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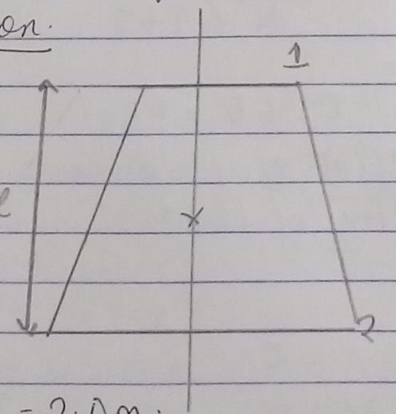
MATRIC NOS: 18/ENG02/095
COURSE CODE & TITLE: FLUID MECHANICS ENG214
DEPARTMENT: COMPUTER ENGINEERING

1. A conical tube of length 20m is fixed vertically with its smaller and upwards. The velocity flow at the smaller end is 5m/s while at the smaller end is 2.5m of liquid. The loss of head in the tube is given as $\left(0.35(v-v_2)^2\right)/2g$, where v_1 is the velocity at the smaller end and v_2 is the lower end. Flow takes place in the downward direction.

Solution.



data

length, $L = 2.0m$.

velocity flow at smaller end - V_1 - 5m/s

velocity flow at lower end - V_2 - 2m/s

Pressure at smaller end = P_s = 2.5m of liquid

Head loss of pipe (H_L) $= \frac{0.35(V_1 - V_2)^2}{2g}$

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

Pressure head at the lower end = P_L = ?

Applying Bernoulli's Equation

$$\frac{P_1}{\rho g} + \frac{v_1^2}{2g} + z_1 = \frac{P_2}{\rho g} + \frac{v_2^2}{2g} + z_2 + hl$$

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

$$= 2.5 + \frac{(5)^2}{2 \times 9.81} + 2.0 = P_L + \frac{2^2}{2 \times 9.81} + 0 + 0.16$$

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

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

$P_L = 5.774 - 0.365 = P_L$

$P_L = 5.409$m of fluid

$= 5.41$m 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 mercury. Find the discharge of water through venturimeter.
Take $Cd = 0.98$

Solution.

data.

inlet diameter $= D_1 = 20cm$

throat diameter $= D_2 = 10cm$

inlet area $= A_1 = \frac{\pi (D_1)^2}{4} = \frac{\pi (20)^2}{4}$

$= \frac{\pi 400}{4} = 314.1$

throat area $= A_2 = \frac{\pi (D_2)^2}{4} = \frac{\pi (10)^2}{4} = 78$

$\therefore A_1 = 314.16 cm^2$

$A_2 = 78.54 cm^2$

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

pressure at inlet $= 17.658 N/cm^2$

$= 17.658 \times 10^4 N/m^2$

$\therefore P_2/\rho g = -30cm$ of mercury,

$S.g_{Hg} = 13.6$

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

$= -4.08m$

Let differential Head $= P_1/\rho g - P_2/\rho g$

$= 18 - (-4.08)$

$= 18 + 4.08$

$= 22.08$

$= 22.08m \times 100$
$H = 2208cm.$

Using, $Q = \dfrac{C_d \sqrt{2gh} \cdot A_1 A_2}{\sqrt{(A_1)^2 - (A_2)^2}}$

$= \dfrac{0.98 \times \sqrt{2 \times 9.81 \times 2208} \times 314.16 \times 78.5}{\sqrt{(314.16)^2 - (78.54)^2}}$

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

$= 165455.3 cm^3/s$

$= \dfrac{165455.3}{1000} = 165.455 lt/sec.$

3. An orifice meter with orifice diameter is 15cm is inserted in a pipe of 30cm diameter. The pressure difference measured by a mercury oil differential manometer on the 2 sides of orifice meter gives a reading of 50cm of mercury. Find the rate of flow of oil of specific gravity 0.9, when the coefficient discharge of the meter is 0.64.

Solution.

