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Course Title: ENGINEERING FLUID MECHANICS.

Answers

1. 

Given that, smaller end: $V_1 = 5m/s$

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

Then bigger end: $V_2 = 2m/s$

$$L = Z_1 - Z_2 = 2m$$

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

Considering head loss: $h_f = \frac{0.35(5-2)^2}{2 \times 9.81} = \frac{3.15}{19.62}$

$$h_f = 0.16055 \approx 0.1606m.$$

Applying Bernoulli's equation between the smaller & bigger end

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

$$\frac{P_2}{\omega} = \frac{P_1}{\omega} + \frac{V_1^2}{2g} - \frac{V_2^2}{2g} + Z_1 - Z_2 - h_f.$$

$$= 2.5 + \left(\frac{5^2 - 2^2}{2 \times 9.81}\right) + 2 - 0.1606.$$

$$= 2.5 + 1.0703 + 2 - 0.1606.$$

$$\frac{P_2}{\omega} = 5.4097m$$

2. 

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

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

$$A_1 = 0.0314m^2$$

Throat diameter: $d_2 = 10cm = 10 \times 10^{-2}m.$

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

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

$P_1 = 17.658 N/cm^2.$

$= 17.658 \times 10^4 N/m^2$

$Cd = 0.98.$

To get h:

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

$P_1 = 17.658 \times 10^4 \, N/m^2$

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

but we have that throat vacuum pressure = 30cm of Hg

$= 0.3 mHg$

$= 0.3 \times 13.6 = 4.08$

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

Then $\frac{P_1}{w} = \frac{17.658 \times 10^4 \, N/m^2}{9.81 \times 10^3 \, N/m^3} = 18.$

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

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

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

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

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

3 Orifice meter: Given that,

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

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

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

Sp.g of oil = 0.9. Reading of differential manometer = 50cm of

Coefficient of discharge = 0.64

Differential head $h_1 = y \left[\frac{S_{hl}}{S_o} - 1\right]$.

$S_{hl} = 13.6.$

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

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

$h = 50 \times 10^{-2} \times 14.11 = 7.055m$

Q = Cd A

= 0

= 7

4 Given :

5 Given Act Flow

Pressu

Spee

Norm

Idea

-0.3
pressure)

$$Q = \frac{C_d A_0 A_p \sqrt{2gh}}{\sqrt{A_p^2 - A_0^2}}$$

$$= \frac{0.64 \times 0.01767 \times 0.07069 \times \sqrt{2 \times 9.81 \times 7.063}}{\sqrt{(0.07069^2) - (0.01767^2)}}$$

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

$$= 0.1374\,m^3/s$$

4 Given: Reading of the manometer $y = 170mm\,Hg = 0.17m\,Hg$

Sp gravity of mercury $S_{hl} = 13.6$

Sp gravity of seawater $= 1.026$

$$h = y\left(\frac{S_{hl}}{S_l} - 1\right)$$

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

$$h = 0.17 \times 12.255 = 2.083m.$$

$$V = \sqrt{2gh}$$

$$= \sqrt{2 \times 9.81 \times 2.083} = 6.39m/s$$

$^{-3}$ m

5 Given that:

Actual Flow rate $= 5\,m^3/min$

$$= \frac{0.005m^3}{60s} = 8.33 \times 10^{-5} m^3/s.$$

→ 5Cm Hg

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

Speed = 1700rev/min $= \frac{1700}{60} = 28.33rev/s$

Nominal displacement $= 10cm^3/rev$

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

Ideal flow rate: = Nominal × Speed displacement

$$28.33 \times 10^{-5}$$

$$= 2.833 \times 10^{-4} m^3/sec$$

Volumetric Efficiency = $\frac{\text{Actual Flowrate}}{\text{Ideal Flowrate}} \times 100\%$

$= \frac{8.33 \times 10^{-5}\ m^3/s}{2.833 \times 10^{-4}\ m^3/s} \times 100\%$

$= ~~294.03\%~~\ 29.41\%$

Fluid Power = $Q \cdot dP$

$= 8.33 \times 10^{-4} \times 15 \times 10^{5}$

$= 1249.5\ Nm/sec$

Shaft Power = $T \cdot \omega$

where T = Torque input (Nm)

ω = Angular speed.

$T = 15\ Nm$

$\omega = 2\pi N$ for rps $\quad \omega = \frac{2\pi N}{~~60~~}$ $\quad 2 \times \pi \times 28.3$

$\omega = 177.81\ rad/sec$

~~$\omega = \frac{2 \times 22}{7} \times 15$~~

Shaft Power = $15 \times 177.81 = 2667.21$ Watts.

d) Overall Efficiency = $\frac{\text{Fluid Power}}{\text{Shaft Power}} \times 100$

$= \frac{1260}{2667.2} \times 100 = 46.87\%$