise the pump will not be able to draw the fluid from the tank. To achieve low pressure drop across the filters, a coarse mesh is used. These filters cannot filter out small particles.



Pressure line filters (high-pressure filters): These are placed immediately after the pump to protect valves and actuators and can be a finer and smaller mesh. They should be able to withstand the full system pressure. Most filters are pressure line filters.



Return line filters (low-pressure filters): These filters filter the oil returning from the pressure-relief valve or from the system, that is, the actuator to the tank. They are generally placed just before the tank. They may have a relatively high pressure drop and hence can be a fine mesh. These filters have to withstand low pressure only and also protect the tank and pump from contamination.



3. What are the desirable properties of hydraulic fluids explain any five? **(08 Marks)**

The desirable properties of a hydraulic fluids are listed below:

1. Ideal viscosity.
2. Variation of viscosity with temperature (viscosity Index); must be minimal viscosity change with temperature change.
3. Good lubrication capability.
4. Good chemical stability.
5. High specific heat and thermal conductivity to dissipate heat.
6. Low compressibility.
7. Fire resistance property.
8. System compatibility.
9. Foam resistant properties.
10. Environmental Compatibility.

Explanation of any five:

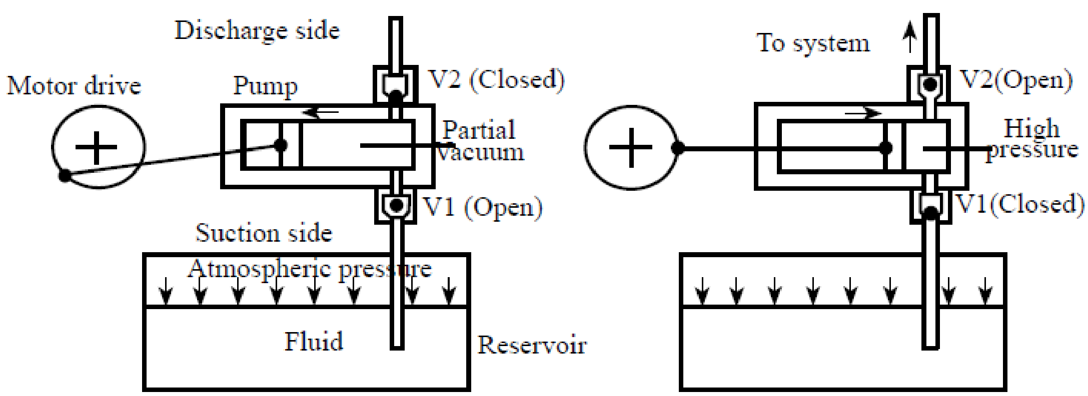
1. Viscosity is the measure of a fluid's resistance to flow and shear. A fluid of higher viscosity will flow with higher resistance compared to a fluid with a low viscosity.
2. Viscosity Index is how the viscosity of a fluid changes with a change in temperature. A high VI fluid will maintain its viscosity over a broader temperature range than a low VI fluid of the same weight.
3. Oxidation Stability is the fluid's resistance to heat-induced degradation caused by a chemical reaction with oxygen. Oxidation greatly reduces the life of a fluid, leaving by-products such as sludge and varnish.
4. Wear Resistance: It is the lubricant's ability to reduce the wear rate in frictional boundary contacts.
5. Incompressibility: Liquids are of very low compressibility, while gases are highly compressible. Therefore, liquids are usually assumed incompressible.

6. Compatibility: The fluid must be fully compatible with other materials used in the hydraulic system, such as those used for bearings, seals, paints, and so on.
7. Chemical stability is an important property of the hydraulic liquid. It is defined as the ability of the liquid to resist oxidation and deterioration for long periods.
8. Cleanliness in hydraulic systems has received considerable attention. Some hydraulic systems, such as aerospace hydraulic systems, are extremely sensitive to contamination.

