Unit-1

Subject Name: Hydraulic and Pneumatic

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① What is fluid power? List out merits and demerits, application of fluid power system?

Fluid power

Fluid power is defined as an energy of flowing fluid under pressure; to transmit from one point to other. It is one among the common three types of power transmission methods. ie, electrical, mechanical and hydraulic.

merits of fluid power?

1) Simple and Accurate operation,
The working condition of fluid power are very simple to operate due to the simple lever and pushbuttons used in the system.

2) Multiplication of forces
with simple mechanism, fluid power multiplies the forces efficiently from lower values input to much higher values of outputs.

3). Constand Application of force / Torque
Independent of variation in speed of the system. Continuous application of forces can be done which is possible only with fluid power system.

4) Simplicity safty and economy.
Maintenance of fluid power system is simple as they provided with less number of moving parts completed to mechanical and electrical system thus the simplicity increase safety of operation and reliability.

Demerits of fluid power system.

1. Bursting of hydraulic lines may take place due to improper design which may cause injuries the operator or people nearby.

2. the sound from pumps may cause damage

3. the oil leakage near the equipment at high temperature leads to fire accidents.

4. The compressor used in pneumatics system causes explosions. If they are operated above the safety pressure limit.

Application of Fluid Power.

(i) Agriculture - Tractor and farm equipment like plough, mowers, chemical sprayer

(ii) Automation - Automated transfer machine.

(iii) Aviation - Fluid power equipment like landing wheels on aeroplane and helicopter aircraft trollys.

(iii) Building Industry: For meeting and mixing of concrete ingredient from hopper.

(iv) Defence: missile-launch system, navigation control

(v) Entertainment: Amusement park, entertainment rides like roller coaster

(vi) Fabrication Industry: Hand tools like pneumatic drills, grinder, borer.

(vii) Food and Beverage: All type of food processing equipment, wrapping

(viii) Foundary: Full and semi automatic moulding machine, filling of furnace, die casting machine

(ix) Jigs and fixture: Fluid power operated clamp

(x) Machine Tool: Automated machine tools NC machine tool.

(2) Describe the basic components of fluid power system and compare hydraulic and pneumatic system

Basic components of fluid power system.

The components of fluid power system are categorized into two types.

1. Hydraulics system components
2. Pneumatic system components

1. Hydraulic system components

It comprises of six component

(1) Tank: It act as a storage of hydraulic oil

(2) Pump: It enables pressurized flow of oil through the system by means of external sources

(3) It act as a prime mover to drive pump

(4) Actuator: This converts the pressure energy of oil into mechanical energy in order to do work

(5) Valves: These are used to regulate the pressure Flow direction and flow rate of oil.

(6) Pipes: Used to carry oil through the system

2. Pneumatic system components:

It also contains six basic components like hydraulic system.

(i) ~~Compressor~~: Used to compress the atmospheric

(ii) Tank: Used to carry (or) store the liquid compressed air

(iii) motor: Used to run the compressor

(iv) Valves: The regulate the rate of flow pressure and flow direction of air.

Actuator:

Like in hydraulic system, there are used to convert pressure energy to air into mechanical energy to do work.

Pipes: Used to carry the compressed air through the system

Pneumatic system	Hydraulic System.
1 The working medium of this systems compressed air	This system is a high pressure liquid.
2. The operating pressure range between 5 bar and 8 bar	pressure range upto 700 bar
3. Leakage of air does not cause system breakdown	Leakage of oil cause system breakdown
4. The weight of pneumatic system is less.	weight more
5. It uses compressor to generate compressed air	high pressure required
6. The working is safe & hazardous environment	not safe hazardous environment
7. The working of pneumatic valves is simple.	Valve complex.
8. Auxiliary lubricating equipment is necessary	no need Auxiliary system

(3) What is gear pump? Explain any one gear pump with its advantage and disadvantage.

