2nd term 2010 - 2011 EME312

Q1

a) $V_1 = 1 m^3$ $P_1 = 10$ bar $P_2 = 20$ bar

$V_2 = ??$

(i) ideal gas

$$\frac{P_1 V_1}{P_2 V_2} = \frac{mRT}{mRT}$$

$$V_2 = \frac{P_1 V_1}{P_2} = \frac{10 * 1}{20} = \frac{1}{2} m^3$$

(ii) water $K = 2 * 10^9 N/m^2$

$$K = -\frac{P_2 - P_1}{\left(\frac{V_2 - V_1}{V_1}\right)} = -\frac{(20-10) * 10^5}{\left(\frac{V_2 - 1}{1}\right)}$$

$$V_2 - 1 = \frac{-10 * 10^5}{2 * 10^9} = -5 * 10^{-4}$$

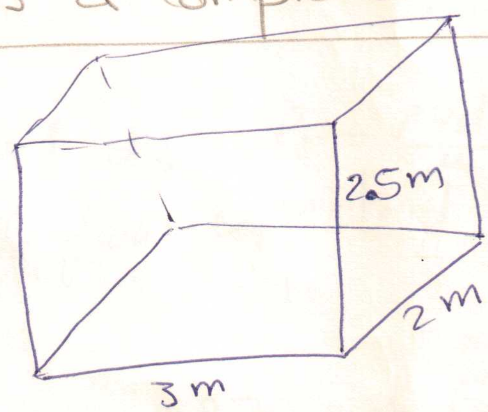
$$V_2 = 1 - 5 * 10^{-4} = 0.9995 m^3$$

from results

water is an incompressible fluid

ideal gas is a compressible fluid

(b)



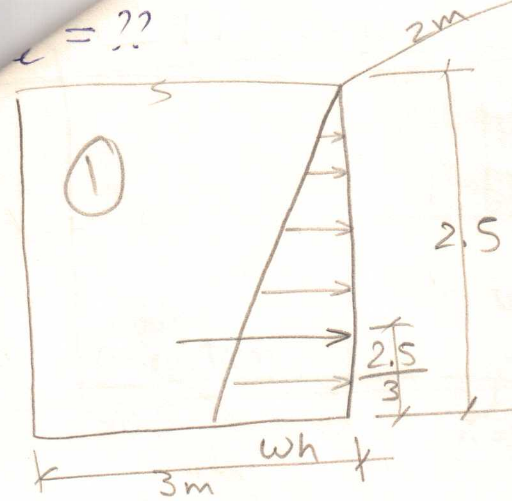
$F_{side} = ??$

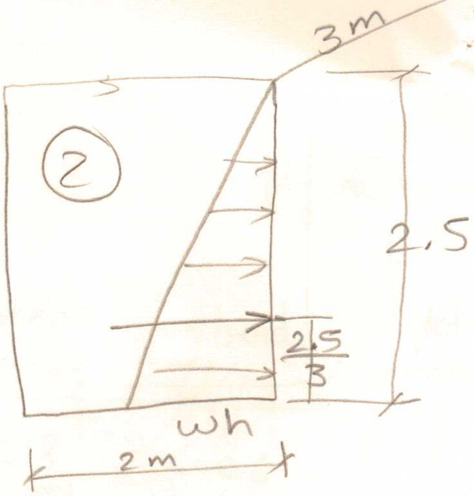
$F_{bottom} = ??$

$$\rho_{oil} = \gamma_{oil} \rho_{water} = 0.9 * 1000 = 900 \quad Kg/m^3$$

$$w_{oil} = \rho_{oil} * g = 900 * 9.8 = 8820 \quad N/m^3$$

= ??



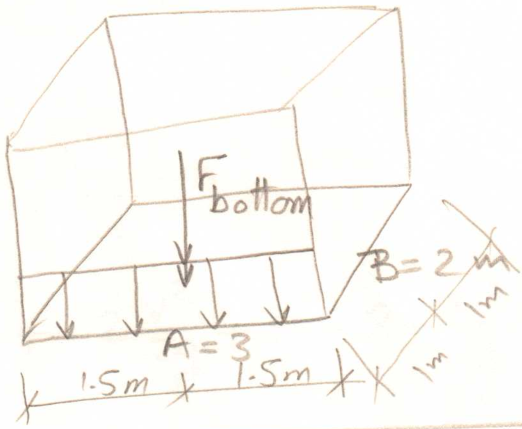


$F_{side} = wh * \frac{h}{2} * B$

$F_{side1} = 8820 * 2.5 * \frac{2.5}{2} * 2 = 55{,}125$ Newton

$F_{side2} = 8820 * 2.5 * \frac{2.5}{2} * 3 = 82{,}687.5$ Newton

(ii) F_{bottom} = ??