Module-2

Explain pumping theory and what are the factors considered for selecting hydraulic pump. **(8 Marks)**

A positive displacement hydraulic pump is a device used for converting mechanical energy into hydraulic energy. It is driven by a prime mover such as an electric motor. It basically performs two functions. First, it creates a partial vacuum at the pump inlet port. This vacuum enables atmospheric pressure to force the fluid from the reservoir into the pump. Second, the mechanical action of the pump traps this fluid within the pumping cavities transports it through the pump and forces it into the hydraulic system. It is important to note that pumps create flow not pressure. Pressure is created by the resistance to flow.



(a) Suction stroke (b) Return stroke

All pumps operate by creating a partial vacuum at the intake, and a mechanical force at the outlet that induces flow. This action can be best described by reference to a simple piston pump shown in Fig.

(a) As the piston moves to the left, a partial vacuum is created in the pump chamber that holds the outlet valve in place against its seat and induces flow from the reservoir that is at a higher (atmospheric) pressure. As this flow is produced, the inlet valve is temporarily displaced by the force of fluid, permitting the flow into the pump chamber (suction stroke).

(b) When the piston moves to the right, the resistance at the valves causes an immediate increase in the pressure that forces the inlet valve against its seat and opens the outlet valve thereby permitting the fluid to flow into the system. If the outlet port opens directly to the atmosphere, the only pressure developed is the one required to open the outlet valve (delivery stroke).

Pumps are selected by taking into account a number of considerations for a complete hydraulic system involving a particular application. The main parameters affecting the selection of a particular type of pump are as follows:

1. Maximum operating pressure.

2. Maximum delivery.

3. Type of control.

4. Pump drive speed.

5. Type of fluid.

6. Pump contamination tolerance.

7. Pump noise.

8. Size and weight of a pump.

9. Pump efficiency.

10. Cost.

11. Availability and interchangeability.

12. Maintenance and spares.

The selection of pump typically entails the following sequence of operations:

1. Select the actuator (hydraulic cylinder or motor) that is appropriate based on the loads encountered.

2. Determine the flow-rate requirements. This involves the calculation of the flow rate necessary to drive the actuator to move the load through a specified distance within a given time limit.

3. Select the system pressure. This ties in with the actuator size and the magnitude of the resistive force produced by the external load on the system. Also involved here is the total amount of power to be delivered by the pump.

4. Determine the pump speed and select the prime mover. This, together with the flow-rate calculation, determines the pump size (volumetric displacement).

5. Select the pump type based on the application (gear, vane or piston pump and fixed or variable displacement).

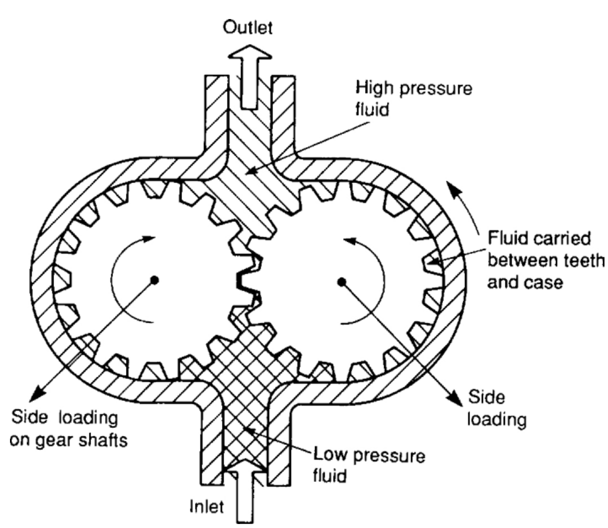
6. Select the reservoir and associated plumbing, including piping, valving, hydraulic cylinders, and motors and other miscellaneous components.

7. Consider factors such as noise levels, horsepower loss, need for a heat exchanger due to generated heat, pump wear, and scheduled maintenance service to provide a desired life of the total system.

