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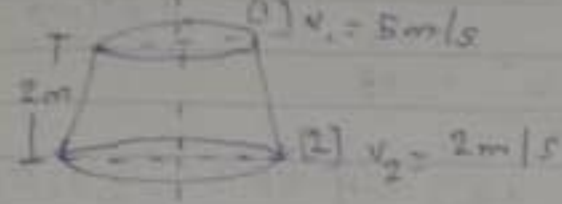
Chemical Engineering
18/ENG01/021
Fluid Mechanics {ENG 214?}

1)



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

$H_L = \frac{0.35(v_1 - v_2)^2}{2g}$

$$\frac{P_1}{w} + \frac{v_1^2}{2g} + Z_1 = \frac{P_2}{w} + \frac{v_2^2}{2g} + Z_2 + H_L$$

$$\frac{P_2}{w} = \frac{P_1}{w} + \frac{v_1^2 - v_2^2}{2g} + (Z_1 - Z_2) - \frac{0.35(v_1 - v_2)^2}{2g}$$

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

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

$$\frac{P_2}{w} = ~~5.40~~\ 5.409\text{m of liquid}$$

2)

INLET: $d_1 = 20cm = 20 \times 10^{-2}m$

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

$A_1 = 0.0314\ m^2$

$P_1 = 17.668\ N/cm^2$

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

$C_d = 0.98$

THROAT DIAMETER, $d_2 = 10cm$

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

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

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

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 = 30cm of Hg

$= 0.3 m\ Hg$

$= 0.3 \times 13.6 = 4.08$

$\frac{P_2}{w} = -4.08$ [Since Vacuum pressure]

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

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

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

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

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

3) Orificemeter : Given that

$d_o = 15cm = 15 \times 10^{-2} m$ Pipe diameter, $d_p = 30cm = 30 \times 10^{-2} m$

$A_o = \frac{\pi \times (15 \times 10^{-2})^2}{4}$ $A_p = \frac{\pi \times (30 \times 10^{-2})^2}{4}$

$= 0.01767 m^2$ $= 0.07069 m^2$

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

Coefficient of discharge = 0.64

Reading of differential = 50cm hg

Differential head $h_1 = y\left[\frac{S_{hL}}{S_0} - 1\right]$

$S_{hL} = 13.6$

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

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

$h = 50 \times 10^{-2} \times 14.11$

$= 7.055 m$

$Q = \frac{C_d A_o A_p \sqrt{2gh}}{\sqrt{A_p^2 - A_o^2}}$

$= \frac{0.64 \times 0.01767 \times 0.07069 \times \sqrt{2 \times 9.81 \times 7.065}}{\sqrt{(0.07069)^2 - (0.01767)^2}}$

$= 0.1374 m^3/s$

4) y = 170mm Hg

Ah

Au

Au

v

5) Q = 0.05

Speed of

Nominal O.

Torq

Pressure

- Ideal fl

a) Volume

b) fl

c) Shaft

d) Over

4) $y = 170\,mmHg = 0.17\,mHg$, $S.g^{Hg} = 13.6$, $S.g^{SW} = 1.026$

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

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

$$\Delta H = 2.08\,m$$

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

$$v = \sqrt{2 \times 9.81 \times 2.08}$$

$$v = 6.388\,m/s$$

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

Speed of Rotation $= 1700\,Rev/min = 28.3\,Rev/sec$

Nominal Displacement $= 10\,cm^3/rev = 10^{-5}\,m^3/rev$

Torque Input $= 15\,Nm$

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

- Ideal flow rate = Nominal displacement × Speed Rotation

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

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, $P_f = Q \times \Delta P$

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

$$= 124.94\ \text{watts}$$

c) Shaft power $= \tau \times \omega$

$\omega = 2 \times \pi \times$ 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 $= \frac{\text{Fluid Power}}{\text{Shaft power}} \times 100$

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

$$= 4.68\%$$