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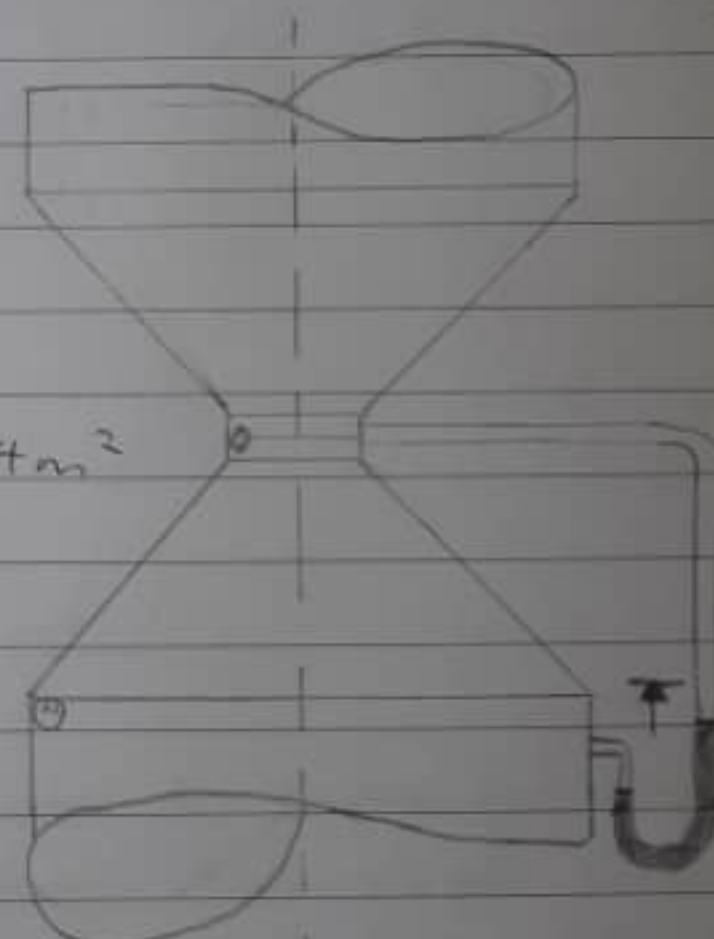
DEPT: CHEMICAL ENGINEERING
COURSE: ENG 214. (BASIC FLUID MECHANICS.

1) A vertical venturimeter carries a liquid of relative density 0.8 and has inlet and throat diameters of 750mm and 75mm respectively. The pressure connection at the throat is 150mm above that at the inlet. If the actual flow rate is 40litres/sess and the Cd = 0.96, calculate the pressure difference between inlet and throat in N/m²



Solution

$D_1 = 150mm = 0.15m$

$A_1 = \frac{\pi D_1^2}{4} = \frac{\pi \times 0.15^2}{4} = 0.0177m^2$

$D_2 = 75mm = 0.075m$

$A_2 = \frac{\pi D_2^2}{4} = \frac{\pi \times 0.075^2}{4} = 0.0044m^2$

$Q = 40litres/sec = 0.04m^3/s$

$Cd = 0.96$

$\rho = 0.8$

$Z_2 - Z_1 = 150mm = 0.15m$

$$Q_{act} = \frac{Cd \times A_1 A_2 \times \sqrt{2gh}}{\sqrt{A_1^2 - A_2^2}}$$

$$0.04 = \frac{0.96 \times 0.0177 \times 0.0044 \times \sqrt{2 \times 9.81 \times h}}{\sqrt{0.0177^2 - 0.004^2}}$$

$$0.04 = \frac{7.47648 \times 10^{-5} \times \sqrt{19.62h}}{\sqrt{2.9393 \times 10^{-4}}}$$

$$0.04 = \frac{7.47648 \times 10^{-5} \times \sqrt{19.62h}}{0.017}$$

$$\Rightarrow 6.8\times10^{-4} = 7.47648\times10^{-5}\times\sqrt{19.62h}$$

$$\sqrt{19.62h} = \frac{6.8\times10^{-4}}{7.47648\times10^{-5}}$$

$$\sqrt{19.62h} = 9.095$$

$$19.62h = 9.095^2$$

$$\frac{19.62h}{19.62} = \frac{82.719}{19.62}$$

$h = 4.216m$ of the liquid.

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

$$4.216 = \left(\frac{P_1}{w} - \frac{P_2}{w}\right) - (z_2 - z_1)$$

$$4.216 = \left[\left(\frac{P_1}{w} - \frac{P_2}{w}\right) - (0.15)\right]$$

$$\frac{P_1}{\rho g} - \frac{P_2}{\rho g} = 4.216 + 0.15 = 4.366$$

Therefore; $\frac{P_1 - P_2}{\rho g} = 4.366$

$$P_1 - P_2 = 4.366\times\rho g$$
$$= 4.366\times0.8\times9810$$
$$= 34264.368\ N/m^2$$
$$\simeq 34264\ N/m^2$$
$$= 34.264\ kN/m^2$$

$\therefore$ Presure difference, $P_1 - P_2 = 34.264\ kN/m^2$

2) A 300mm * 150mm venturimeter is provided in a vertical pipeline carrying oil of specific cavity 0.9, flow being up-ward. The difference in elevation of the throat section and entrance of the venturimeter is 300mm. The differencial u-tube mercury manometer shows a guage deflection of 250mm, calculate

i) The discharge of oil, and

ii) The pressure difference between the entrance section and the throat section. take the coefficient of meter as 0.98 and specific gravity of mercury as 13.6

Solution

$D_1 = 300mm = 0.3m$

$A_1 = \frac{\pi D_1^2}{4} = \frac{\pi \times 0.3^2}{4} = 0.07m^2$

$y = 250mm = 0.25m$

$D_2 = 150mm = 0.15m$

$A_2 = \frac{\pi D_2^2}{4} = \frac{\pi \times 0.15^2}{4} = 0.0177m^2$

$h = \frac{P_1 - P_2}{\omega} = h = y\left[\frac{S_h}{S_o} - 1\right] = 0.25\left[\frac{13.6}{0.9} - 1\right]$

$= 0.25(15.1 - 1)$

$= 0.25 \times 14.1 = 3.525m$

$\simeq 3.53m$ of oil

$C_d = 0.98$

i) Discharge

$Q_{act} = \frac{C_d \times A_1 A_2 \times \sqrt{2gh}}{\sqrt{A_1^2 - A_2^2}}$

$$Q_{act} = \frac{0.98 \times 0.07 \times 0.0177 \times \sqrt{2 \times 9.81 \times 3.53}}{\sqrt{0.07^2 - 0.0177^2}}$$

$$Q_{act} = \frac{0.0101}{0.0677}$$

$\therefore Q_{act} = 0.149 m^3/s$

ii) Pressure difference

$$\frac{P_1 - P_2}{w} + (Z_2 - Z_1) = 3.53$$

$$Z_2 - Z_1 = 300mm = 0.3m$$

$$\left(\frac{P_1 - P_2}{w}\right) - 0.3 = 3.53$$

$$\frac{P_1 - P_2}{w} = 3.53 + 0.3$$

$$\frac{P_1 - P_2}{w} = 3.83$$

$$P_1 - P_2 = 3.83 \times w$$

$$P_1 - P_2 = 3.83 \times 9810 \times 0.9$$

$$= 33815.07 N/m^2$$

$\therefore P_1 - P_2 = 33.8 KN/m^2$.