8. Calculate the overall cost of the system.

Explain external gear pump. **(04 Marks)**

External gear pumps are the most popular hydraulic pumps in low-pressure ranges due to their long operating life, high efficiency and low cost. These are 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, It consist of a pump housing in which a pair of precisely machined meshing gears runs with minimal radial and axial clearance. One of the gears, called a driver, is driven by a prime mover. The driver drives another gear called a follower. As the teeth of the two gears separate, the fluid from the pump inlet gets trapped between the rotating gear cavities and pump housing. The trapped fluid is then carried around the periphery of the pump casing delivered to outlet port. The teeth of precisely meshed gears provide almost a perfect seal between the pump inlet and the pump outlet. When the outlet flow is resisted, pressure in the pump outlet chamber builds up rapidly and forces the gear diagonally outward against the pump inlet. When the system pressure increases, imbalance occurs. This imbalance increases mechanical friction and the bearing load of the two gears. Hence, the gear pumps are operated to the maximum pressure rating stated by the manufacturer. The direction of rotation of the gears should be carefully noted; it is the opposite of that intuitively expected by most people.



A hydraulic motor has a displacement of 130 cm3, operates with a pressure of 105 bar and has a speed of 2000 rpm. If the actual flow rate consumed by the motor is 0.005 m3/s and the actual torque delivered by the motor is 200 N-m, find

i) Volumetric efficiency
ii) Mechanical efficiency
iii) Overall efficiency
iv) Power developed by motor in kW. **(08 Marks)**

Solution:

i) To find the volumetric efficiency, we first calculate flow rate:

$$Q_T = V_D \times N$$

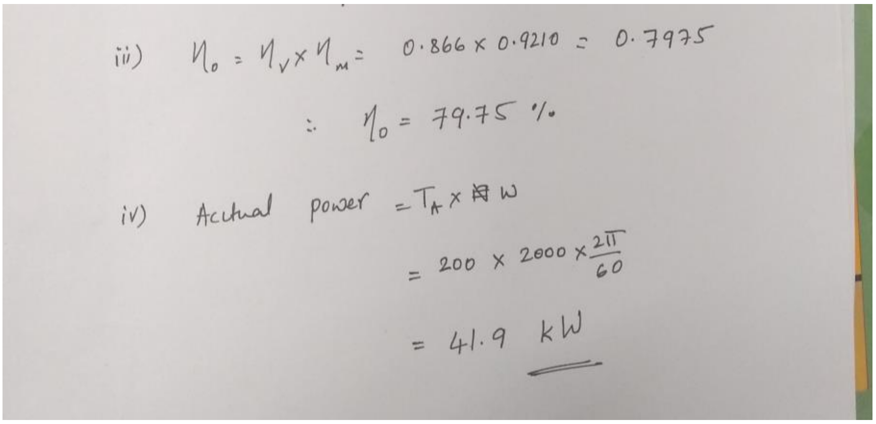
$$= 0.000130 \ m^3/rev \times \frac{2000}{60} \ rev/s = 0.00433 \ m^3/s$$

$$\eta_v = \frac{Q_T}{Q_A} = \frac{0.00433}{0.005} = 0.866 \Rightarrow \eta_v = 86.7\%$$

ii) To find η_M, We need to calculate the theoratical torque

$$T_T = \frac{V_D P}{2\pi} = \frac{0.000130 \times 105 \times 10^5}{2\pi} = 217.15 \ N.m$$

$$\eta_M = \frac{T_A}{T_T} = \frac{200}{217.15} = 0.9210 \Rightarrow \eta_m = 92.1\%$$



iii) $\eta_o = \eta_v \times \eta_m = 0.866 \times 0.9210 = 0.7975$

$\therefore \eta_o = 79.75\ \%$

iv) Actual power $= T_A \times \omega$

$= 200 \times 2000 \times \frac{2\pi}{60}$

$= 41.9\ kW$

A gear pump has a 75mm outside diameter a 50mm inside diameter and a 25mm width. If the volumetric efficiency is 90% at rated pressure, what is the corresponding actual flow rate? The pump speed is 1000 rpm. **(04 Marks)**

