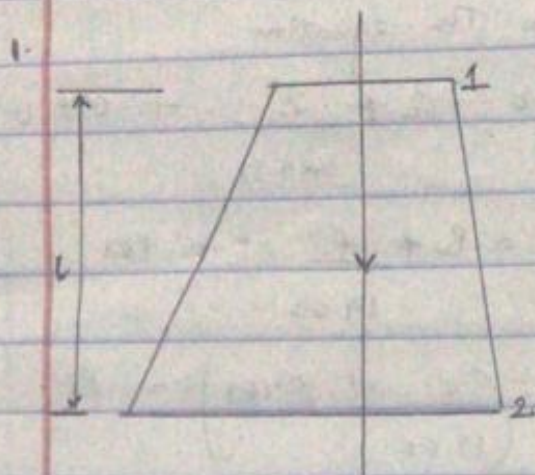


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MATHS No 18 / ENCOF / 015

FLUID MECHANICS



length,  $L = 2.5\text{m}$

$$V_1 = 5\text{m/s}$$

$$V_2 = 2\text{m/s}$$

$P_0 = 2.5\text{m}$  of liquid

$$h_L = \frac{0.35 (V_1 - V_2)^2}{2g} = \frac{0.35 (5 - 2)^2}{2 \times 9.81} = 0.161\text{m}$$

$P_L = ?$

Applying Bernoulli's Equation

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

where  $P_0 = \frac{P_1}{\rho g}$  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

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

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

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

$$5.774 - 0.305 = P_2$$

$P_2 = 5.469 \text{ m of fluid}$

2.  $D_1 = 20 \text{ cm}; D_2 = 10 \text{ cm}$

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

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

$$P = 1000 \text{ kg/m}^3$$

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

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

$$\frac{P_2}{\rho g} = -30 \text{ cm of mercury, } 5 \text{ g/cc} = 13.6$$

$$\frac{P_2}{\rho g} = -30 \times 10^{-2} \text{ m of mercury} \times 13.6 = -4.08 \text{ m}$$

$$h_a = \frac{P_1}{\rho g} - \frac{P_2}{\rho g}$$
$$= 18 - (-4.08)$$

$$= 18 + 4.08 = 22.08 \text{ m} \times 100 = 2208 \text{ cm}$$

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

$$= \frac{0.98 \times 2091.37 \times 24674.1264}{309.18412}$$

$$= 165455.3 \text{ cm}^3/\text{s}$$

$$= \frac{165455.3}{1000} = 165.455 \text{ lit/sec}$$

3.  $d_1 = 30 \text{ cm}$

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

$$d_2 = 15 \text{ cm}$$

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

$$S_o = 0.9; S_{Hg} = 13.6; X = 50 \text{ cm of mercury}$$

$$C_d = 0.64$$

$$h = X \left( \frac{S_{Hg}}{S_o} - 1 \right)$$

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

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

∴ The rate of flow of oil is

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

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

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

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

$$4 \quad X = 170 \text{ mm} = 170 \times 10^{-3} = 0.17 \text{ m}$$

$$S_g = 13.6$$

$$S_o = 1.026$$

$$V = ?$$

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

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

$$\therefore h = 2.0834 \text{ m}$$

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

In km/hr

$$v = \frac{6.393 \times 60^2}{1000} = 23.07 \text{ km/hr}$$

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

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

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

$$T = 15 \text{ N/m}, \text{ PD} = 10 \text{ cm}^3/\text{rev}$$

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

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

$$\text{Ideal flow rate} = \frac{17000}{100000} = 0.17 \text{ m}^3/\text{min}$$

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

$$\therefore \text{Volumetric efficiency} = \frac{0.05}{0.17} = 0.294 \times 100\% = 29.4\%$$

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

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

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

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

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

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

$$= 1249.5 \times 10^{0.5}$$

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

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

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

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

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

$$\text{Shaft Power}$$

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