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ASSIGNMENT

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

where $\frac{P_1}{\rho g} \Rightarrow$ ~~head loss~~ Pressure head at smaller end

$\frac{P_2}{\rho g} \Rightarrow$ Pressure head at lower end

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

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

$Z_1 - Z_2 =$ length of pipe $= 2m$

$\frac{P_1}{\rho g} = 2.5m$

$V_1 = 5m/s$

$V_2 = 2m/s$

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

$\frac{P_2}{\rho g} = 5.41m$ //

2) $d_1 = 20cm = 0.2m$

$d_2 = 10cm = 0.1m$

Pressure at inlet $(P_1) = 17.658\ N/cm^2$

Vacuum pressure at the throat $(P_2) = 30cm\ Hg = 0.3m\ Hg$

$C_d = 0.98$

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

$$P_2 = P_2(m\ Hg)\left[\frac{S.G(Hg)}{S.G(H_2O)} - 1\right] \times \rho g$$

$S.G(Hg) = 13.6$

$S.G(H_2O) = 1$

$$P_2 = 0.3\left[\frac{13.6}{1} - 1\right] \times 1000 \times 9.81$$

$$P_2 = 37081.8\ N/m^2$$

$$P_1 = \frac{17.658\ N}{1\ cm^2} = \frac{17.658\ N}{10^{-4}\ m^2} = 17.658 \times 10^4\ N/m^2$$

$$P_1 = 176580\ N/m^2$$

$$h = \frac{P_1 - P_2}{\rho g},\quad h = \frac{176580 - 37081.8}{1000 \times 9.81}$$

$$h = 14.22m$$

$$A_1 = \frac{\pi d_1^2}{4} = \frac{\pi \times 0.2^2}{4} \Rightarrow A_1 = 0.0314\ m^2$$

$$A_2 = \frac{\pi d_2^2}{4} = \frac{\pi \times 0.1^2}{4} \Rightarrow A_2 = 7.854 \times 10^{-3}\ m^2$$

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

$$Q = \frac{0.98 \times 0.0314 \times 7.854 \times 10^{-3} \times \sqrt{2 \times 9.81 \times 14.22}}{\sqrt{0.0314^2 - (7.854 \times 10^{-3})^2}}$$

$$Q = 0.133\ m^3/sec$$

3.) $d_o = 15cm = 0.15m$
$d_1 = 30cm = 0.3m$
$C_d = 0.64$
$S.G(Hg) = 13.6$
$S.G(oil) = 0.9$
Differential manometer reading$(y) = 50cm\,Hg = 0.5m\,Hg$

$$h = y\left[\frac{S.G(Hg)}{S.G(oil)} - 1\right]$$

$$h = 0.5\left(\frac{13.6}{0.9} - 1\right)$$

$h = 7.056m$

$$A_o = \frac{\pi d_o^2}{4} = \frac{\pi \times 0.15^2}{4} \Rightarrow A_o = 0.0177m^2$$

$$A_1 = \frac{\pi d_1^2}{4} = \frac{\pi \times 0.3^2}{4} \Rightarrow A_1 = 0.0707m^2$$

$$Q = \frac{C_d A_o A_1 \sqrt{2gh}}{\sqrt{A_1^2 - A_o^2}}$$

$$Q = \frac{0.64 \times 0.0177 \times 0.0707 \times \sqrt{2 \times 9.81 \times 7.056}}{\sqrt{0.0707^2 - 0.0177^2}}$$

$Q = 0.137 m^3/sec$

4.) $S.G(Hg) = 13.6$
$S.G(\text{sea water}) = 1.026$
$y(m\,Hg) = 170mm\,Hg = 0.17m\,Hg$

$$h = y\left[\frac{S.G(Hg)}{S.G(\text{sea water})} - 1\right]$$

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

$h = 2.083m$
$H = Z_2 - Z_1 = 15m$

$$V = \sqrt{2g(H-h)}$$

$$V = \sqrt{2 \times 9.81 \times (15 - 2.083)}$$

$V = 15.92 m/s$

5) Actual flow rate $(Q_1) = 5 dm^3/min$

$= 0.005 m^3/min$

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

Speed = 1700 rev/min

~~Gag~~ Torque = 15 Nm

Normal displacement $= 10 cm^3/rev$

Ideal flow rate (Q_2) = Normal displacement X Speed

$= \sout{10 cm} \; 10 \times 1700$

$= 17000 cm^3/min$

$Q_2 = \frac{17000 cm^3}{1 min} = \frac{17000 \times 10^{-6} m^3}{1 min}$

$Q_2 = 0.017 m^3/min$

i) Volumetric Efficiency = $\frac{\text{Actual flow rate}}{\text{Ideal flow rate}} \times 100\%$

Volumetric efficiency $= \frac{0.005}{0.017} \times 100\%$

Volumetric efficiency = 29.41 %

ii) Fluid power = Volumetric flow rate X Pressure

Fluid power = Q x P

~~Fluid power = 0.005~~

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

Fluid Power $= 8.33 \times 10^{-5} m^3/s \times 15 \times 10^5 N/m^2$

$= 125 W$ //

iii) shaft power = Torque X Angular Velocity (ω)

~~Angular~~ Speed = 1700 rev/min

1 rev — 360° — 2π rad

1 rev — 2π rad

1 min — 60 seconds

$\therefore$ angular velocity $= \frac{1700 \times 2\pi \text{ rad}}{1 \times 60 \text{ sec}}$

$\omega = 178.024$ rad/s

Shaft power = 15×178.021

Shaft power = $2670.35\ W$

iv.) Overall efficiency = $\frac{\text{Fluid power}}{\text{Shaft power}} \times 100\%$

$= \frac{125}{2670.35} \times 100\%$

Overall efficiency = 4.68%