* Question (1) :-

a) Advantages of air :

* Air is not messy, unlike fluids .
* Fire Resistant .
* Can be returned back to the atmosphere

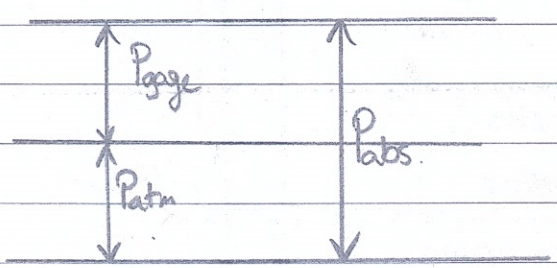
Disadvantages of air :

* Air is sluggish
* A lubricant must be added with air to lubricate moving parts & valves in order to prevent corrosion
* Air contains water & oxygen which increases the corrosion rate .
* Can't be used at very high pressure as there is a hazard of bursting of compressed tank .
* Air is compressible

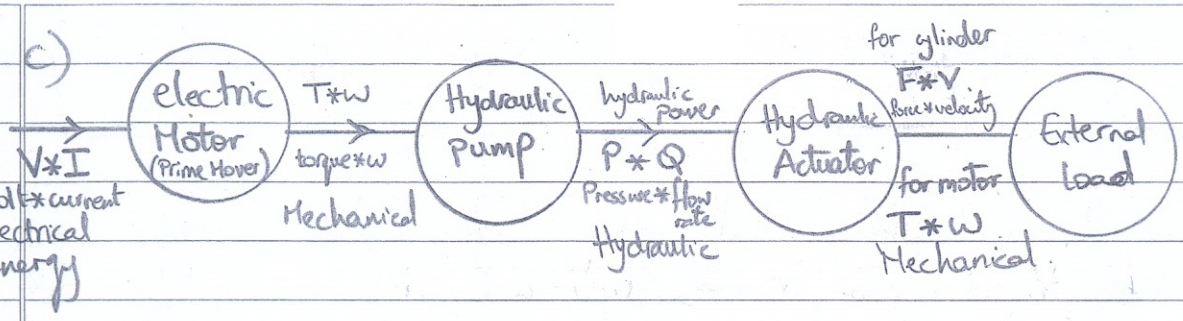
b) Gage Pressure → it is the pressure relative to the atmospheric pressure .

Absolute Pressure → is the pressure relative to zero pressure .

$$P_{abs} = P_{atm} + P_{gage}$$



c)



d) $F_{applied} = 100N$

$F_{applied} * 0.5 = F_{Rod} * 0.25$

$100 * 0.5 = F_{Rod} * 0.25$

$\therefore F_{Rod} = 200N$

$$Area_{oil\ piston} = \frac{\pi}{4}(0.05)^2 = 1.9635 * 10^{-3}\ m^2$$

$$Pressure = \frac{F_{Rod}}{Area_{oil}} = \frac{200}{1.9635 * 10^{-3}} = 101859.1636 Pa$$

$$Area_{Piston/clamp} = \frac{\pi}{4}(0.1)^2 = 7.85398 * 10^{-3}\ m^2$$

$\therefore$ clamping force $= P * A = 101859.1636 * 7.85398 * 10^{-3}$

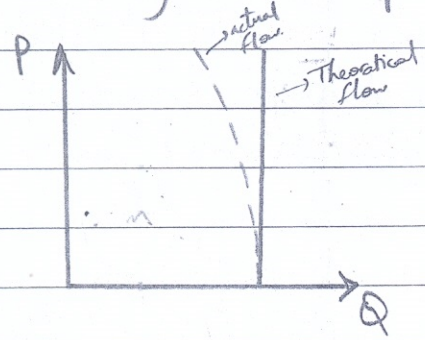
$F = 800\ N$

* Question (2)

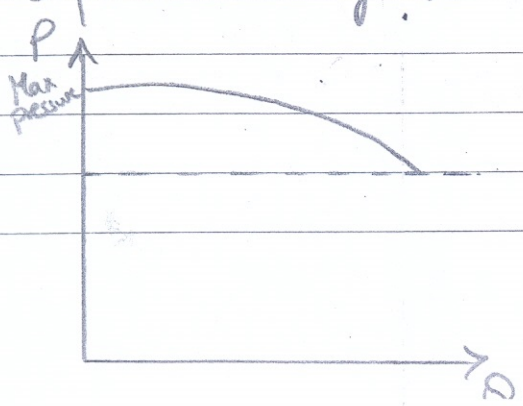
a) Positive displacement pump: it ejects a fixed amount of fluid in each revolution, it can be used for pressures higher than centrifugal pump & it provides higher volumetric efficiency as it can overcome the resistance force from the fluid due to back slip

