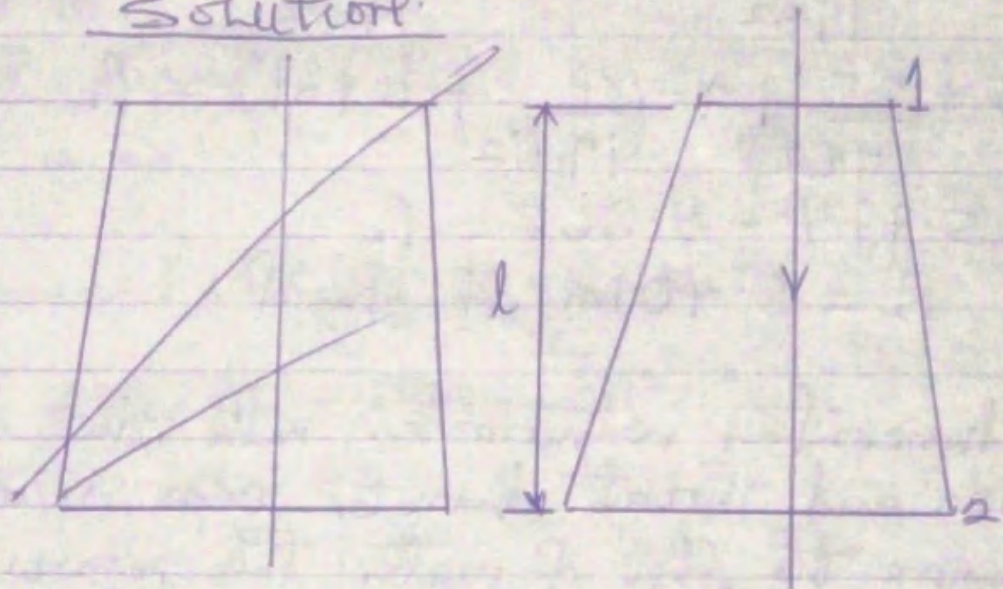


(1) A conical tube of length 2.0m is fixed vertically with its smaller end upwards. The velocity flow at the smaller end is 5m/s while at the lower end it is 2m/s. The pressure head at the smaller end is 2.5m of liquid. The loss of head in the tube is given as $(0.35(v_1 - v_2)^2) / 2g$, where v_1 is the velocity at the smaller end and v_2 is the lower end respectively. Determine the pressure head at the lower end. Flow takes place in the downward direction.

Solution:



length, $l = 2.0\text{m}$

The velocity flow at smaller end = $v_1 = 5\text{m/s}$

The velocity flow at lower end = $v_2 = 2\text{m/s}$

Let the pressure head at the smaller end = $P_s = 2.5\text{m}$ of liquid

$$\begin{aligned} \text{Let the loss of head} &= h_f = \frac{0.35(v_1 - v_2)^2}{2g} \\ &= \frac{0.35(5-2)^2}{2 \times 9.81} = 0.161\text{m} \end{aligned}$$

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

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 $\rho = \rho$ and $\rho = \rho$

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

Inputting values into the equation

$$2.5 + \frac{5^2}{2 \times 9.81} + 2.0 = P_2 + \frac{2^2}{2 \times 9.81} + 0 + 0.161$$

$$2.5 + \frac{25}{19.62} + 2 = P_2 + \frac{4}{19.62} + 0.161$$

$$2.5 + \frac{25}{19.62} + 2 - \left(\frac{4}{19.62} + 0.161 \right) = P_2$$

$$5.774 - 0.365 = P_2$$

$$P_2 = 5.409 \text{ m of fluid}$$

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/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 = $D_1 = 20 \text{ cm}$

let throat diameter = $D_2 = 10 \text{ cm}$

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

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

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

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

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

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

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

$$= -4.08 \text{ m}$$

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

$$= 18 - (-4.08)$$

$$= 18 + 4.08 = 22.08 \text{ m} \times 100$$

$$H_d = 2208 \text{ cm}$$

$$\begin{aligned}
 \text{Using, } Q &= \frac{C_d \sqrt{2gh} \cdot A_1 A_2}{\sqrt{A_1^2 - A_2^2}} \\
 &= \frac{0.98 \times \sqrt{2 \times 981 \times 2208} \times 314.16 \times 78.54}{\sqrt{(314.16)^2 - (78.54)^2}} \\
 &= \frac{0.98 \times 2081.37 \times 24674.1264}{304.184112} \\
 &= 165455.3 \text{ cm}^3/\text{s} \\
 &= \frac{165455.3}{1000} = 165.455 \text{ lit/sec}
 \end{aligned}$$

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 $d_1 = 30 \text{ cm}$

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

Diameter of orifice, $d_2 = 15 \text{ cm}$

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

Specific gravity of oil, $S_o = 0.9$

Specific gravity of mercury, $S_{Hg} = 13.6$

Differential manometer reading, $x = 50 \text{ cm}$ of mercury

Coefficient of discharge, $C_d = 0.64$

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

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

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

∴ The rate of flow of oil is:

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

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

$$Q = 137443.29 \text{ cm}^3/\text{s}$$

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

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 1.026 with respect to fresh water.

Solution.

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

The specific gravity of mercury, $S_g = 13.6$

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

The speed, $v = ?$

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

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

$$= 2.0834\text{m}$$

$$\therefore v = \sqrt{2 \times 9.81 \times 2.0834} = 6.393\text{m/s}$$

In Km/hr

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

5. A pump delivers at the rate of $0.05 \text{ m}^3/\text{min}$ with a pressure change of 15 bar . The speed of rotation is 1700 rev/min while the normal displacement is given as $10 \text{ cm}^3/\text{rev}$. If the torque input is 15 Nm . Compute (i) Volumetric efficiency (ii) fluid power (iii) Shaft Power and (iv) Overall efficiency shortly.

$$Q = 0.05 \text{ m}^3/\text{min} = 50 \text{ dm}^3/\text{min}$$

$$P_0 = 15 \text{ bar} = 15 \times 100000 = 15 \times 10^5 \text{ N/m}^2$$

$$\text{Speed} = 1700 \text{ rev/min}$$

$$T = 15 \text{ Nm}, \text{ MD} = 10 \text{ cm}^3/\text{rev}$$

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

$$\begin{aligned} \text{Ideal flow rate} &= \text{Nominal flow rate} \times \text{Speed} \\ &= 10 \text{ cm}^3/\text{rev} \times 1700 \text{ rev/min} \\ &= 17000 \text{ cm}^3/\text{min} \end{aligned}$$

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

$$\text{Actual flow rate} = 0.05 \text{ m}^3/\text{min}$$

$$\therefore \text{Volumetric flow rate}$$

$$\therefore \text{Volumetric efficiency} = \frac{0.05}{0.017} = 2.94\% = 29.4\%$$

$$(ii) \text{ Fluid Power} = P \times Q$$

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

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

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

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

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

$$\text{Fluid Power} = 1249.5 \text{ watts}$$

$$(iii) \text{ Shaft Power} = \frac{2 \pi N P}{60} = \frac{2 \pi \times 1700 \times 15}{60}$$

$$\text{Shaft Power} = 2670.35 \text{ watts}$$

$$(iv.) \text{ Overall efficiency} = \frac{\text{Fluid Power}}{\text{Shaft Power}}$$

$$\frac{\text{Fluid Power} = 1219.5}{\text{Shaft Power} = 2670.35} = 0.468$$

$$\text{Overall efficiency} = 0.468 \times 100 = 46.8\%$$