

Question 1

Solution

Pressure head at smaller end = 2.5m ρ/ω

Length of tube = 2.0m

Velocity of flow at lower end = $5\text{ms}^{-1} V_1$

Velocity of flow at higher end = $2\text{ms}^{-1} V_2$

$$\text{loss of head} = \frac{0.35(V_1 - V_2)^2}{2g} h_2$$

$$\text{loss of head} = \frac{0.35(5-2)^2}{2 \times 9.81} = 0.16\text{m}$$

Pressure head at higher end, $\frac{P_2}{\omega}$

$$\frac{P_1}{\omega} + \frac{V_1^2}{2g} + z_1 = \frac{P_2}{\omega} + \frac{V_2^2}{2g} + z_2 + h_2$$

$$z_2 = 0, z_1 = 2.0\text{m}$$

$$2.5 + \frac{5^2}{2 \times 9.81} + 2 = \frac{P_2}{\omega} + \frac{2^2}{2 \times 9.81} + 0.16$$

$$5.775 = \frac{P_2}{\omega} + 0.364$$

$$\frac{P_2}{\omega} = 5.775 - 0.364 = 5.41\text{m of liquid}$$

Pressure head at higher end = 5.41m

Thanks for coming

2

$$\text{inlet diameter} = 20\text{cm} = 0.2\text{m}$$

$$\text{throat diameter} = 10\text{cm} = 0.1\text{m}$$

$$\text{Pressure of inlet} = 17.65\text{Pa/cm}^2 = 17653\text{N/m}^2$$

30cm of mercury

$$\text{Coeff. of discharge} = 0.98$$

Solution

$$\text{Area of inlet} = A_1 = \frac{\pi}{4} \times 0.2^2 = 0.0314\text{m}^2$$

$$\text{Area of throat} = \frac{\pi}{4} \times 0.1^2 = 0.00785\text{m}^2$$

$$\frac{P_1}{\rho} = \frac{17653}{9800} = 1.801\text{m}$$

Vacuum pressure at the throat

$$\frac{P_2}{\rho} = -300\text{mm} = -0.3 \times 13.6 = -4.08\text{m of water}$$

$$\text{Differential head, } h = \frac{P_1}{\rho} - \frac{P_2}{\rho} = 1.801 - (-4.08) = 22.09\text{m}$$

Rate of flow Q

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

$$Q = 0.9 \times \frac{0.0314 \times 0.00785}{\sqrt{(0.0314)^2 - (0.00785)^2}} \times \sqrt{2 \times 981 \times 22.09}$$

$$= \frac{0.000241 \times 20.82}{0.0304}$$

$$Q = 0.165 \text{ m}^3/\text{s}$$

Discharge of water through Venturimeter = $0.165 \text{ m}^3/\text{s}$

3

Orifice diameter $A_0 = 15 \text{ cm} = 0.15 \text{ m}^2$

Pipe diameter = $30 \text{ cm} = 0.3 \text{ m}^2$

Manometer reading = 0.5 m of mercury

S.g of oil = 0.9 ($\rho = 0.9 \rho_w$)

Solution

Area of orifice, $\frac{\pi}{4} \times 0.15^2 = 0.0177 \text{ m}^2 = A_0$

Area of pipe $\frac{\pi}{4} \times 0.30^2 = 0.707 \text{ m}^2 = A_1$

Differential head, $h = \left[\frac{\rho_w}{\rho} \frac{S_0}{S_1} - 1 \right]$

$$= 0.5 \left[\frac{13.6}{0.9} - 1 \right] = 7.06 \text{ m of oil}$$

Thanks for coming

5

$$\text{Actual flow rate} = 0.05 \text{ m}^3/\text{min} = 0.05/60 = 8.3 \times 10^{-4} \text{ m}^3/\text{sec}$$

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

$$\text{Speed of rotation} = 1700 \text{ rev/min} = \frac{1700}{60} = 28.3 \text{ rps}$$

$$\text{Normal Displacement} = 100 \text{ cm}^3/\text{rev} = 1 \times 10^{-5} \text{ m}^3/\text{rev}$$

$$\text{Torque input} = 15 \text{ Nm}$$

$$\text{Ideal flow rate} = \text{Normal} \times \text{Speed Displacement}$$

$$= 28.3 \times 1 \times 10^{-5}$$

$$= 2.83 \times 10^{-4} \text{ m}^3/\text{sec}$$

$$\text{(1) Volumetric efficiency} = \frac{\text{Actual flow rate} \times 100\%}{\text{Ideal flow rate}}$$

$$= \frac{8.3 \times 10^{-4} \times 100}{2.83 \times 10^{-4}}$$

$$= 296\%$$

$$\text{(b) Fluid Power} = Q \cdot p$$

$$= 8.3 \times 10^{-4} \times 15 \times 10^5$$

$$= 1245 \text{ Watts or Nm/sec}$$

$$\text{(c) Shaft Power} = T \cdot \omega$$

Where T = Torque input

ω = Angular speed

$$T = 15 \text{ Nm}$$

$$W = 2 \text{ Nm for 1 rev}$$

$$W = \frac{2 \text{ Nm}}{60} \text{ for 1 rpm}$$

$$W = 2 \times \frac{32}{7} \times 28.3 = 177.59 \text{ Nm/sec}$$

$$\text{Shaft Power} = \cancel{1.5} 15 \times 177.89 = 2668.35 \text{ Watts}$$