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Scheme

Internal Assessment Test 1 – Sep. 2019

Sub:	Fluid Power Systems				Sub Code:	15ME72	Branch:	ME
Date:	06/09/2019	Duration:	90 min's	Max Marks: 50	Sem / Sec:	7th sem A & B		OBE

Answer any FIVE FULL Questions	MARKS	CO	RBT
1. Sketch and explain the structure of a hydraulic control system. (Neat diagram & Explanation)	[6+4]	CO1	L2
2. Using a neat diagram, explain the construction and functioning of an unbalanced hydraulic vane pump. (Neat diagram & Explanation)	[6+4]	CO1	L2
3. Differentiate hydraulics and pneumatics. (Any 5 important differences)	[2*5]	CO1	L1
4. Define the terms: a) Theoretical flow rate, b) Pump cavitation, c) Volumetric efficiency and d) Mechanical efficiency. (Definition and important expressions if any)	[2.5*4]	CO2	L1
5. State Pascal's law. Illustrate with a neat sketch. Give any 2 applications of Pascal's law. (Statement of pascal law, neat sketch with illustration and 2 examples)	[4+4+2]	CO2	L1
6. Explain the criteria to be considered in selecting a pump. (All important criteria with procedure)	[10]	CO2	L1
7. A pump having a displacement of 15 cm^3 is driven at 1400 rpm and operates against a maximum pressure of 170 bar. The volumetric efficiency is 0.9 and the overall efficiency is 0.83. Find: Pump delivery in LPM. $\boldsymbol{Q_A = 19.44}$ **LPM** The input power required in kW. **P = 6.6 kW** The drive torque at the pump shaft. $\boldsymbol{T_A}$ **= 44.0 N-m** (Step by step solution with all necessary formulae)	[10]	CO1	L2

Solutions

1. Sketch and explain the structure of a hydraulic control system.

Functions of the components shown in Fig. are as follows:
1. A **reservoir** is used to hold the hydraulic oil.
2. An **actuator** to convert the fluid power into mechanical power to perform useful work.
3. A **pump** is used to force the fluid from the reservoir.
3. **Valves** are used to control the direction, pressure and flow rate of a fluid.
4. An **electric motor** is required to drive the pump.
6. **Piping system** carries the hydraulic oil from one place to another.
7. **Filters** are used to remove any foreign particles so as keep the fluid system clean and efficient.
8. **Pressure regulator** regulates (i.e. maintains) the required level of pressure in the hydraulic fluid.

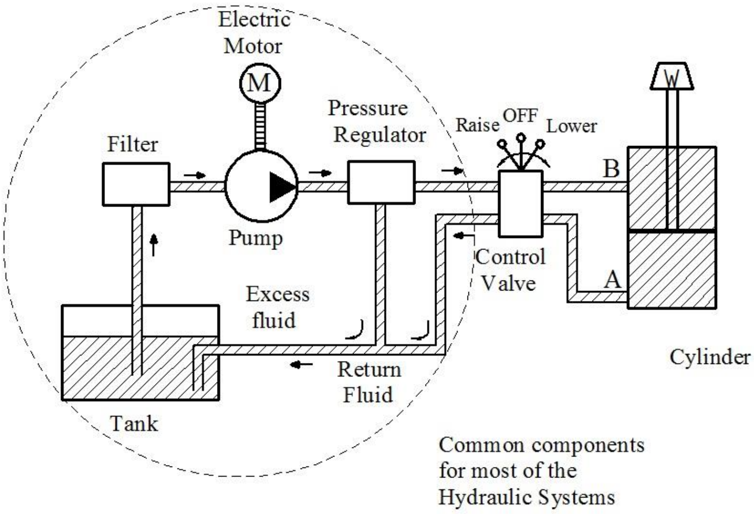


Figure. Basic components of a hydraulic System

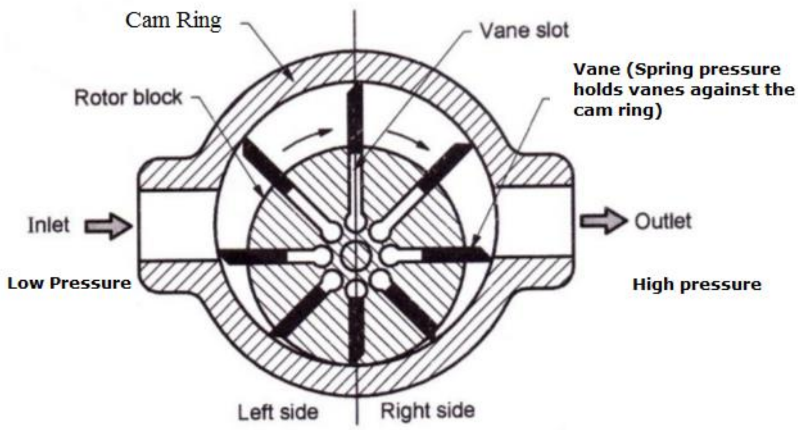
A hydraulic linear actuator suitable for this application is the ram; shown schematically in Figure This consists of a movable piston connected directly to the output shaft. If fluid is pumped into pipe A, the piston will move up and the shaft will extend; if fluid is pumped into pipe B, the shaft will retract.

