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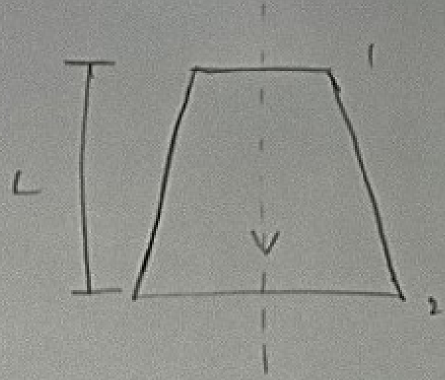
BIOMEDICAL ENG.
18/ENG02/087

ENG 214 ASSIGNMENT

1).

$L = 2.0m,\ V_1 = 5m/s,\ V_2 = 2m/s$



Pressure head at the smaller end

$P_s = 2.5$ m of liquid

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

$\frac{0.35(5-2)^2}{2 \times 9.81} = 0.151m$

Pressure head at the lower end, P_2 =)

∴ Applying Bernoulli's equation,

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

$P_S = \frac{P_1}{\rho g}$ & $P_L = \frac{P_2}{\rho g}$, $Z_1 = 2.0$ & $Z_2 = 0$

$2.5 + \frac{5^2}{2 \times 9.81} + 2.0 = P_L + \frac{2^2}{2 \times 9.81} + 0.151$

$2.5 + \frac{25}{19.62} + 2 - \left(\frac{4}{19.62} + 0.151\right) = P_L$

$P_L = 5.774 - 0.365 = 5.409m$

(2) $d_1 = 20cm = 0.2m$, $A_1 = \frac{\pi d_1^2}{4} = \frac{\pi \times 0.2^2}{4} = 0.0314\ m^2$

$d_2 = 10cm = 0.1m$, $A_2 = \frac{\pi d_2^2}{4} = \frac{\pi \times 0.1^2}{4} = 7.85\times10^{-3} m$

$\rho = 1000 kg/m^3$

Pressure at inlet, $P_1 = 17.658 N/cm^2 = 17.658 \times 10^4 N/m^2$

$\frac{P_1}{\rho g} = \frac{17.658\times10^4}{1000\times9.81} = 18m$

$P_2/\rho g = -30cm$ of mercury, $S.g\ Hg = 13.6$, $\frac{P_2}{\rho g} = -30\times10^{-2}$ m of mercury $\times 13.6$

$= -4.08m$

Differential head, $Hd = \frac{P_1}{\rho g} - \frac{P_2}{\rho g} = 18 - (-4.08)$

$= 18 + 4.08 = 22.08m \times 100$

$Hd = 2208 cm$

Using $Q = \frac{Cd\sqrt{2gh} \cdot A_1 A_2}{\sqrt{A_1^2 - A_2^2}} = \frac{0.98 \times \sqrt{2\times981\times2208} \times 314.2 \times 78.55}{\sqrt{(314.2)^2 - (78.55)^2}}$

$= \frac{0.98\times2081.37\times24680.41}{304.222848} = 165476.3441\ cm^3/s$

$= \frac{165476.3441}{1000} = 165.476\ lit/sec$

(3) $d_1 = 30cm$, $A_1 = \frac{\pi d_1^2}{4} = \frac{\pi (30)^2}{4} = 706.95 cm^2$

$d_2 = 15cm$

$A_2 = \frac{\pi d_2^2}{4} = \frac{\pi (15)^2}{4} = 176.73 cm^2$

S.g of oil = 0.9, S.g of mecury = 13.6

$C_d = 0.64$, Differential manometer reading, x = 50 cm of mecury

Differential head, $h = x\left(\frac{S_g}{S_o} - 1\right)$

$h = 50\left(\frac{13.6}{0.9} - 1\right) = 705.56 cm$

$$Q = \frac{C_d \sqrt{2gh}\; A_1 \cdot A_2}{\sqrt{A_1^2 - A_2^2}} = \frac{0.64 \times \sqrt{2 \times 9.81 \times 705.56} \times 706.95 \times 176.73}{\sqrt{(706.95)^2 - (176.73)^2}}$$

$Q = 13744.21 cm^3/s$, $Q = \frac{13744.21}{1000} = 13.744$ lit/s

(4) Difference of mecury $x = 170mm = 170 \times 10^{-3} = 0.17m$

S.g of mecury, S.g = 13.6, S.g of sea water, $S_o = 1.026$

Speed, V = ?

$V = \sqrt{2gh}$, h = ?

$h = x\left[\frac{S_g}{S_o} - 1\right] = 0.17\left[\frac{13.6}{1.026} - 1\right] = 2.0834 m$

$V = \sqrt{2 \times 9.81 \times 2.0834} = 6.393 m/s$, $V = \frac{6.393 \times 60^2}{1000} = 23.014 km/h$

(5) $Q = 0.5 m^3/min = 50 dm^3/min$

$P_o = 15 bar = 15 \times 100000 = 15 \times 10^5 N/m^2$, Speed = 1700 rev/min,

ND = 10 cm³/rev, T = 15 Nm

i). Volumetric efficiency = $\frac{\text{Actual flow rate}}{\text{Ideal flow rate}}$

Ideal flowrate = Nominal flow rate × Speed

$= 10 cm^3/rev \times 1700 rev/min = 17000 cm^3/min$

$= 0.017 m^3/min$

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

Volumetric efficiency $= \frac{0.05}{0.017} = 2.94\%$

ii) Fluid Power = P×Q

$P = 15 \times 10^5 N/m^2$, $Q = 0.05 m^3/min = \frac{0.05}{60} = 8.33 \times 10^{-4} m^3/s$

$F_P = 15 \times 10^5 \times 8.33 \times 10^{-4} = 1249.5$ watts

iii). Shaft Power $= \frac{2\pi NT}{60} = \frac{2\pi \times 1700 \times 15}{60} = 2670.35$ watts

iv). Overall efficiency = $\frac{\text{Fluid Power}}{\text{Shaft Power}} = \frac{1249.5}{2670.35} = 0.468$

Overall efficiency = $0.468 \times 100 = 46.8\%$