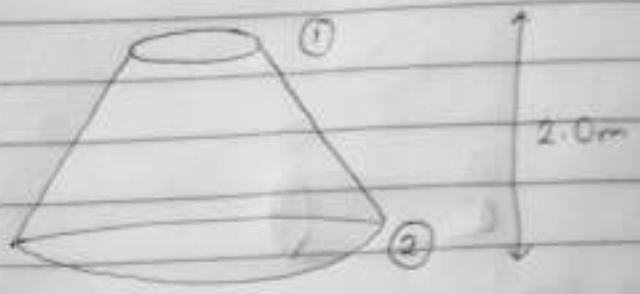
LAW - ADUE EMMANUEL
19/ENG05/069
MECHATRONICS . 200Lvl

1



$V_1 = 5ms^{-1}$

$V_2 = 2ms^{-1}$

Pressure head at smaller end, $\frac{P_1}{\omega} = 2.5m$

Pressure head at lower end, $\frac{P_2}{\omega} = ?$

Head loss $= 0.35 \times (5-2)^2 / 2 \times 9.81$

$= 0.35 \times 9 / 19.62$

$= 0.161$

Recall, head loss $= \frac{P_1}{\omega} - \frac{P_2}{\omega}$; let $\frac{P_2}{\omega} = x$

$\Rightarrow \quad 0.161 = 2.5 - x$

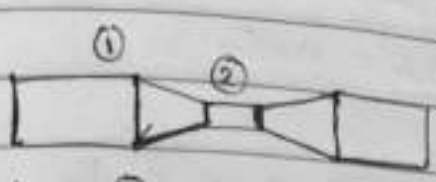
$\Rightarrow \quad 0.161 - 2.5 = -x$

$\Rightarrow \quad \neq 2.34m = \neq x$

$\Rightarrow \quad \therefore x = 2.34m$

$\equiv \frac{P_2}{\omega} = 2.34m$ ///

2



Inlet = ①

Throat = ②

$d_1 = 20cm = 0.2m$; $A_1 = \pi d^2/4 = 0.0314$

$d_2 = 10cm = 0.1m$; $A_2 = \pi d^2/4 = 0.00786$

$P_1 = 17.658\ N/cm^2 = 17,6850\ N/m^2$

$P_2 = 30cm\ Hg$

$= 30 \times 10^{-6}$ mHg 30×10^{-3} mHg $0.3m$ of Hg

$C_d = 0.98$

$\frac{P_1}{\omega} = \frac{17\,6850}{1000 \times 9.81} = 18$

$\frac{P_2}{\omega} = 30 \times 10^{-3} \times 13.6 = 0.3 \times 13.6 = 4.08$

$h = \frac{P_1}{\omega} - \frac{P_2}{\omega}$

$= 18 - 4.08 = 13.92$

$Q = C_d \left(\frac{A_1 A_2 \sqrt{2gh}}{\sqrt{A_1^2 - A_2^2}} \right)$

$= 0.98 \times \frac{0.0314 \times 0.00786 \times \sqrt{2 \times 9.81 \times 13.92}}{\sqrt{0.0314^2 - 0.00786^2}}$

$= \frac{3.997 \times 10^{-3}}{0.0304} = 0.1315$ ///

3 Orifice diameter, $d_2 = 15cm = 0.15m$

Pipe diameter, $d_1 = 30cm = 0.3m$

$Cd = 0.64$

Manometer reading = 50cm Hg = 0.5m Hg

$$a_1 = \frac{\pi d_1^2}{4} = \frac{3.142 \times 0.15^2}{4} = 0.0177m^2$$

$$a_2 = \frac{\pi d_2^2}{4} = \frac{3.142 \times 0.3^2}{4} = 0.0707m^2$$

$$h = y\left(\frac{SG\ of\ Hg}{SG\ of\ oil} - 1\right) = 0.5\left(\frac{13.6}{0.9} - 1\right)$$

$$= 0.5 \times 14.11 = 7.055$$

$$\text{Rate of flow, } Q = Cd\left(\frac{a_1 a_2 \sqrt{2gh}}{\sqrt{a_1^2 - a_2^2}}\right)$$

$$= 0.64\left(\frac{0.0177 \times 0.0707 \times \sqrt{2 \times 9.81 \times 7.055}}{\sqrt{-0.0177^2 + 0.0707^2}}\right)$$

$$= \frac{0.64 \times 0.0147}{0.0684}$$

$$= 0.138 \text{ ///}$$

SG of mercury = 13·6
SG of sea-water = 1·026
Difference of mercury levels, $y = 170\ mmHg$

4 $h = \left[\frac{\text{S.G of liquid} - 1}{\text{S.G of oil}}\right] y$

$y = 170\ mmHg$
$= 170 \times 10^{-3}\ mHg = 0.17\ mHg$

$h = \left[\frac{13.6}{1.026} - 1\right] 0.17$

$h = 2.083\ m$ of water

Speed of the sub-marine, $v = \sqrt{2gh}$
$= \sqrt{2 \times 9.81 \times 2.083}$
$= 6.39\ ms^{-1}$ ///

∴ the speed of the sub-marine $= 6.39\ ms^{-1}$

5 $Q = 0.05 m^3/min$

$P_2 - P_1 = 15 bar$

$S = 10 cm^3/rev$

torque = 15 Nm

i) Volumetric Efficiency = $\frac{\text{theoritical flow}}{\text{actual flow}}$

$\therefore F_t = 17\omega \times 10 = 17\omega\, cm^3 min^{-1}$

$= 0.017 m^3 min^{-1}$

$V.E = \frac{0.017}{0.05} \times 1\omega$

$= 34\%$

ii) Fluid Power = $\frac{\text{Pressure } (P_{ii}) \times \text{flow}}{1714}$

$[15 bar = 217.557 P_{sc}] = \frac{217.557 \times 0.05}{1714} = 0.0063 hp$

$[1 hp = 746 W] = 0.0063 \times 746 = 4.73 W$

(iii) Hydraulic power = $\frac{50 \times 15 W}{60,\omega} = 1.25 kW$

iv Shaft Power = $\frac{\text{hydraulic power}}{\text{efficiency}}$

$= \frac{1.25}{0.34 \times 1} = 3.67\ KW$

Overall Efficiency = Volumetric eff × Mech eff

* Mech. eff = $\frac{\text{displacement} \times \text{pressure}}{2\pi}$

$= \frac{0.00001 \times 15 \times 10^5}{2\pi} = 24\%$ Approx

∴ Overall efficiency

$= \frac{34 \times 24}{1W} = 3.16\%$ //