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19/ENG05/067
Mechatronics
Fluid mechanics

1) Length of tube $L = 2.0m$
$V_1 = 5m/s$
$P_1/\rho g = 2.5$ m of liquid
$V_2 = 2m/s$

Loss of head $= h_L = \frac{0.35(V_1 - V_2)^2}{2g}$

$= \frac{0.35(5-2)^2}{2g} = \frac{0.35 \times 9}{2 \times 9.81} = 0.16m$

Pressure head $\frac{P_2}{\rho g} = ?$

Applying

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

$$2.5 + \frac{5^2}{2 \times 9.81} + 2 = \frac{P_2}{\rho g} + \frac{2^2}{2 \times 9.81} + 0 + 0.16$$

$$2.5 + 1.27 + 2.0 = \frac{P_2}{\rho g} + 0.205 + 0.16$$

$$\frac{P_1}{\rho g} = (2.5 + 1.27 + 2.0) - (0.205 + 0.16)$$

$$\frac{P_2}{\rho g} = 5.77 - 0.363 = 5.407m$$

2) Given inlet $d_1 = 20cm$

$$a_1 = \frac{\pi}{4} \times (20)^2 = 314.16 cm^2$$

Throat dm: $d_2 = 10cm$

$$a_2 = \frac{\pi}{4} \times 10^2 = 78.74 cm^2$$

$$\frac{P_1}{\rho g} = \frac{17.658 \times 10^4}{9.81 \times 1000} = 18m \text{ of water}$$

$$\frac{P_2}{\rho g} = -30cm \text{ of mercury}$$

$$= -0.30m \text{ of mercury}$$

$$-0.30 \times 13.6 = -4.08m \text{ of water}$$

Differential head $h = \frac{P_1}{\rho g} - \frac{P_2}{\rho g}$

The discharge

$$Q = C_d \frac{a_1 a_2}{\sqrt{a_1^2 - a_2^2}} \times \sqrt{2gh}$$

$$= \frac{0.98 \times 314.16 \times 78.54 \times \sqrt{2 \times 9.81 \times}}{\sqrt{(314.16)^2 - (78.74)^2}}$$

$$= \frac{50328837.21}{304} \times 165555 cm^3/s$$

$$= 165555.7 /sec$$

Question 3

Orifice diameter = 15 cm

$Q_0 = \frac{\pi}{4}(15)^2 = 176.7 cm^3$

Dia of pipe $d_1 = 30 cm$

$Q_1 = \frac{\pi}{4} \times 30^2 = 706.85 cm^3$

Specific gravity of oil = 0.9

Reading of manometer $x = 50 cm$

Differential head

$h = x\left(\frac{S_g}{S_o} - 1\right) = 50\left(\frac{13.6}{0.9} - 1\right) cm$

$= 50 \times 14.11 = 705.5 cm$ of oil

$C_d = 0.64$

The discharge

$$Q = C_d = \frac{Q_1 Q_2}{\sqrt{Q_1^2 - Q_2^2}} \times \sqrt{2gh}$$

$$= 0.64 \times \frac{176.7 \times 706.85}{\sqrt{(706.85)^2 - (176.7)^2}} \times \sqrt{2 \times 9.81 \times 705.5}$$

$$= \frac{94.04631 7.18}{684.4} = 137.414 \text{ litres/sec}$$

question 4

Diff of mercury level $x = 170mm = 0.17m$

specific gravity of mercury $Sg = 13.6$

" " " oil $So = 1.026$

$\therefore h = x\left(\frac{Sg}{So} - 1\right) = 0.17\left(\frac{13.6}{1.026} - 1\right)$

$\therefore v = \sqrt{2gh} = \sqrt{2 \times 9.81 \times 2.0854} = 6.393m/s$

$= \frac{6.393 \times 60 \times 60}{1000} = 23.01 km/hr$

question 5

Actual flow rate $= 0.05 m^3/min$

$m^3/min$ to $m^3/sec$

$\frac{0.05}{60} = 8.33 \times 10^{-4} m^3/sec$

$\therefore Q = 8.33 \times 10^{-4} m^3/se$

speed of rotation = 1700rev/min

$= \frac{1700}{60} = 28.3 rps$

Pressure change $= 15 bar = 15 \times 10^5 N/m^2$

normal displacement $= 10cm^3/rev$

$100cm^3 = 1m^2$

$x = \frac{10}{1000000} = 1 \times 10^{-5} m^3/rev$