The system requires a liquid fluid to operate; this is expensive and messy and, consequently, the piping must act as a closed loop, with fluid transferred from a storage tank to one side of the piston, and returned from the other side of the piston to the tank. Fluid is drawn from the tank by a pump which produces fluid flow at the required pressure.

Cylinder movement is controlled by a three-position direction control valve (DCV). To extend the cylinder, port A is connected to the pressure line and port B to the tank. To reverse the motion, port B is connected to the pressure line and port A to the tank. In its centre position the valve locks the fluid into the cylinder.

2. Using a neat diagram, explain the construction and functioning of an unbalanced hydraulic vane pump.

The main components of the vane pump are the cam ring and the rotor. The rotor contains radial slots splined to drive shaft. The rotor rotates inside the cam ring. Each radial slot contains a vane, which is free to slide in or out of the slots due to centrifugal force. The vane is designed to mate with surface of the cam ring as the rotor turns. The cam ring axis is offset to the drive shaft axis. When the rotor rotates, the centrifugal force pushes the vanes out against the surface of the cam ring. The vanes divide the space between the rotor and the cam ring into a series of small chambers. During the first half of the rotor rotation, the volume of these chambers increases, thereby causing a reduction of pressure. This is the suction process, which causes the fluid to flow through the inlet port. During the second half of rotor rotation, the cam ring pushes the vanes back into the slots and the trapped volume is reduced. This positively ejects the trapped fluid through the outlet port.



3. Differentiate hydraulics and pneumatics.

S. No.	Hydraulic System	Pneumatic System
1.	It employs a pressurized liquid as a fluid	It employs a compressed gas, usually air, as a fluid
2.	An oil hydraulic system operates at pressures up to 700 bar	A pneumatic system usually operates at 5–10 bar
3.	Generally designed as closed system	Usually designed as open system
4.	The system slows down when leakage occurs	Leakage does not affect the system much
5.	Valve operations are difficult	Valve operations are easy
6.	Heavier in weight	Lighter in weight
7.	Pumps are used to provide pressurized liquids	Compressors are used to provide compressed gases
8.	The system is unsafe to fire hazards	The system is free from fire hazards
9.	Automatic lubrication is provided	Special arrangements for lubrication are needed

4. Define the terms: a) Theoretical flow rate, b) Pump cavitation, c) Volumetric efficiency and d) Mechanical efficiency.

a) Theoretical flow rate: It is the volume of fluid which is produced theoretically by the pump per unit time. Usually represented by the symbol Q_T. The SI unit is m^3/s.
It is the product of volumetric displacement and the speed of the pump.

b) Pump cavitation: During the working of a positive displacement pump, vacuum is created at the inlet of the pump. This allows atmospheric pressure to push the fluid in. In some situations, the vacuum may become excessive, and a phenomenon known as cavitation occurs. Cavitation is the formation of oil vapor bubbles due to a very low pressure (high vacuum) on the inside of the pump.

c) Volumetric efficiency (η_v) indicates the amount of leakage that takes place within the pump. This is due to manufacture tolerances and flexing of the pump casing under designed pressure operating conditions.It is the ratio of actual flow rate of the pump to the theoretical flow rate of the pump.

d) Mechanical efficiency (η_m) indicates the amount of energy losses that occur for reasons other than leakage. This includes friction in bearings and between mating parts.It is the ratio of the pump output power assuming no leakage to actual power delivered to the pump.

5. State Pascal's law. Illustrate with a neat sketch. Give any 2 applications of Pascal's law.
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".

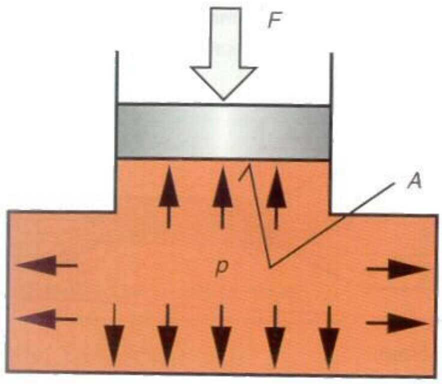


Figure: Pressure in an enclosed fluid

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 the 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.

6. Explain the criteria to be considered in selecting a pump.
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.

7. A pump having a displacement of 15 cm^3 is driven at 1400 rpm and operates against a maximum pressure of 170 bar. The volumetric efficiency is 0.9 and the overall efficiency is 0.83. Find:
   i. Pump delivery in LPM.
   ii. The input power required in kW.
   iii. The drive torque at the pump shaft.

Given data:
$V_D = 15$ cm^3
N = 1440 rpm
P = 170 bar
η_V = 0.9
η_o = 0.8
Theoretical discharge is given by $Q_T = V_D \times N$.

$$15 \times 10^{-6} \times 1440 = 0.0216 \text{ m}^3\text{/min}$$

$$Q_A = \eta_V \times Q_T$$

$$\boldsymbol{Q_A = 0.01944} \textbf{ m}^3\textbf{/min}$$

The theoretical torque (T_T) is determined as follows:

$$T_T = \frac{V_D \times N}{2\pi}$$

$$\boldsymbol{T_T} \textbf{ = 40.84 N-m}$$

$$T_A = \frac{T_T}{\eta_m}$$

$$\boldsymbol{T_A} \textbf{ = 44.0 N-m}$$

Input Power = $2\pi N T_A/60$
P = 6.6 kW