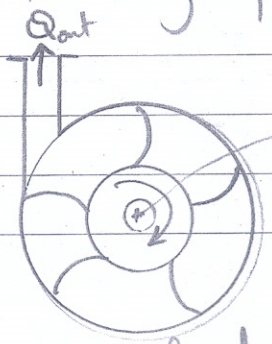
- compact in size
- high volumetric efficiency
- small changes in efficiency through out pressure changes
- great flexibility as it can operate at different motor speeds

it can be either variable displacement or fixed displacement
it mainly consists of 3 types : Gear, vane, piston



Centrifugal pump: it is used for low pressure, high volume applications, although it produces a high flow rate, but a big amount is lost due to resistance of fluid with the walls & back slip, & thats why its not widely used in many application, its advantage is that it doesn't need a pressure relief valve to protect it from high pressure





Centrifugal pump

b) volumetric displacement : it is the volume of fluid ejected by the pump per revolution.

$$V_{D_{Gear}} = \frac{\pi}{4}\left[d_o^2 - d_i^2\right] * \text{Gear width}$$

$$V_{D_{piston}} = \frac{\pi}{4} d^2 * D * Y * \tan\theta$$

(d: piston dia., D: cylinder block dia., Y: no. of pistons, θ: offset angle)

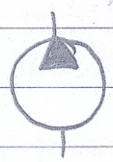
$$V_{D_{vane}} = \frac{\pi}{4}\left[d_c + d_r\right] * 2e * L$$

(d_c: dia. of core, d_r: dia. of rotor, e: eccentricity)

flow Rate : it is the volume produced by the pump per unit time.

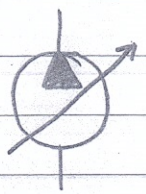
$$Q_{(m^3/sec)} = V_D^{\rightarrow m^3} * \frac{N^{\rightarrow rpm}}{60}$$

c) Internal gear pump symbol



bidirectional balanced vane pump symbol

Variable displacement piston pump. symbol



d) $V_D = 9.84 * 10^{-5}\ m^3$

$Q_{act} = 0.00152\ m^3/s$

$N = 1000\ rpm \quad P = 70 * 10^5\ Pa \quad T_{act} = 124.3\ Nm$

$Q_{th} = V_D * \frac{N}{60} = 9.84 * 10^{-5} * \frac{1000}{60} = 1.64 * 10^{-3}\ m^3/s$

$\eta_{vol} = \frac{Q_{act}}{Q_{th}} = 0.9268 = 92.68\%$

* $T_{th} = \frac{V_D * P}{2\pi} = \frac{9.84 * 10^{-5} * 70 * 10^5}{2\pi} = 109.625\ Nm$

$\eta_{mech} = \frac{T_{th}}{T_{act}} = 0.8819 = 88.19\%$

* $\therefore \eta_{O/A} = \eta_{vol} * \eta_{mech} = 0.8174 = 81.74\%$

or $\eta_{O/A} = \frac{P * Q_{act}}{T_{act} * w} = \frac{70 * 10^5 * 0.00152}{124.3 * 2\pi * \frac{1000}{60}} = 0.8174 = 81.74\%$

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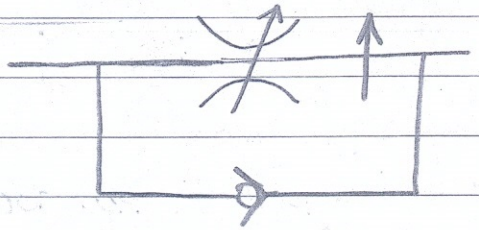
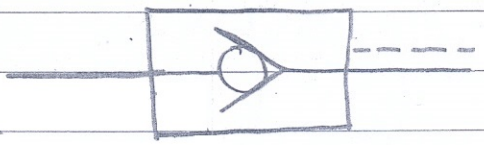
* Question (3):

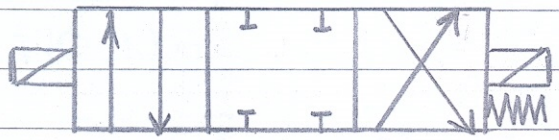
a) * Pressure compensated flow control valve