DATA

$d_1 - 30cm.$

$A_1 = \dfrac{(\pi d_1)^2}{4} = \dfrac{\pi (30)^2}{4} = 706.95 cm^2$

$D_2 - 15cm$

$A_2 - \dfrac{\pi (d_2)^2}{4} = \dfrac{\pi (15)^2}{4} = 176.73 cm$

Specific gravity of oil $- Sp.g\,O - 0.9$

Specific gravity of mercury – Spg M = 13.6
differential manometer reading – x – 50cm
Coefficient of discharge – cd – 0.64
differential head, $h = x\left(\frac{Smg}{So} - 1\right)$

$$h = x\left(\frac{Smg}{So} - 1\right)$$

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

$$= 50\left(15.11 - 1\right)$$

$$= 50\left(14.11\right) = 705.5$$

h = 705.5cm of oil

4. A submarine moves horizontally in sea and has its axis 15m below the surface of water. A pitot-tube properly placed just infront of the sub-marine and along its axis is connected to the 2 limbs of a U-tube containing mercury. The difference of mercury level is found to be 170mm. Find the speed of the sub-marine knowing the Sp. gr of mercury is 13.6 and that of sea water is 1.026 with respect to the fresh water.

Solution:

$x - 170mm = 170 \times 10^{-3} = 0.17m.$

Specific gravity of mercury – S.g – 13.6
Specific gravity of sea water – 1.026
Speed, (v) – ?
h – ?

$v = \sqrt{2gh}$

$h = x\left[\frac{s_g}{s_o} - 1\right]$

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

$= 0.17\left[13.25 - 1\right]$

$= 0.17\left[12.25\right]$

$= 2.0825$

$\simeq 2.08m$

$\therefore v = \sqrt{2gh}$

$= \sqrt{2 \times 9.81 \times 2.0825}$

$= 6.391 m/s$

In Km/hr

$v = \frac{6.391 \times (60)^2}{1000}$

$= v = \frac{6.391 \times 3600}{1000} = 23.0076$

$\simeq 23.01 km/hr.$

5. A pump delivers at the rate of $0.05 m^3/min$ with a pressure change of 15bar. The speed of rotation is 1700 rev/min while the normal displacement is given as $10 cm^3/rev$. If the torque input is 15Nm, compute the

(i) volumetric Efficiency

(ii) fluid power

(iii) shaft power

(iv) overall efficiency.

Solution:

data

$Q - 0.05 m^3/min = 50 dm^3/min$

$P_0 = 15bar = 15 \times 100\,000 = 15 \times 10^5 N/m^2$

Speed = 1700 rev/min

$T = 15 Nm$, NO (normal displ) $= 10 cm^3/rev$.

(i) volumetric Efficiency

$$\text{volumetric Efficiency} = \frac{\text{Actual flowrate}}{\text{Ideal flow rate}}$$

Ideal flow rate = NO x flow rate x speed

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

$= 17000 cm^3/min.$

$$\text{Ideal flow rate} = \frac{17000}{1000000} = 0.017 m^2/min$$

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

$$\therefore \text{vol Eff} = \frac{0.05}{0.017} = 2.94\,\%.$$

(ii) Fluid Power $= P \times Q$

$P = 15 \times 10^5 N/m^2$

$Q = 0.05 m^3/min = \frac{0.05}{60} = 8.3$

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

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

$\cancel{= 1249.5 \times 10}$ $= 1249.5 \times 10^{-5}$

$= 1249.5$ watts

(iii) Shaft Power

$$= \frac{2\pi N T}{60}$$

$$= \frac{2\pi \times 1700 \times 15}{60}$$

$= 2670.35$ watts

Shaft power $= 2670.35$ watts.

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

$$\frac{\text{Fluid Power}}{\text{Shaft Power}} = \frac{1249.5}{2670.35} = 0.468$$

overall Efficiency $= 0.468 \times 100$

$= 46.8\%$.