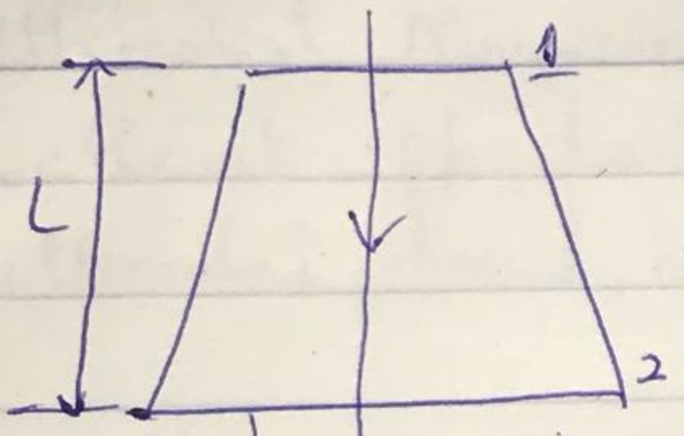
EGBUNU HIKMAT IGANYA
18/ENG03/025
CIVIL ENGINEERING

FLUID MECHANICS.

1. A Conical tube of length 2.0m is fixed Vertically with its Smaller end upwards. The Velocity of flow at the Smaller end is 5m/s while at the Lower end it is 2m/s. The Pressure head at the Smaller end is 2.5m of liquid. The loss of head in the tube is given as $(0.35(V_1-V_2)^2)/2g$. where V_1 is the Velocity at the Smaller end and V_2 at the lower end respectively. Determine d pressure head at d lower end. Flow takes place in d downward direction.

Soln



$L = 2.0m$, $V_1 = 5m/s$ $V_2 = 2m/s$

Let the Pressure head at the Smaller end $P_s = 2.5m$ of liquid

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

$= \frac{0.35(5-2)^2}{2 \times 9.81} = 0.161m$.

Let the pressure head at the lower end $P_F = ?$

Applying Bernoulli's Equation;

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

where $P_s = \frac{P_1}{\rho g}$ and $P_L = \frac{P_2}{\rho g}$

$Z_1 = 2.0$ and $Z_2 = 0$ (datum line passes through Section 2)

Substituting the Values Into the Equation;

$$2.5 + \frac{5^2}{2 \times 9.81} + 2.0 = P_L = \frac{2^2}{2 \times 9.81} + 0 + 0.161$$

$$2.5 + \frac{25}{19.62} + 2 = P_L + \frac{4}{19.62} + 0.161$$

$$2.5 + \frac{25}{19.62} + 2 - \left(\frac{4}{19.62} + 0.161\right) = P_L$$

$$5.774 - 0.365 = P_L$$

$\therefore P_L = 5.409m$ of fluid.

2. A horizontal Venturimeter with inlet diameter 20cm and throat diameter 10cm is used to measure the flow of water. The pressure at inlet is $17.658 N/cm^2$ and the Vacuum pressure at the throat is 30cm of mercury. Find the discharge of water through Venturimeter. Take $C_d = 0.98$

Soln

Let; Inlet diameter, $D_1 = 20cm$

throat ", $D_2 = 10cm$

Inlet Area $A_1 = \frac{\pi d_1^2}{4} = \frac{\pi (20)^2}{4} = 314.16 cm^2$

Throat Area, $A_2 = \frac{\pi d_2^2}{4} = \frac{\pi (10)^2}{4} = 78.54 cm^2$

Density of water $\rho = 1000 kg/m^3$

Pressure at inlet $= 17.658 N/cm^2 = 17.658 \times 10^4 N/m^2$

$\therefore \frac{P_1}{\rho g} = \frac{17.658 \times 10^4}{1000 \times 9.81} = 18m.$