$F_{bottom} = wh * A * B$

$= 8820 * 2.5 * 2 * 3$

$= 132{,}300$ Newton

Q2

a) i) × higher total energy to lower total energy.

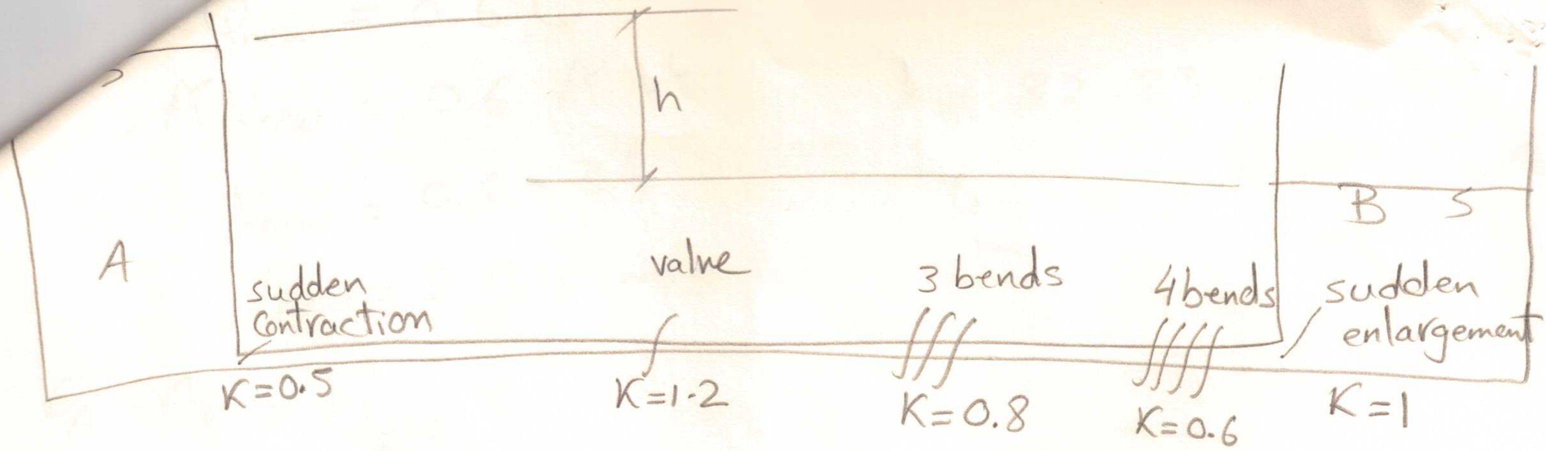
ii) × friction loss and eddy loss

iii) ✓

iv) × $\mu \uparrow$ $d \downarrow$ $R_e = \frac{\rho v d}{\mu}$ expected to be small
the flow expected to be laminar.

v) ✓

vi) × $C_{dv} = 0.97$ & $C_{do} = 0.65$



$d = 15 * 10^{-2} = 0.15\ m$

$l = 800\ m$

$f = 0.025 \qquad \varepsilon = 0.25 * 10^{-3}\ m$

(i) $h = ??$ $\qquad Q = 60 * 10^{-3}\ m^3/sec$

$$E_A = E_B + h_{loss\ A \to B}$$

$$E_A - E_B = h_{loss\ A \to B}$$

$$h = 0.5 \frac{V^2}{2g} + f \frac{l}{d} \frac{V^2}{2g} + 1.2 \frac{V^2}{2g} + 3 * 0.8 * \frac{V^2}{2g} + 4 * 0.6 * \frac{V^2}{2g} + 1 * \frac{V^2}{2g}$$

$$h = \frac{V^2}{2g}\left(0.5 + 0.025 * \frac{800}{0.15} + 1.2 + 3 * 0.8 + 4 * 0.6 + 1\right)$$