Given Data:

External dia: D_o = 75 mm

Inside dia: D_i = 50 mm

Width of teeth: L= 25 mm

Efficiency: 0.9

Speed: 1000 rpm

Volumetric displacement is given by $V_D = \frac{\pi}{4}({D_o}^2 - {D_i}^2)\ L$

$$V_D = 61383.98\ mm^3$$

Theoretical flow rate is given by $Q_T = V_D \times N$

$$Q_T = 61383.98 \times 1000$$

$$Q_T = 613839800\ {mm^3}/{m}$$

Now, actual flow rate is given by $Q_A = \eta_V \times Q_T$

$$Q_A = 55245528\ {mm^3}/{m}$$

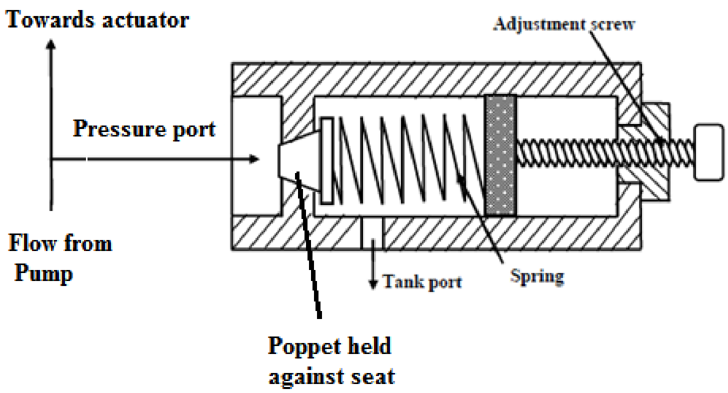
$$= 0.0553\ {m^3}/{m}$$

$$Q_A = 55.3\ Lpm$$

Module 3

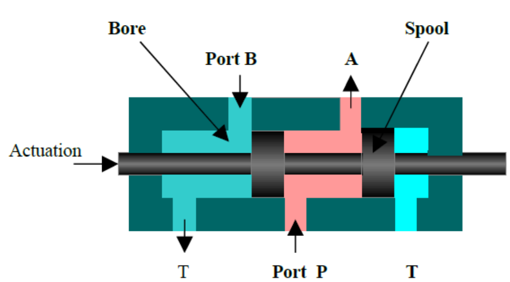
Brief the construction feature and working of pressure relief valve.

The pressure relief valves are used to protect the hydraulic components from excessive pressure. This is one of the most important components of a hydraulic system and is essentially required for safe operation of the system. Its primary function is to limit the system pressure within a specified range. It is similar to a fuse in an electrical system. Pressure relief valve is normally a closed type and it opens when the pressure exceeds a specified maximum value by diverting pump flow back to the tank. The simplest type valve contains a poppet held in a seat against the spring force. The fluid enters from the opposite side of the poppet. When the system pressure exceeds the preset value, the poppet lifts and the fluid is escaped through the orifice to the storage tank directly. It reduces the system pressure and as the pressure reduces to the set limit again the valve closes.

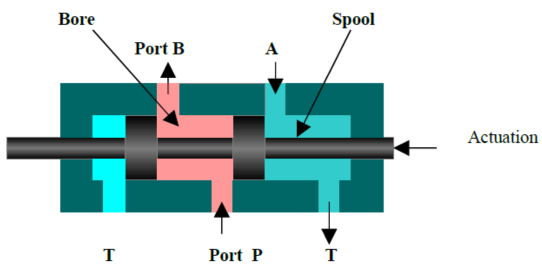


Explain the working of 4/2 manually operated DCV with a neat sketch.