$\frac{P_2}{\rho g} = -30cm$ of mercury, $S.g_{Hg} = 13.6$

$P_2/\rho g = -30 \times 10^{-2} m$ of mercury $\times 13.6$

$= -4.08m.$

Differential Head, $H_d = \frac{P_1}{\rho g} - \frac{P_2}{\rho g}$

$= 18 - (-4.08)$

$= 18 + 4.08 = 22.08m \times 100$

$H_d = 2208 cm$

Using, $Q = \frac{C_d \sqrt{2gh} \times A_1 A_2}{\sqrt{A_1^2 - A_2^2}}$

$= \frac{0.98 \times \sqrt{2 \times 9.81 \times 2208} \times 314.16 \times 78.54}{\sqrt{(314.16)^2 - (78.54)^2}}$

$= \frac{0.98 \times 2081.37 \times 24674.1264}{304.184112}$

$= 165455.3 cm^3/s$

$= \frac{165455.30}{1000} = 165.455 lit/sec.$

3. Diameter of the pipe, $d_1 = 30cm$

$$A_1 = \frac{\pi d_1^2}{4} = \frac{\pi(30)^2}{4} = 706.86cm^2$$

Diameter of orifice, $d_2 = 15cm$

$$A_2 = \frac{\pi d_2^2}{4} = \frac{\pi(15)^2}{4} = 176.72cm$$

Specific gravity of oil, $S_o = 0.9$

" " " Mercury, $S_{hg} = 13.6$

Differential Manometer reading, $X = 50cm$ of mercury

Coefficient of discharge, $Cd = 0.64$

Differential head, $h = x\left(\frac{S_{hg}}{S_o} - 1\right)$

$$h = 50\left(\frac{13.6}{0.9} - 1\right)$$

$$h = 705.56cm \text{ of oil.}$$

∴ The rate of flow of oil is ;

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

$$Q = \frac{0.64 \times \sqrt{2 \times 9.81 \times 705.56} \times (706.86 \times 176.72}{\sqrt{(706.86)^2 - (176.72)^2}}$$

$$Q = \frac{137443.29}{1000} = 137.44 \text{ lit/s.}$$

4. The differential of Mercury level, $x = 170mm = 170 \times 10^{-3} = 0.17m$

The Specific gravity of Mercury, $S_g = 13.6$

" " " " Sea water, $S_o = 1.026$

Speed, $V = ?$

Recall; $V = \sqrt{2gh}$, $h = ?$

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

$$= 2.0834m$$

$\therefore V = \sqrt{2 \times 9.81 \times 2.0834}$

$V = 6.393\, m/s$

In Km/hr; $V = \frac{6.393 \times 60^2}{1000} = 23.01\, km/hr.$

5. $Q = 0.05\, m^2/min = 50\, dm^3/min$

$P_o = 15\, bar = 15 \times 10^5\, N/m^2$

Speed, $v = 1700\, rev/min$ $\quad T = 15\, Nm$, $N_D = 10\, cm^3/rev.$

i) Volumetric Efficiency $= \frac{\text{Actual flow rate}}{\text{Ideal flow rate}}$

Actual flow rate $= 0.05\, m^3/min$

Ideal flow rate = Nominal flow rate X Speed

$= 10\, cm^3/rev \times 1700\, rev/min$

$= 17000\, cm^3/min$

Ideal flow rate $= \frac{17000}{1000000} = 0.017\, m^3/min$

$\therefore$ Volumetric Efficiency $= \frac{0.05\, m^3/min}{0.017\, m^3/min}$

$= 2.94 \times 100 = 294\%$

ii) Fluid Power $= P \times Q$ $\quad Q = 0.05\, m^3/min = \frac{0.05}{60} = 8.33 \times 10^{-4}\, m^3/s.$

$= 15 \times 10^5 \times 8.33 \times 10^{-4}$

$= 15 \times 10^5 \times 83.3 \times 10^{-5}$

$= 12495 \times 10^{-5}$

Fluid Power = 1249.5 Watts.

) Shaft Power $= \frac{2\pi NT}{60} = \frac{2\pi \times 1700 \times 15}{60}$

Shaft Power = 2670.35 watts.

iv) Overall Effic

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iv) Overall Efficiency = $\frac{\text{Fluid Power}}{\text{Shaft Power}}$

$= \frac{1249.5}{2670.35}$

$= 0.468$

Overall Efficiency $= 0.468 \times 100 = 46.8\%$