$h = 7.185\ V^2 \longrightarrow (1)$

$Q = AV = \frac{\pi}{4} d^2 V$

$60 * 10^{-3} = \frac{\pi}{4}(0.15)^2 * V \qquad \therefore V = 3.4\ m/sec$

sub. in (1)

$h = 82.83\ m$

$Q_{new} = 0.6\, Q$

$\cancel{A}\, V_{new} = 0.6\, \cancel{A}\, V$

$V_{new} = 0.6 * 3.4$

$V_{new} = 2.04$ m/s

$h = 82.83$ m

$h_{loss\ valve} = ??$

$$E_A - E_B = h_{loss\ A \to B}$$

$$82.83 = 0.5 \frac{V_{new}^2}{2g} + f \frac{l}{d} \frac{V_{new}^2}{2g} + h_{loss\ valve} + 3 * 0.8 \frac{V_{new}^2}{2g} + 4 * 0.6 \frac{V_{new}^2}{2g} + 1 * \frac{V_{new}^2}{2g}$$

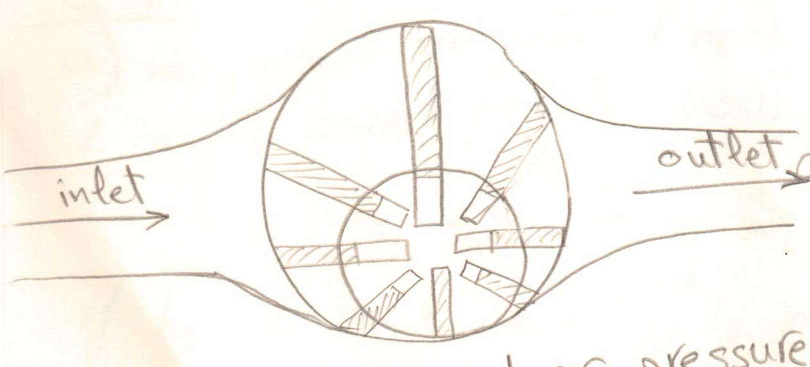
$$h_{loss\ valve} = 82.83 - \frac{(2.04)^2}{2 * 9.8} \left[0.5 + 0.025 * \frac{800}{0.15} + 3 * 0.8 + 4 * 0.6 + 1 \right]$$

$$h_{loss\ valve} = 53.18 \text{ m}$$

Q3

a) vane pump

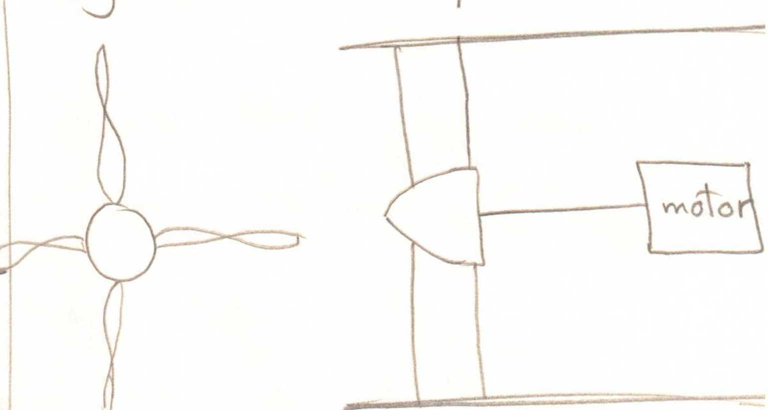
* positive displacement pump



* working at 500 bar pressure
* expensive.