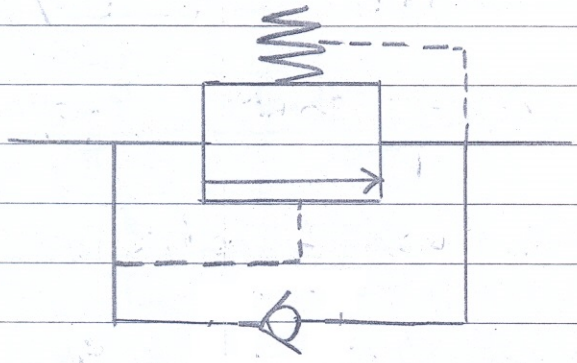
* Pilot operated check valve



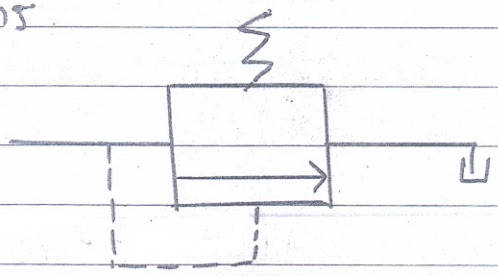
* Solenoid-actuated, four way, three position, spring offset D.C.V.



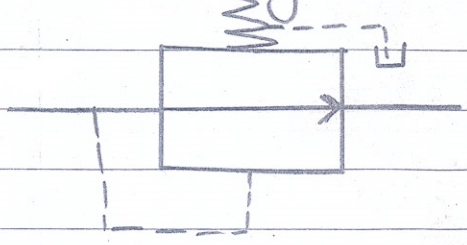
* Pressure counter balance valve.



b) Relief valve: it is a pressure control valve which is normally closed, it limits the pump pressure to a max pressure setting & opens to return the fluid to the tank if max. pressure exceeded., it is mainly used for protection in most hydraulic systems.



Reducing valve: it is a pressure control valve which is normally open, it ensures reduced pressures in specific locations in the hydraulic system



c) $V_D = 1.64 * 10^{-4}\ m^3$ $P = 70 * 10^5\ Pa$.
$N = 2000$ rpm.
$Q_{act} = 0.006\ m^3/s$
$T_{act} = 170\ N.m$

$$Q_{th} = V_D * \frac{N}{60} = 1.64 * 10^{-4} * \frac{2000}{60} = 5.46667 * 1$$

* $$\eta_{vol} = \frac{Q_{th}}{Q_{act}} = 0.9111 = 91.11\ \%$$

$$T_{th} = \frac{V_D * P}{2\pi} = \frac{1.64 * 10^{-4} * 70 * 10^5}{2\pi} = 182.71\ Nm$$

* $$\eta_{mech} = \frac{T_{act}}{T_{th}} = \frac{170}{182.71} = 0.93 = 93\ \%$$

* $$\eta_{o/A} = \eta_{vol} * \eta_{mech} = 0.8477 = 84.77\ \%.$$

or $$\eta_{o/A} = \frac{T_{act} * w}{P * Q_{act}} = 0.8477 = 84.77\ \%.$$

* Actual power delivered by motor $= T_{act} * w = 170 * 2\pi * 2$
Power $= 35604.7$ watt

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* Question (4).

