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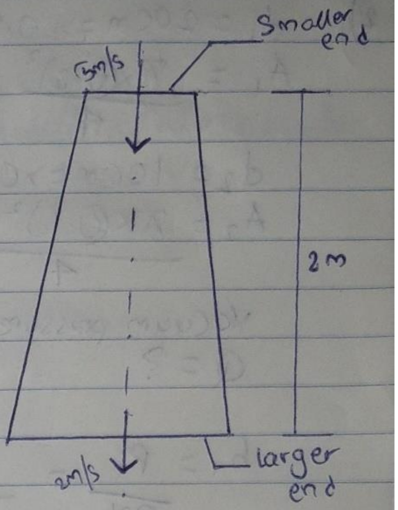
Fluid Mechanics Assignment



1) length of Conical tube = 2.0m

$V_1 = 5m/s$

$V_2 = 2m/s$

Pressure head of smaller end = 2.5m

$$\text{loss of head} = \frac{0.35(V_1-V_2)^2}{2g}$$

$$\text{loss of head} \Rightarrow \frac{0.35\times(5-2)^2}{2\times9.81} = \frac{0.35(3)^2}{19.62}$$

$$h_L = 0.160m$$

The pressure at Larger end $\Rightarrow \frac{P_2}{w}$

Applying Bernoulli's equation for Conical tube

$$\frac{P_1}{w} + \frac{V_1^2}{2g} + Z_1 = \frac{P_2}{w} + \frac{V_2^2}{2g} + Z_2 + h_L$$

$Z_1 = 2m, \quad Z_2 = 0$

$$2.5 + \frac{5^2}{2\times9.81} + 2 = \frac{P_2}{w} + \frac{2^2}{2\times9.81} + 0 + 0.160$$

$$2.5 + 1.27 + 2 = \frac{P_2}{w} + 0.203 + 0.160$$

$$5.77 = \frac{P_2}{w} + 0.363$$

$$\frac{P_2}{w} = 5.77 - 0.363$$

head at Larger end $= \frac{P_2}{w} \Rightarrow 5.41m$

2) $d_1 = 20cm \Rightarrow 0.2m$ (inlet)

$A_1 = \frac{\pi\times(0.2)^2}{4} = 0.03142m^2$

$d_2 = 10cm \Rightarrow 0.1m$ (throot)

$A_2 = \frac{\pi\times(0.1)^2}{4} = 0.00785m^2$

Vacuum pressure = 30cmHg => 0.3m Hg

$Q = ?$

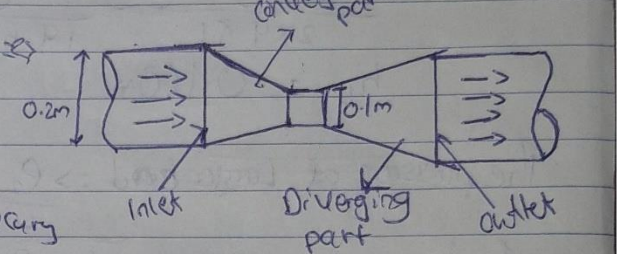
$c_d = 0.98$

$P_1 = 17.658N/cm^2$

$\Rightarrow \frac{17.658}{10^{-4}} = 176580N/m^2$

$h_1 = \frac{P_1}{\rho g} = \frac{176580}{9.81\times1000}$

$\Rightarrow 18m$



$h_2 = \frac{P_2}{\omega} = -0.3m$ of mecury

$\Rightarrow -0.3\times 13.6 = -4.08m$ of water

$h = \frac{P_1}{\omega} - \frac{P_2}{\omega} \Rightarrow 18-(-4.08) = 22.08m$

$$Q = \frac{c_d A_1 A_2 \sqrt{2gh}}{\sqrt{A_1^2 - A_2^2}}$$

$$Q = \frac{0.98\times0.03142\times0.00785\times\sqrt{2\times9.81\times22.08}}{\sqrt{0.03142^2 - 0.00785^2}}$$

$$Q \Rightarrow \frac{\overset{2.42\times10^{-4}}{\cancel{0.03}9}\times\sqrt{433.21}}{\sqrt{9.26\times10^{-4}}}$$

