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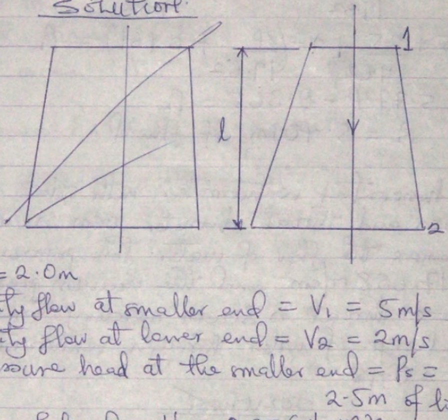
DEPARTMENT: BIOMEDICAL ENGINEERING

ASSIGNMENT

(1.) A conical tube of length 2.0m is fixed vertically with its smaller end upwards. The velocity 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 $(0.35(V1-V2)^2)/2g$. where V_1 is the velocity at the smaller end and $V2$ is the lower end respectively. Determine the pressure head at the lower end. Flow takes place in the downward direction.

SOLUTION.



length, $L = 2.0m$

The velocity flow at smaller end $= V_1 = 5m/s$

The velocity flow at lower end $= V_2 = 2m/s$

Let the pressure head at the smaller end $= P_s =$ 2.5m of liquid

Let the loss of head $= H_L = \frac{0.35(V1-V2)^2}{2g}$

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

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

Applying Bernoulli's Equation :

$$\frac{P_1}{\rho g} + \frac{V_1^2}{2g} + z_1 = \frac{P_2}{\rho g} + \frac{V_2^2}{2g} + z_2 + H$$

where $P_3 = \frac{P_1}{\rho g}$ and $P_L = \frac{P_2}{\rho g}$

$z_1 = 2.0$ and $z_2 = 0$ (datum line passes through section 2.

Inputting values into the equation

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

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

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

$$5.774 - 0.365 = P_L$$

$$P_L = 5.409 \text{m of fluid}$$

(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/cm² and the vacuum pressure at the ~~the t~~ throat is 30cm mercury. Find the discharge of water through venturimeter. Take $C_d = 0.98$.

SOLUTION

~~Pressure at inlet = $P_1 = 17.658\ N/cm^2$~~ $= 17.658 \times 10^4\ N/m^2$

~~$\rho = 1000\ kg/m^3$~~

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 $C_d = 0.98$

Solution

let inlet diameter $= D_1 = 20cm$

let throat diameter $= D_2 = 10cm$

let inlet area $= A_1 = \dfrac{\pi D_1^2}{4} = \dfrac{\pi (20)^2}{4} = 314.16cm^2$

let throat area $= A_2 = \dfrac{\pi D_2^2}{4} = \dfrac{\pi (10)^2}{4} = 78.54cm^2$

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

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

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

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

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

$$= -4.08m$$

Let Differential Head $= H = \dfrac{P_1}{\rho g} - \dfrac{P_2}{\rho g}$

$$= 18 - (-4.08)$$

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

$$H = 2208cm$$

~~$\therefore$ Using, $Q = C_d \dfrac{A_1 A_2}{\sqrt{A_1^2 - A_2^2}}$~~ $\times$

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

$= \dfrac{0.98 \times \sqrt{2 \times 981 \times 2208} \times 314.16 \times 78.54}{\sqrt{(314.16)^2 - (78.54)^2}}$

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

$= 165455.3 \, cm^3/s$

$= \dfrac{165455.3}{1000} = 165.455 \, lit/sec$

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

Solution

Diameter of ~~orifice~~ pipe ~~$d_1 = 15cm$~~ $d_1 = 30cm$

$A_1 = \dfrac{\pi d_1^2}{4} = \dfrac{\pi (30)^2}{4} = 1706.86 cm^2$

Diameter of orifice, $d_2 = 15cm$

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

Specific gravity of oil, $S_o = 0.9$

specific gravity of mercury, $S_{hg} = 13.6$

Differential manometer reading, $x = 50cm$ of mercury

Coefficient of discharge, $C_d = 0.64$

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

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

$h = 705.56 cm$ of oil

8.54

15cm is
· The pressure
differential
orifice meter
Find the
gravity 0.9,
the meter is

$^2 = 1706.86 cm^2$

6.72cm

m of mercury

∴ The rate of flow of oil is:

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

$$Q = 0.64 \times \frac{\sqrt{2 \times 981 \times 705.56} \times 706.86 \times 176.72}{\sqrt{(706.86)^2 - (176.72)^2}}$$

$$Q = 137443.29 \ cm^3/s$$

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

4 A sub-marine moves horizontally in sea and has its axis 15m below the surface of water. A pitot-tube properly placed just in front of the sub-marine and along its axis is connected to the two 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~~ 1.026 with respect to fresh water.

Solution:

The difference of mercury level, $x = 170mm = 170 \times 10^{-3} = 0.17m$

The specific gravity of mercury, $S_g = 13.6$

The specific gravity of sea water, $S_o = 1.026$

The speed, $V = ?$

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

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

$$= 2.0834 m$$

$$\therefore V = \sqrt{2 \times 9.81 \times 2.0834} = 6.393 m/s.$$

In Km/hr

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

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 $10cm^3/rev$. If the torque input is 15Nm. Compute (i.) Volumetric efficiency (ii.) fluid power (iii.) Shaft Power and (iv.) Overall efficiency.

Solution.

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

$P_o = 15bar = 15 \times 100000 = 15 \times 10^5 \; N/m^2$

Speed = 1700rev/min

$T = 15Nm$, $ND = 10cm^3/rev$

(i.) Volumetric efficiency $= \frac{\text{Actual flow rate}}{\text{Ideal flow rate}}$

Ideal flow rate = Nominal flow rate X speed

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

$= 17000 \; cm^3/min$

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

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

∴ ~~Volumetric flow rate~~

∴ Volumetric efficiency $= \frac{0.05}{0.017} = 2.94\% = 294\%$

(ii.) Fluid power $= P \times Q$

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

$Q = 0.05m^3/min = \frac{0.05}{60} = 8.33 \times 10^{-4} m^3/s$

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

$= 15 \times 10^5 \times 833 \times 10^{-5}$

$= \cancel{12495 \times 10^{5-5}} = 1249.5 \times 10^{5-5}$

Fluid Power = 1249.5 watts

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

Shaft Power = 2670.35 watts

(iv.)

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

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

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