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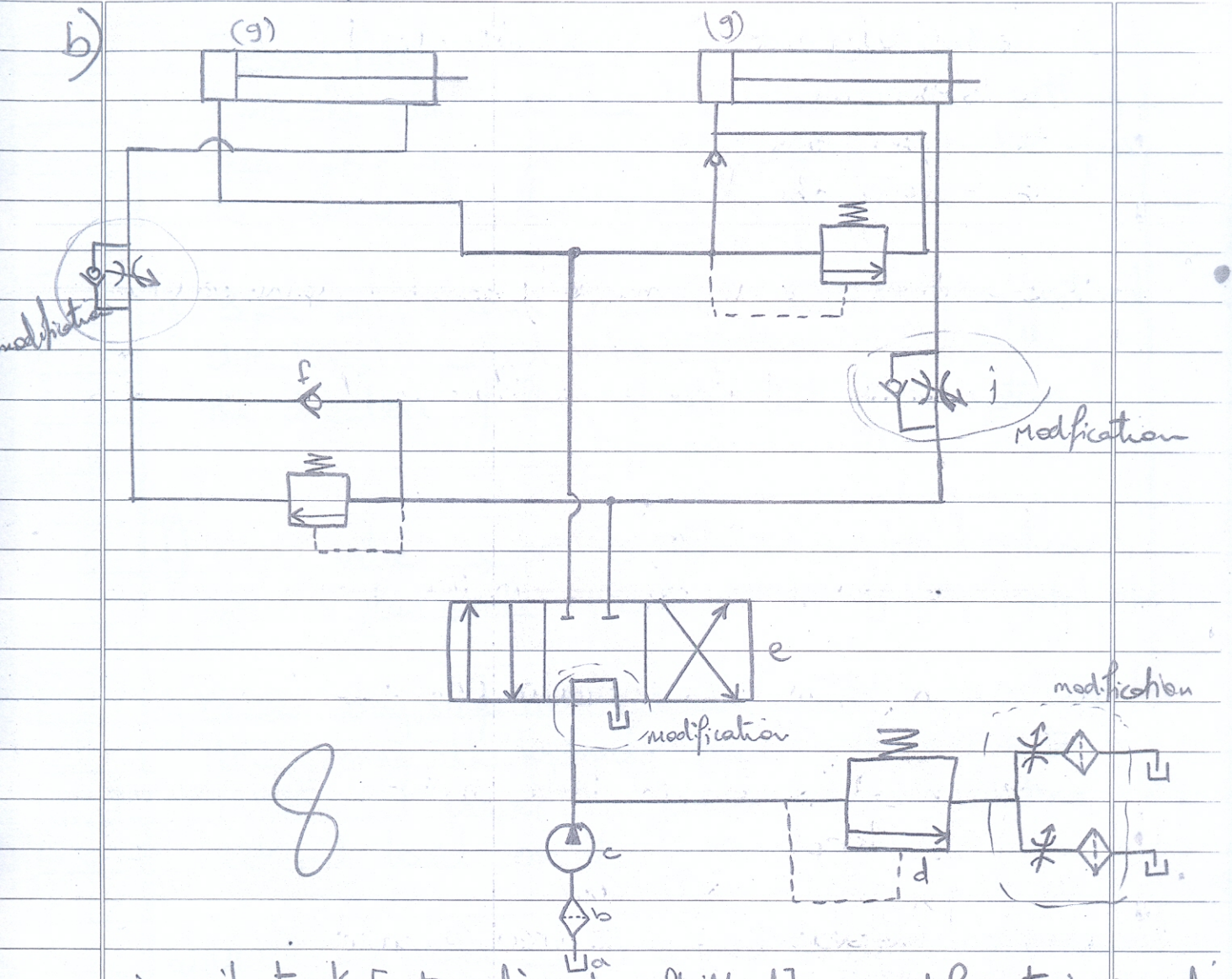
a) $P = 140 * 10^5\ Pa$ $Q = 0.0016\ m^3/s$

Power loss $= P * Q = 140 * 10^5 * 0.0016 = 22400 W$

After Modification.

b)



a) oil tank [return line above fluid level] → used for storing & cooling of hydraulic oil.

b) filter → used for removing the impurities & contamination in the hydraulic oil circulating the system.

c) uni-directional, fixed displacement pump → it is the heart of the hydraulic system, which is used to eject flow rate by changing the mechanical energy gained from the prime mover, into hydraulic energy.

d) Pressure Relief valve → a normally closed valve, which limits the pump pressure to a max. pressure setting then after this pressure is exceeded the valve opens to allow the flow back to the tank.

e) 3 positions, 4 ways, manually actuated, spring centered directional control valve → used for controlling the direction of flow of the fluid in the system

f) check valve → permits the flow in one direction & prevents flow in the opposite direction [Directional control valve]

g) Double acting, single rod, hydraulic cylinder → it is used for transforming the hydraulic power in the system to mechanical power in Linear motion affecting an external load on it

h) unloading valve → it is used to build up pressure pressure at a specific location & then opens to allow the flow.

i) Sequence Pressure control valve → used to operate the system with a specific sequence.

j) Non-pressure compensated flow control valve → used to control the speed of the motor in systems where there is no pressure changes.

k) counter balance Pressure control valve → used in vertical

This circuit is a sequence control system, which is mainly controlled by the directional control valve
In its middle envelope, the cylinders are locked in their positions & the flow is blocked, so the pressure increases causes the pressure relief valve to open, inorder to prevent this loss in the modified circuit, the inlet ports in the middle envelope are connected together & so the flow will directly return to the tank.

- When the left envelope of the DCV is in action this allows the flow into the circuit which will first expand the cylinder on the left, untill the unloading valve build up pressure to open the way for the expansion of the cylinder on the right
- When the right envelope of the DCV is in action the opposite occurs, the right cylinder will retract first & then the left cylinder.

The modification of reinstalling a filter can be done by adding 2 filters in case one of them is blocked due to contamination, & inorder to control the speed of retraction a flow control valve is used in the retracting line of the cylinders