These valves are also used to operate double acting cylinder. These valves are also called as impulse valve as 2 / 4 DCV has only two switching positions, i.e. it has no mid position. These valves are used to reciprocate or hold and actuating cylinder in one position. They are used on machines where fast reciprocation cycles are needed. Since the valve actuator moves such a short distance to operate the valve from one position to the other, this design is used for punching, stamping and for other machines needing fast action. Fig 4.15 a and b shows the two position of 2 / 4 DCV.



a. 1 Position : P to A and B to T



b. 2 Positon, P to B and A to T

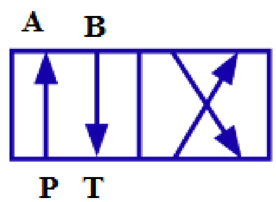


Figure Graphical symbol for 4/2 DCV

Explain needle flow control valve. **(05 Marks)**

The needle valve is quite commonly used valve. It is also termed as plug valve. Schematic of Needle or plug valve is shown in Figure. This valve has a conical disc which can be adjusted in vertical direction by setting flow adjustment screw. The adjustment of needle alters the orifice size between plug and valve seat. Thus the adjustment of plug controls the fluid flow in the pipeline. The characteristics of these valves can be accurately predetermined by machining the taper of the plug. The typical example of needle valve is stopcock that is used in laboratory glassware. The valve body is made of glass or Teflon. The plug can be made of plastic or glass. Special glass stopcocks are made for vacuum applications.

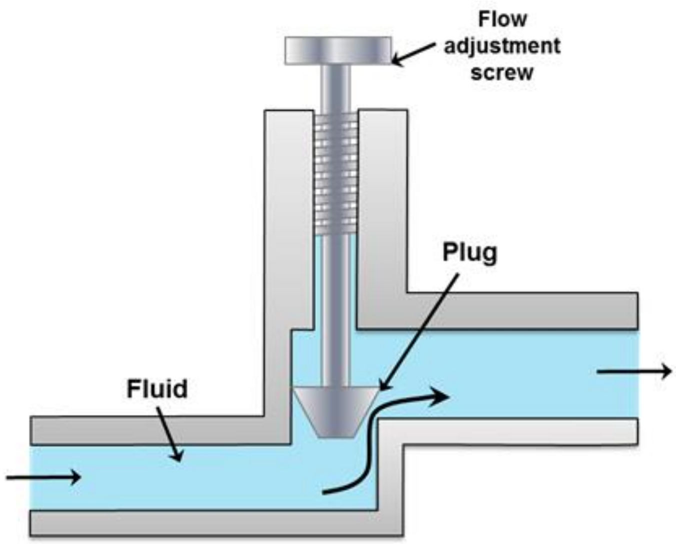
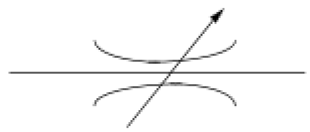


Fig: Needle or plug valve



Graphical symbol for Flow control valve

Explain regenerative circuit. **6 Marks**

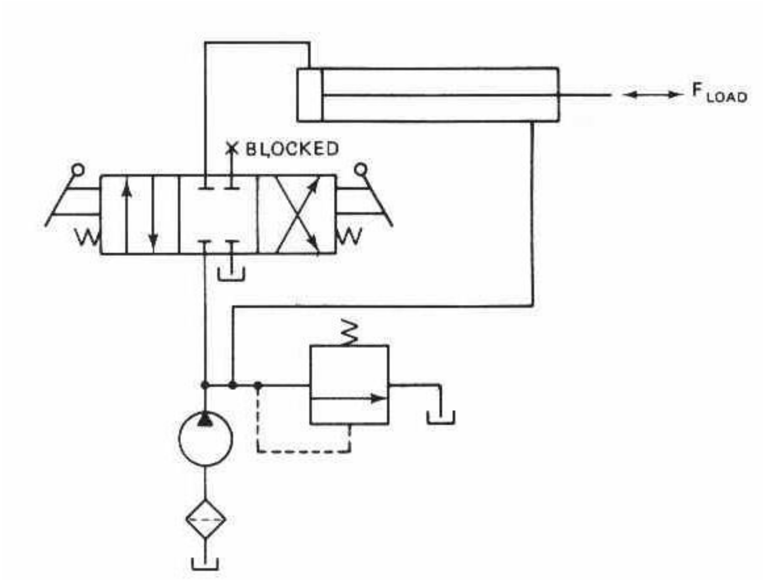


Figure shows a regenerative circuit that is used to speed up the extending speed of a double-acting cylinder. The pipelines to both ends of the hydraulic cylinder are connected in parallel and one of the ports of the 4/3 valve is blocked by simply screwing a thread plug into the port opening. During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

