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DEPARTMENT: BIOMEDICAL ENGINEERING

COURSE CODE: ENG 214

COURSE TITLE: FLUID MECHANICS

QUESTIONS

QUESTION 1

A 300 mm X 150 mm venturimeter is provided in a vertical pipeline carrying oil of specific gravity 0.9, flow being upward. The difference in elevation of the throat section and entrance section of the venturimeter is 300 mm. The differential U-rube mercury manometer shows a gauge deflection of 250 mm. Calculate: (I) The discharge of oil, and (ii) The pressure difference between the entrance section and of the throat section. Take Cd = 0.98 and specific gravity of mercury as 13.6.

QUESTION 2

A vertical venturimeter carries a liquid of relative density 0.8 and has inlet and throat diameters of 150mm and 75mm respectively. The pressure connection at the throat is 150mm above that at the inlet. If the actual flow rate of flow is 40litres/sec and the C_d = 0.96, calculate the pressure difference between inlet and throat in N/m^2.

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Question 1

Given;

Diameter at inlet = 300mm

Area at inlet = $\frac{\pi d^2}{4}$

$= \frac{\pi \times (300)^2}{4}$

$= 70685.83471$

$= 7.0686 \times 10^4 mm^2$

$= 7.0686 \times 10^{-2} m^2$

Diameter at throat = 150mm

Area at throat = $\frac{\pi d^2}{4}$

$= \frac{\pi \times (150)^2}{4}$

$= 17671.45868$

$= 1.7671 \times 10^4 mm^2$

$= 1.7671 \times 10^{-2} m^2$

Inlet will be section 1 and Throat will be section 2.

Then, $z_2 - z_1 = 300mm = 300 \times 10^{-3} m = 0.3m$

Specific gravity of oil = 0.9

Specific gravity of mercury = 13.6

Manometer reading = 250mm = 0.25m

Cd = 0.98

Differential head, $h = \left(\frac{P_1}{\rho g} + z_1\right) - \left(\frac{P_2}{\rho g} + z_2\right)$

$= x\left[\frac{S_m}{S_o} - 1\right] = 0.25\left[\frac{13.6}{0.9} - 1\right]$

$= 0.25(15.1 - 1)$

$= 0.25 \times 14.1 = 3.525m$ of oil

Discharge of oil, $Q = Cd \times \frac{a_1 a_2}{\sqrt{a_1^2 - a_2^2}} \times \sqrt{2gh}$

$= 0.98 \times \frac{(7.0686 \times 10^{-2} \times 1.7671 \times 10^{-2})}{\sqrt{(7.0686 \times 10^{-2})^2 - (1.7671 \times 10^{-2})^2}}$

$\times \sqrt{2 \times 9.81 \times 3.525}$

$= 0.98 \times 0.01825 \times 8.3163 = 0.14874 = 0.1488 m^3/s$

ii The pressure difference

$(p_1 - p_2) = ?$

$$h = \left(\frac{P_1}{\rho g} + z_1\right) - \left(\frac{P_2}{\rho g} + z_2\right) = 3.525$$

$$\text{So} \left(\frac{P_1}{\rho g} - \frac{P_2}{\rho g}\right) + z_1 - z_2 = 3.525$$

$$z_2 - z_1 = 0.3m$$

$$\frac{P_1}{\rho g} - \frac{P_2}{\rho g} - 0.3 = 3.525$$

$$\frac{P_1}{\rho g} - \frac{P_2}{\rho g} = 3.525 + 0.3 = 3.825m$$

$$(P_1 - P_2) = 3.825 \times \rho g$$

$$= 3.825 \times 0.9 \times 1000 \times 9.81$$

$$= 33770.925 \ N/m^2$$

$$= 33.77 \ KN/m^2$$

Question 2

Given,

Diameter of inlet = 150mm = 0.15m

Area of inlet $= \frac{\pi d^2}{4}$

$$= \frac{\pi \times (0.15)^2}{4}$$

$$= 0.01767$$

$$= 1.767 \times 10^{-2} m^2$$

Diameter of throat = 75mm = 0.075m

Area of throat $= \frac{\pi d^2}{4}$

$$= \frac{\pi \times (0.075)^2}{4}$$

$$= 4.418 \times 10^{-3} m^2$$

Flow rate = 40litres/sec =

$(P - p) = ?$

$C_d = 0.96$

Relative density = 0.8

$Z_2 - Z_1 = 150mm = 0.15m$

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

$$\frac{V_2^2 - V_1^2}{2g} = \frac{P_1 - P_2}{\rho g} - (z_2 - z_1)$$

$$\frac{V_2^2 - V_1^2}{2g} = \frac{P_1 - P_2}{\rho g} - (0.15)$$

$$A_1 V_1 = A_2 V_2$$

$$\frac{V_2}{V_1} = \frac{A_1}{A_2} = \frac{0.15}{0.075} = 2$$

$$\frac{V_2}{V_1} = (2)^2 = 4$$

$V_2/V_1 = 4 \qquad V_1 = V_2/4$

$$\frac{V_2^2 - V_2^2/16}{2g} = \frac{P_1 - P_2}{\rho g} - 0.15$$

$$\frac{15V_2^2}{32g} = \frac{P_1 - P_2}{\rho g} - 0.15$$

$$V_2 = \sqrt{\frac{32g}{15}\left[\frac{P_1 - P_2}{\rho g} - 0.15\right]}$$

Discharge, $Q = Cd \times V_2 \times A_2$

$$0.4 = 0.96 \times \sqrt{\frac{32 \times 9.81}{15}\left[\frac{P_1 - P_2}{\rho g} - 0.15\right]} \times \pi \times \frac{(0.075)^2}{4}$$

$$P_1 - P_2 = 33820 N/m^2$$
$$= 33.82 KN/m^2$$