$$Q \Rightarrow \frac{5.037\times10^{-3}}{0.0304} = \underline{0.166m^3/s}$$

3) $d_0 = 15cm \Rightarrow 0.15m$

$d_1 = 30cm \Rightarrow 0.30m$

$A_0 = \frac{\pi \times (0.15)^2}{4} = 0.0177m^2$

$A_1 = \frac{\pi (0.3)^2}{4} = 0.07m^2$

$C_d = 0.64$

S.g of oil = 0.9

Reading of differential Manometer

$y \Rightarrow 50cm\,Hg$

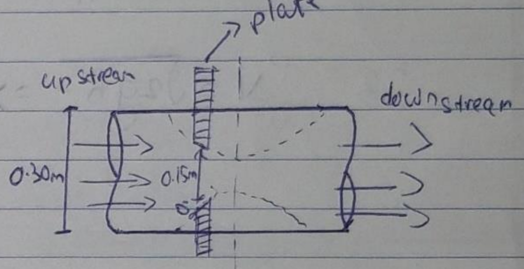
$\Rightarrow 0.5m\,Hg$

~~hg~~ $h = y\left[\frac{S_{hL}}{S_0} - 1\right] \Rightarrow 0.5\left[\frac{13.6}{0.9} - 1\right]$

$h \Rightarrow 7.05m$

$$Q = \frac{C_d A_0 \times A_1 \sqrt{2gh}}{\sqrt{A_1^2 - A_0^2}}$$

$$Q = \frac{0.64 \times 0.0177 \times 0.07 \times \sqrt{2 \times 9.81 \times 7.05}}{\sqrt{0.07^2 - 0.0177^2}}$$



$$Q \Rightarrow \frac{7.9296 \times 10^{-4} \times \sqrt{138.32}}{\sqrt{4.59 \times 10^{-3}}}$$

$$Q \Rightarrow \frac{9.326 \times 10^{-3}}{0.068} \Rightarrow 0.137 m^3/s$$

4) Reading from Differential manometer = 170mm Hg = 0.17m Hg

Specific gravity of mercury is 13.6

Specific gravity of sea water = 1.026

~~h = 0.17~~ $h = y\left[\frac{S_m}{S_L} - 1\right]$

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

$$h \Rightarrow 0.17[12.26]$$

$$h = 2.084m$$

$$V = \sqrt{2gh} \Rightarrow \sqrt{2 \times 9.81 \times 2.084} = \sqrt{40.89}$$

$$\Rightarrow 6.39 m/s$$

5) Actual flow rate = $5 dm^3/min$ = 5l/min

(a)

P = 15bar   Speed = 1700rpm   Displacement = 10cc/rev

Torque = 15Nm , volumetric Efficiency = $\frac{\text{Theoretical flow}}{\text{Actual flow}} \times 100$

Theoretical flow => Displacement × Speed

=>

but $10cm^3/rev = 10\times10^{-3} \Rightarrow 0.01 l/rev$

Theoretical flow = $0.01\times1700 \Rightarrow 17 l/min$

volumetric efficiency = $\frac{5}{17} \times 100 \Rightarrow 0.294\times100$

$\Rightarrow 29.4\%$

(b) Fluid power => $\frac{\overset{(P)}{\text{Pressure}} \times \overset{(Q)}{\text{Actual flow}}}{600}$ P in bar
Q in l/min

$= \frac{15\times5}{600} \Rightarrow 0.125kW \Rightarrow 125W$

(c) Shaft power = $\frac{\text{fluid power}}{\text{efficiency of pump}} \Rightarrow \frac{125}{0.294} = 425.17W$

General/Overall Efficiency
= volumetric eff × hydraulic/mechanical efficiency

Hydraulic efficiency = $\frac{\text{Theoretical torque}}{\text{Actual torque}}$ ~~× 100~~

Theoretical torque = $\frac{\text{Displacement} \times \text{Pressure}}{20\pi}$

$$\Rightarrow \frac{10 \times 15}{20 \times 3.142} \Rightarrow 2.39\,\text{Nm}$$

Hydraulic/mechanical eff $\Rightarrow \dfrac{2.39}{15} = 0.16$

overall efficiency $= 0.294 \times 0.160 \times 100$

$\Rightarrow \underline{4.7\%}$