Expression for the Cylinder Extending Speed

The total flow rate Q_T entering the blank end of the cylinder is given by

$$Q_T = Q_P + Q_r$$

Where Q_P is the pump flow rate and is Q_r the regenerative flow or flow from the rod end.

Hence, Pump flow rate,

$$= Q_P = Q_T — Q_r$$

But the total flow rate acting on the blank rod end is given by

$$Q_P = A_P V_{ext}$$

Similarly, the flow rate from the rod end is given by

$$Q_r = (A_P — A_r) V_{ext}$$

So pump flow rate is

$$Q_P = A_P V_{ext} — (A_P — A_r) V_{ext}$$

$$Q_P = A_r V_{ext}$$

The extending speed of the piston is given as

$$V_{ext} = Q_P / A_r$$

Thus, a small area provides a large extending speed. The extending speed can be greater than the retracting speed if the rod area is made smaller.

Explain the working of sequencing hydraulic circuit.

In many applications, it is necessary to perform operations in a definite order. 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. 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.

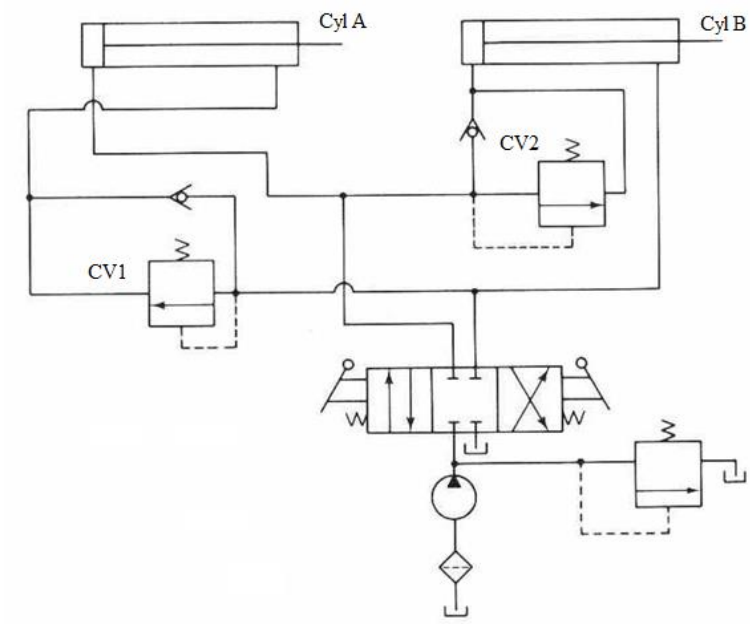


Figure Sequencing circuit.

The sequence of operation realized by the circuit shown in Figure 1.7 is:
Step A – Extend Cylinder A (To clamp the work piece)
Step B – Extend Cylinder B while holding pressure on Cylinder A (To perform drilling operation)
Step C – Retract Cylinder B (To retract the spindle after drilling)
Step D – Retract Cylinder A (To unclamp the work piece)

When the DCV is shifted into its left envelope mode, the cylinder A extends completely. When the pressure reaches the pressure setting of sequence valve (SV1), the valve opens and fluid flow is allowed to the cylinder B as a result cylinder B extends. If the DCV is then shifted into its right envelope mode cylinder B retracts fully, and then the cylinder A retracts. Hence this sequence of cylinder operation is controlled by the sequence valves. The spring cantered position of the DCV locks both cylinders in place.