USMAN HABIBA ABIMI
18/ENG08/025
BIOMEDICAL ENGINEERING

1. Data

Diameter at inlet = 300mm

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

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

$= 70685.8347$

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

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

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 = 950mm = 0.25m

Cd = 0.98

Differential head, $h = \left(\frac{P_1}{P_g} + Z_1\right) - \left(\frac{P_2}{P_g} + Z_2\right)$

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

$= 0.25(15.1 - 1)$

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

$A_1 V_1 = A_2 V_2$

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

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

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

$\frac{V_2}{V_1} = 4 \qquad V_1 = \frac{V_2}{4}$

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

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

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

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

$0.9 = 0.96 \times \sqrt{\frac{32 \times 9.81}{15}\left[\frac{P_1 - P_2}{\rho g} - 0.15\right]} \times \pi \times \frac{(0.075)^2}{4}$

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

$= 33.82 kN/m^2$

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

$$= 0.98 \times \frac{(1.0696 \times 10^{-3} \times 1.7671 \times 10^{-3})}{\sqrt{(1.0696 \times 10^{-3})^2 - (1.7671 \times 10^{-3})^2}}$$

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

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

ii The Pressure difference

$(P_1 - P_2) = ?$

$$h = \left(\frac{P_1}{P_g} + Z_1\right) - \left(\frac{P_2}{P_g} + Z_2\right) = 3.525$$

$$So \left(\frac{P_1}{P_g} - \frac{P_2}{P_g}\right) + Z_1 - Z_2 = 3.525$$

$$Z_2 - Z_1 = 0.3m$$

$$\frac{P_1}{P_g} - \frac{P_2}{P_g} - 0.3 = 3.525$$

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

$$(P_1 - P_2) = 9.895 \times P_y$$

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

$$= 33770.925 N/M^2$$

$$= 33.77 KN/m^2$$

Question 2

Data

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 = 10 litres/sec = $(P - P) = ?$

$Cd = 0.96$ Relative density = 0.8

$Z_2 - Z_1 = 150mm = 0.15mm$

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

$\frac{V_2^2 - V_1^2}{2g} = \frac{P_1 - P_2}{Pg} - (Z_2 - Z_1)$

$\frac{V_2^2 - V_1^2}{2g} = \frac{P_1 - P_2}{Pg} - (\overset{0.15}{Z_2 - Z_1})$