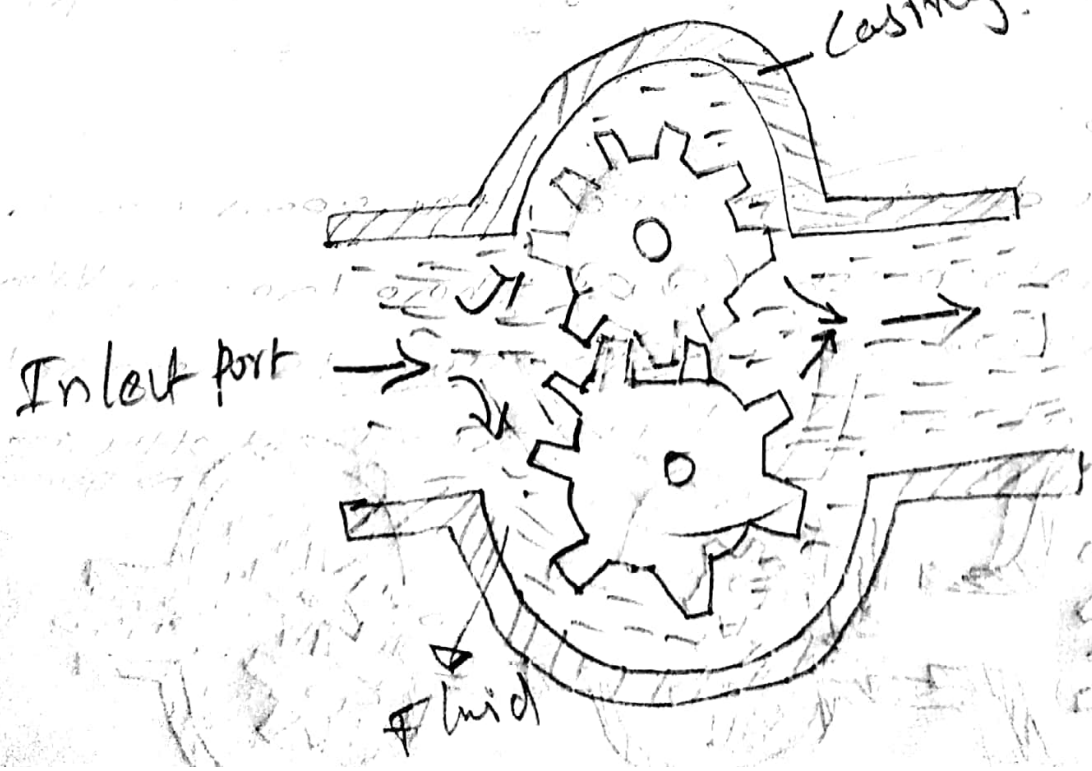
Gear pump is the positive displacement pump in which the suction is created by rotation and meshing of two gears. The fluid enters into the pump through the inlet and transferred through the outlet port. Based on arrangement of gears

Gear pumps classified two types

1. External gear pump
2. Internal gear pump

External Gear Pump:

In this type of gear pump, two similar gear mesh externally and are rotated in opposite direction, one of the gears is known as driver gear and is connected to a electric motor. Whereas the other gear is known as driven gear which is in constant mesh with driver gear.



Working.

The working of external gear pump consist of three stages.

Stage-1

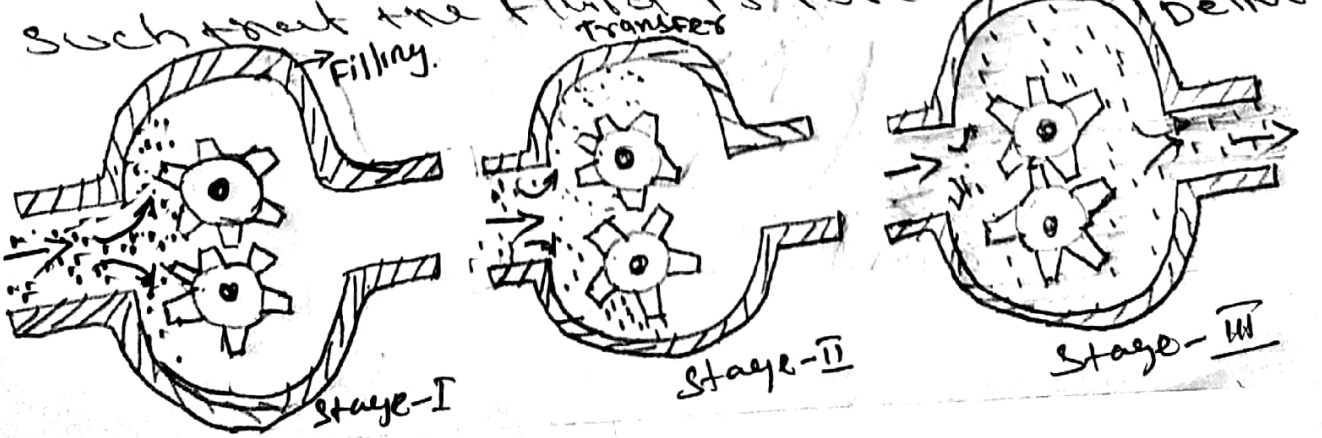
When the gears start rotating and create a mesh, a suction pressure is created at the inlet port. This allows the fluid to enter into the pump. At inlet of the pump, the rotation of gears causes the teeth out of mesh. i.e. the teeth start coming out enter into the pump. At inlet of the pump, the rotation of gears causes the volume expansion of fluid and reduces the pressure, less than the atmospheric pressure.

