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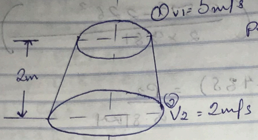
18/ENG01004
Chemical Engineering
Fluid Mechanics

1)



$\frac{P_1}{w} = 2.5m$

$H_L = \frac{0.35(V_1 - V_2)^2}{2g}$

$\frac{P_1}{w} + \frac{V_1^2}{2g} + z_1 = \frac{P_2}{w} + \frac{V_2^2}{2g} + Z_2 + H_L$

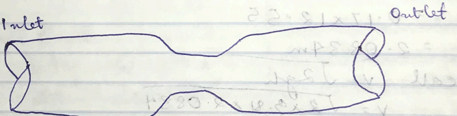
$\frac{P_2}{w} = \frac{P_1}{w} + \frac{V_1^2 - V_2^2}{2g} + (z_1 - z_2) - \frac{0.35(V_1 + V_2)^2}{2g}$

$\frac{P_2}{w} = 2.5 + \frac{5^2 - 2^2}{2(9.81)} + 2 - \frac{0.35(5-2)}{2(9.81)}$

$\frac{P_2}{w} = 2.5 + 1.07 + 2 - 0.161$

$\frac{P_2}{w} = 5.409m$ of liquid

2)



Inlet ; $d_1 = 20cm = 20 \times 10^{2} m$

$A = \frac{\pi d^2}{4} = \frac{\pi \times (20 \times 10^{-2})^2}{4}$

$A_1 = 0.0314 m^2$

$P_1 = 17.668 N/cm^2$

$= 17.668 \times 10^4 N/m^2$

$cd = 0.98$

Throat Diameter = 10cm

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

$A = \frac{\pi d^2}{4} = \frac{\pi \times (10 \times 10^{-2})^2}{4}$

$A_2 =$ ~~7.88~~ $7.85 \times 10^{-3} m^2$

To get h ; $\frac{P_1}{w} - \frac{P_2}{w} = h$.

$P_1 = 17.668 \times 10^4 N/m^2$

$w = 9.81 \times 10^3 N/m^3$

But we have that throat vacuum Pressure = 30 cm of Hg

$= 0.3 m Hg$

$= 0.3 \times 13.6 = 4.08$

$\frac{P_2}{w} = -4.08$ (Since vacuum pressure)

Then $\frac{P_1}{w} = \frac{17.658 \times 10^4}{9.81 \times 10^3} = 18$

$\therefore \frac{P_1}{w} - \frac{P_2}{w}$; $18 - (-4.08) = 22.08$

$$Q = Cd\, A_1 A_2 \sqrt{\frac{2gh}{(A_1^2 - A_2^2)}}$$

$= 0.98 \times 0.0314 \times 7.85 \times 10^{-3} \times \sqrt{\frac{2 \times 9.81 \times 22.08}{(0.0314^2 - (7.85 \times 10^{-3})^2)}}$

$= 2.4156 \times 10^{-4} \times 684.59 = 0.1653$

$Q_{actual} = 0.1653 m^3/s$

3) Orifice meter

given.

$d_0 = 15 cm = 15 \times 10^{-2} m$

$d_P = 30 cm = 30 \times 10^{-2} m$

$A_0 = \frac{\pi \times (15 \times 10^{-2})^2}{4}$

$= 0.01767 m^2$

$A_P = \frac{\pi \times (30 \times 10^{-2})^2}{4}$

$= 0.07069 m^2$

S.P.G of oil = 0.9 (S_0)

Coefficient of discharge = 0.64

Reading of differential = 50 cmHg

Differential head $h = y\left[\frac{S_H}{S_0} - 1\right]$

$S_H = 13.6$ $\therefore y = 50 \times 10^{-2}$

$h = 50 \times 10^{-2}\left[\frac{13.6}{0.9} - 1\right]$ $\therefore h = 50 \times 10^{-2} \times 14.11$

$= 7.055 m$

$Q = \frac{Cd\, A_0 A_P \sqrt{2gh}}{\sqrt{A_P^2 - A_0^2}} = \frac{0.64 \times 0.01767 \times 0.07069 \times \sqrt{2 \times 9.81 \times 7.055}}{\sqrt{(0.07069^2) - (0.01767^2)}}$

$= \frac{7.994 \times 10^{-4} \times 11.765}{\sqrt{4.68 \times 10^{-3}}} = 0.1374 m^3/s$

4 $y = 170mmHg = 0.17mHg$

$S.g\ Hg = 13.6$

$S.g\ sw = 1.026$

$$\Delta h = y\left(\frac{S.g\,Hg}{S.g\,sw} - 1\right)$$

$$\Delta h = 0.17\left(\frac{13.6}{1.026} - 1\right)$$

$\Delta h = 2.08m$

$v = \sqrt{2g\Delta h}$

$v = \sqrt{2 \times 9.81 \times 2.08}$ $\therefore V = 6.388m/s$

5 $Q = 0.05dm^3/m = 8.33 \times 10^{-5} m^3/sec$

Speed of rotation = 1700 rev/min = 28.3 rev/sec

Nominal displacement = $10cm^3/rev = 10^{-5} m^3/rev$

Torque Input = 15 Nm

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

- Ideal flow rate = Nominal displacement × Speed rot.

$= 10^{-5} \times 28.3 = 2.83 \times 10^{-4} m^3/sec$

a) Volumetric efficiency $= \frac{\text{actual flowrate}}{\text{Ideal flowrate}} \times 100$

$= \frac{8.33 \times 10^{-5}}{2.83 \times 10^{-4}} \times 100 = 29.45\%$

b Fluid Power, $P_F = Q \times \Delta P$

$= 8.33 \times 10^{-5} \times 15 \times 10^5$

$= 124.95$ watts

c Shaft Power, $= T \times \omega$

$\omega = 2 \times \pi \times$ Speed of rotation

$\omega = 2 \times \pi \times 28.3$

$\omega = 177.81$ rad/sec

$\therefore$ Shaft power $= 15 \times 177.81 = 2667.2$ watts

d Overall efficiency $= \frac{\text{Fluid power}}{\text{Shaft Power}} \times 100$

$= \frac{124.95}{2667.2} \times 100 = 4.68\%$