MICHAEL Ransome O
18/ENG05/032
Mechatronics Engineering

Date No.

1.

Given,

rel. density = 0.8

$D_1 = 150mm = 0.15m$

$D_2 = 75mm = 0.075m$

$z_2 - z_1 = 150mm = 0.15m$

$Q_{act.} = 40L/sec = 0.04m^3/s$

$C_d = 0.96$

Pressure diff, $(p_1 - p_2) = ?$

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

$A_1 = \frac{\pi}{4} \times D_1^2 = \frac{\pi}{4} \times 0.15^2 = 0.01767m^2$

$A_2 = \frac{\pi}{4} \times D_2^2 = \frac{\pi}{4} \times 0.075^2 = 0.00442m^2$

then,

$$0.04 = \frac{0.96 \times 0.1767 \times 0.00442}{\sqrt{0.01767^2 - 0.00442^2}} \times \sqrt{2 \times 9.81 \times h}$$

$$0.04 = 0.96 \times \frac{7.81014 \times 10^{-5}}{0.0171} \times 4.429\sqrt{h}$$

$$0.04 = 0.96 \times 0.004565 \times 4.429\sqrt{h}$$

$$0.04 = 0.0043824 \times 4.429\sqrt{h}$$

$$h = \left(\frac{0.04}{0.0043824 \times 4.429}\right)^2$$

$$h = 4.247m$$

Also, $h = \left(\frac{p_1}{w} + z_1\right) - \left(\frac{p_2}{w} + z_2\right)$

$$4.247 = \left[\frac{p_1}{w} - \frac{p_2}{w}\right] + (z_1 - z_2)$$

$$4.247 = \left[\frac{p_1 - p_2}{\rho g}\right] + 0.15$$

since $(z_2 - z_1) = 0.15m$

$$(p_1 - p_2) = \rho g(4.247 + 0.15)$$

$$= (0.8 \times 1000 \times 9.81) \times (4.247 + 0.15)$$

$$= 7848 \times 4.397$$

$$= 34507.656$$

$$= 34.51 kN/m^2$$

$$\therefore (p_1 - p_2) = 34.51 kN/m^2$$

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2.

Given,

diameter at inlet, $D_1 = 300mm = 0.3m$

Area of inlet, $A_1 = \frac{\pi}{4} \times 0.3^2 = 0.07m^2$

diameter at throat, $D_2 = 150mm = 0.15m$

Area of throat, $A_2 = \frac{\pi}{4} \times 0.15^2 = 0.01767m^2$

specific gravity of heavy liquid (mercury) in U-tube manometer,

$S_{hg} = 13.6$

specific gravity of liquid (oil) flowing through pipe,

$S_p = 0.9$

Reading of differential manometer, $y = 250mm = 0.25m$

The differential 'h' is given by;

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

$$= y\left[\frac{S_{hg}}{S_p} - 1\right]$$

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

$$= 3.53m \text{ of oil}$$

i.) Discharge of oil, Q =

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

$$Q = 0.98 \times \frac{0.07 \times 0.01767}{\sqrt{0.07^2 - 0.01767^2}} \times \sqrt{2 \times 9.81 \times 3.53}$$

$$= 0.98 \times 0.1826 \times \cancel{69.2586}\ 8.32$$

$$= 1.4889 m^3/s$$

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ii) Pressure diff. b/w entrance and throat section, $p_1 - p_2$

We know that, $\cancel{h = \left(\frac{p_1}{w} + z_1\right) - \left(\frac{p_2}{w} + z_2\right)}$ -

$$h = \left(\frac{p_1}{w} + z_1\right) - \left(\frac{p_2}{w} + z_2\right) = 3.53$$

$$= \left(\frac{p_1}{w} - \frac{p_2}{w}\right) + (z_1 - z_2) = 3.53$$

but $(z_2 - z_1) = 300mm = 0.3m$

$$\left(\frac{p_1}{w} - \frac{p_2}{w}\right) \mp 0.3 = 3.53$$

$$\left(\frac{p_1}{w} - \frac{p_2}{w}\right) = 3.83$$

$$\left(\frac{p_1 - p_2}{\rho g}\right) = 3.83$$

$$(p_1 - p_2) = (9.81 \times 0.9) \times 3.83$$

$$= 8.829 \times 3.83$$

$$(p_1 - p_2) = 33.8 kN/m^2$$