Axial flow pump

* Dynamic head pump



* gives very high discharge.
  low pressure head (up to 15m

...m pump three cylinders $S = 60cm = 0.6\,m$

$D = 30\,cm = 0.3\,m$ $h_{st} = 85\,m$ $Q = 80 * 10^{-3}\ m^3/s$

$h_{LS} = 1.2\,m$ $h_{Ld} = 12\,m$ $V = 1\,m/s$

$\eta_m = 0.9$ $\eta_{vol} = 0.98$ $N = ??$ $Power = ??$

$$Q_{act} = \eta_{vol} * \frac{\pi}{4}D^2 * S * \frac{N}{60} * \text{no. of cylinders}$$

$$80 * 10^{-3} = 0.98 * \frac{\pi}{4}(0.3)^2 * 0.6 * \frac{N}{60} * 3$$

$N = 38.5$ rpm

$$h_{pump} = h_{st} + h_{loss\ total} + \frac{V^2}{2g}$$

$$= 85 + (1.2 + 12) + \frac{1^2}{2 * 9.8}$$

$$= 98.25\ m$$

$$power = \frac{w h_p Q}{\eta_m} = \frac{9800 * 98.25 * 80 * 10^{-3}}{0.9}$$

$= 35.2$ watt

Q4

a) All pumps are installed near suction tank (h_{ls} min.) & in the lowest possible position w.r.t suction level (h_{ss} max.)

$$h_{ss} - h_{ls} - \frac{V^2}{2g} > h_{vap} - h_{atm}$$

if h_{ss} is max. and h_{ls} is min. then the L.H.S. will be greater than $h_{vap} - h_{atm}$ then we <u>can avoid cavitation</u>

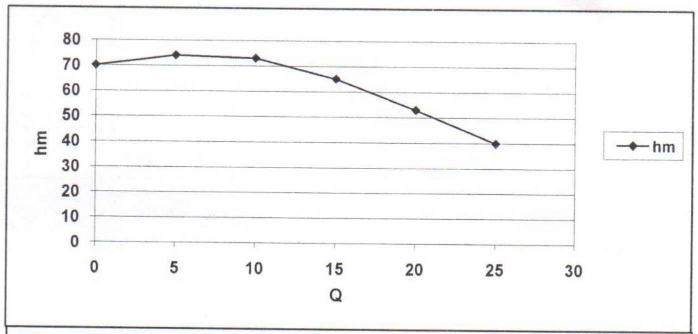
Q	0	5	10	15	20	25
hm	70	74	73	65	53	40
eta	0	60	76	72	58	41
Sh.P.		60433	94132	132708	179103	239024