Stage-2.

due to the continuous rotation of the gears the fluid is transferred to the discharge side. Fluid moves through the gear teeth and housing of the pump and finally to the discharge end.

Stage-3

At the discharge end, the gears teeth comes into mesh (no clearance) therefore the volume is decreased and the pressure is increased such that the fluid is forced out of the pump.



Advantage:

1. These pumps are bidirectional
2. Very compact
3. Less weight
4. High Volumetric efficiency
5. Constant discharge is maintained for given speed
6. It has the ability of self priming.

Disadvantage:

1. Liquids should be free form dust and dirt
2. Requires relief valves
3. pumping rate can be changed using variable speed drive.

(4) What are different types of axial piston pumps? Explain the working of any one with neat sketch.

Axial piston pump:

In this type of pump the piston are arranged parallel to the axis of drive shaft. These pumps are divided into two types

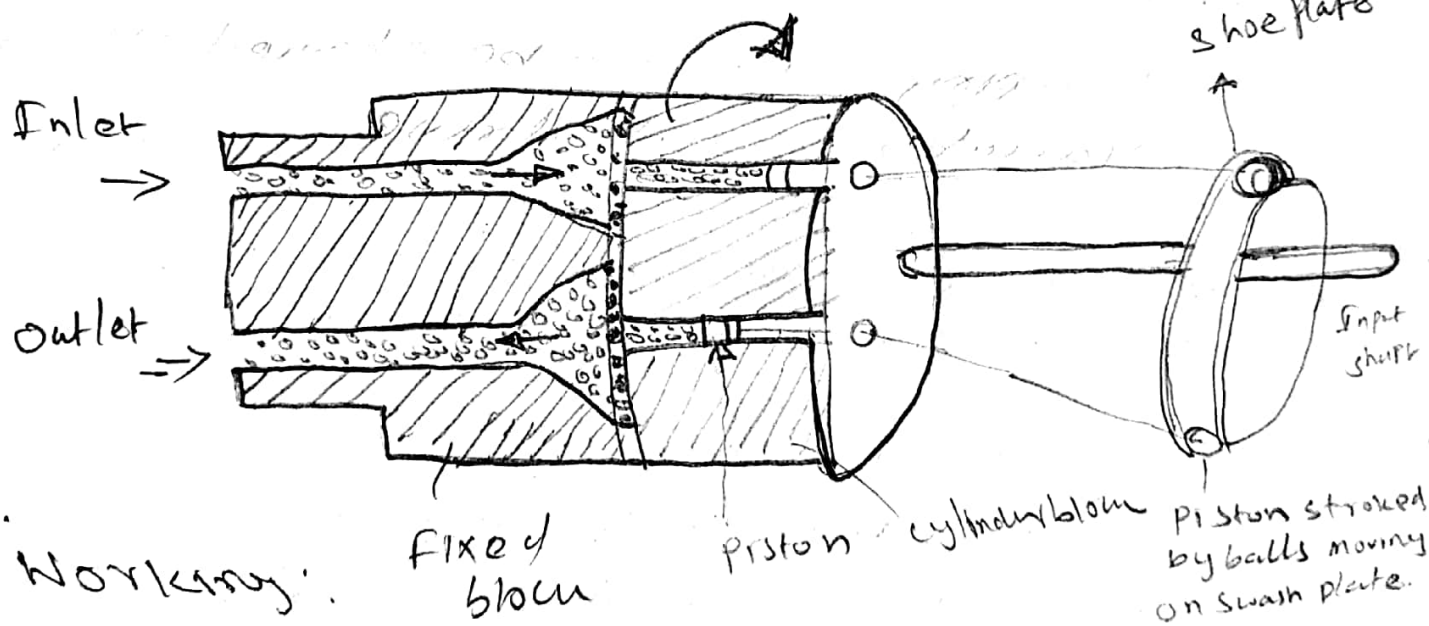
1. Swash plate piston pump
2. Bent axis piston pump.

Swash piston pump

The main parts of pump are

1. Piston
2. cylinder block
3. Swash plate
4. Shoe plate
5. Inlet and outlet.

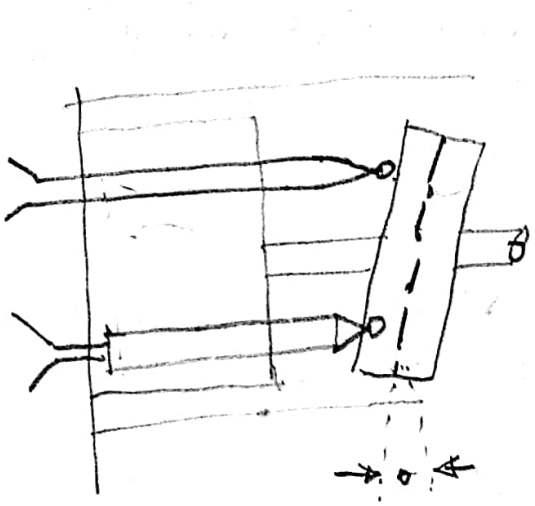
In this pump, the piston are arranged in rotating cylinder block which is parallel to driving shaft. The piston are connected to shoe plate which is placed on swash plate And both the parts are positioned on the valve plate.



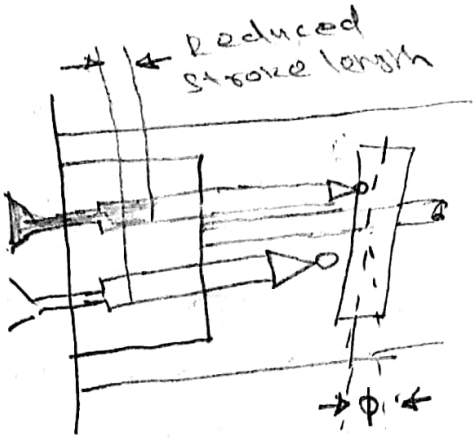
Working:

As the driving shaft rotates, the cylinder block aligned with it also rotates. The piston in the block starts reciprocating in and out of the barrel. In this pump swash plate is used to adjust the stroke length of the piston It is adjusted to various angles to obtain different flow rates.

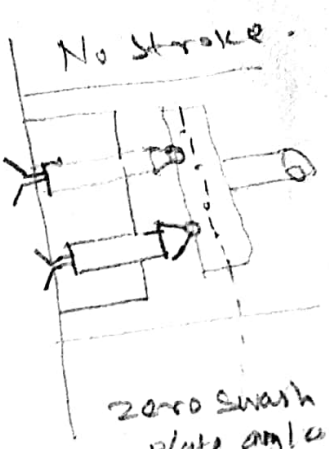
The Vertical piston of the swash plate indicates zero displacement



Maximum swash plate angle.



Decreased swash plate angle



Since the piston shoe follows the piston of swash plate the stroke length of piston depends on the angled surface of swash plate. during the rotating of cylinder block based on the angle tilted by the swash plate half of the piston are in suction phase and half of the piston are in discharge ~~phase~~ phase

During the suction pipe, the pistons are out of barrel and the fluid into the pump, whereas during the discharge phase, the piston are push the barrel and the fluid is pumped out through outlet port.

(5) A hydraulic power delivers oil at 60 bars, 120 litres into a circuit land on a horizontal plane. There are four elbows ($k_e = 0.75$), one globe valve fully open ($k_e = 10$) and a direction control valve (pressure drop = 3 bars) with the inside diameter of the pipe as 30mm. The total length of the straight run pipe is 20 m and the specific gravity of the oil is 0.9. The kinematic viscosity of the oil is 0.001 m²/s Determine the pressure at the exit point of the pipe.