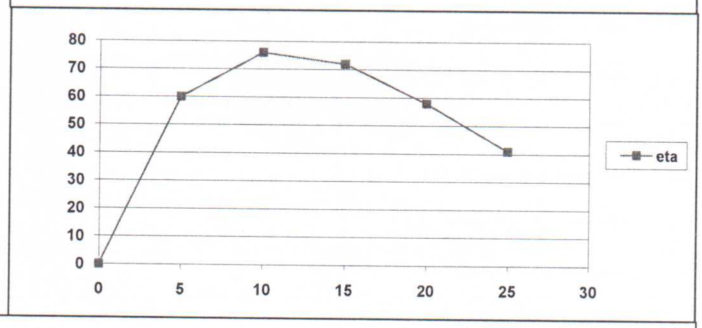
hst	hls	hld	KE	hss
50	5	10	0.2	-3

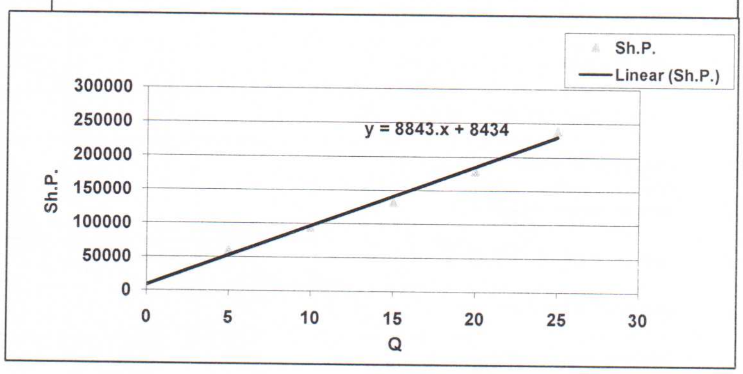
hp = hst + hlt + KE
hp = 65.2 m

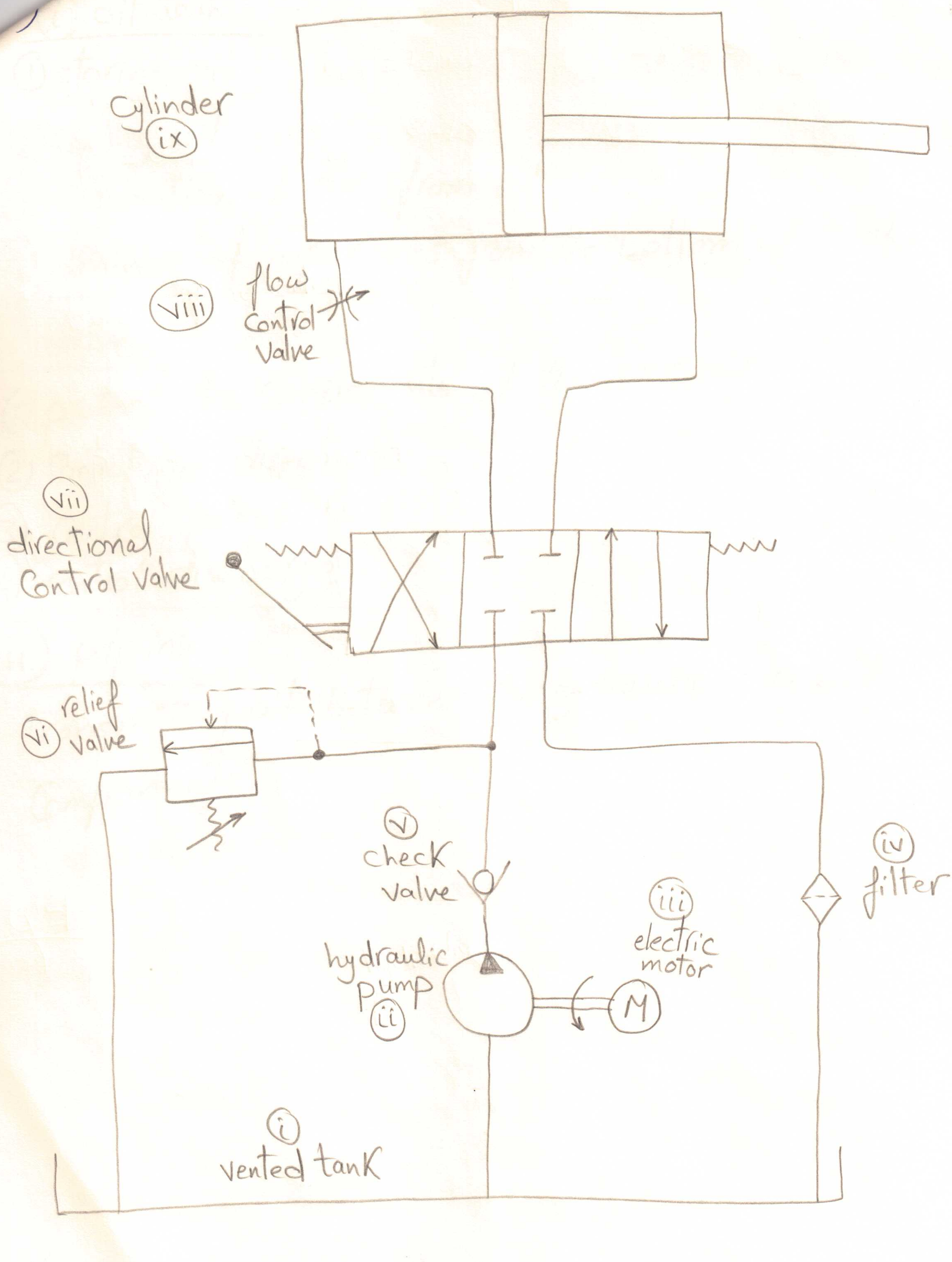
hms = hss - hls - KE
hms = -8.2 m

Sh.P. at operating point
Sh.P. = 132708 watt
Sh.P. = 132.71 kw









Cylinder
ix
viii
flow
Control
Valve
vii
directional
Control valve
relief
vi
valve
v
check
valve
iv
filter
iii
electric
motor
hydraulic
pump
ii
M
i
vented tank

functions of :-

(i) oil tank

1. storing oil
2. Cooling oil
3. separation of air from oil
4. draining of impurities from the bottom of tank.

(ii) valves

1. protect the components of the circuit
2. control oil direction
3. control pressure
4. control discharge

(iii) piping

transmitting oil between the hydraulic circuit components.