Solution

Velocity of Flow $V = \frac{Q}{A}$

$$= \frac{[120 \times 10^{-3}/60]}{\frac{\pi}{4} \times 0.032}$$

$$= 2.83 \text{ m/s}$$

Reynolds number $Re = \frac{VD}{\nu}$

$$= \frac{2.83 \times 0.03}{0.001}$$

$$= 849$$

$Re < 2000$ so the flow is laminar.

friction factor . $f = \frac{64}{Re}$

$= \frac{64}{849}$

$= 0.075$

K Factor . for the valve and Fitting.

2 elbows $(k = 0.75) = 3$

1 Globe valve $(k = 10) = 10$

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Equivalent length for fitting $= \frac{KD}{f} = \frac{13 \times 0.03}{0.075}$

$= 5.2 m$

Le = pipe Length + Equivalent length

$= 20 + 5.2$

$\boxed{Le = 25.2 m}$

Head Loss $H_L = f \left[\frac{Le}{D}\right]\left[\frac{V^2}{2g}\right]$

$= 0.075 \times \left[\frac{25.2}{0.03}\right] \times \left[\frac{2.83^2}{2 \times 9.81}\right]$

$\boxed{H_L = 25.72 m}$

Pressure drop in Pipe and Fitting $= \gamma H_L$

$= (0.9 \times 1000 \times 9.81) \times 25.72$

$= 2.27 \times 10^5 N/mm^2$

$= 2.27 bar$

Pressure drop in direction control valve = 3 bar

Pressure at the exit of the pipe $= 60 - (2.27 + 3)$

$= 54.73 bar.$

A pump has a displacement of 81.9 cm³. It delivers 75.8 x10⁻³ m³/min at 1000 rpm at 67 bar

(6) If the prime mover input torque is 100 Nm

i) What is it overall efficiency and Volumetric efficiency

ii) What is the theoretical torque required to operate the pump?

Solution.

Theoretical displacement $D_p = 81.9 \times 10^{-6} m^3$

Actual discharge $Q_A = 75.8 \times 10^{-3} m^3/min$

Speed of pump $N = 1000$ rpm

Pressure $p = 67$ bar

Torque $T = 100$ Nm

(a) overall efficiency.

$$\eta_o = \frac{PQ_A}{2\pi NT} \times 100$$

$$= \frac{67 \times 10^5 \times 75.8 \times 10^{-3}}{2\pi \times 1000 \times 100}$$

$$\boxed{\eta_o = 80.8\%}$$

Volumetric efficiency $\eta_v = \frac{Q_A}{Q_T} \times 100$

$$= \frac{Q_A}{D_p \times N} \times 100$$

$$= \frac{75.8 \times 10^{-3}}{81.9 \times 10^{-6} \times 1000} \times 100$$

$$= 92.6\%$$

(b) Mechanical efficiency

$$\eta_m = \frac{\eta_o}{\eta_v} \times 100$$

$$= \frac{80.8}{92.6} \times 100$$

$$\boxed{\eta_m = 87.3\%}$$

Theoretical torque required $= 100 \times 0.873$

$= 87.3$ Nm

(7) A hydraulic system requires 32 l/min of fluid at a pressure of 260 bar. The pump to be used is a manually variable axial piston pump having a maximum displacement per revolution of 28 cm3. The pump is driven at 1430 and has an overall efficiency of 0.85 and a volumetric efficiency of 0.9.

$= 54.16$ ...

Calculate

(i) at what percentage of maximum displacement the pump has to be set

(ii) what power is needed to drive the pump

Solution:

Actual flow rate required in the system = 32 l/min

Theoretical flow rate required by the pump $Q_T = DpYN$

$= 28 \times 10^{-6} \times 1430$

$= 0.040 \ m^3/min$

Actual flow rate given by the pump

$Q_A = Q_T \times \eta_V$

$= 0.040 \times 0.9$

$= 0.036 \ m^3/min$

The percentage of maximum displacement at which the pump has to be set

$= \frac{\text{actual flow rate required}}{\text{Actual flow rate given by pump}}$

$= \frac{0.032}{0.036} = 0.88$

Hydraulic output power $= P Q_A$

$= \frac{0.032 \times 260 \times 10^5}{60 \times 1000}$

$= 13.86 \ kW$

$$\therefore \text{Overall efficiency} = \frac{\text{Hydraulic output}}{\text{Input power}}$$

Input power need to drive the pump

$$= \frac{13.86}{0.85}$$

$$= 16.3 \text{ kW}$$

(4)