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Mechanical
ENG 214

1) $L = 2.0m$

$V_1 = 5m/s$

$V_2 = 2m/s$

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

Ph at smaller head = 2.5m

$$\frac{P_2}{w} = \frac{P_1}{w} + \frac{(V_1^2 + V_2^2)}{2g} + (Z_1 - Z_2)h$$

$$= 2.5 + \frac{5^2 + 2^2}{2 \times 9.81} + 2 - \frac{[0.3(5-2)^2]}{2 \times 9.81}$$

$$= 2.5 + 1.07 + 2 - 0.16055$$

Pressure at lower head

$= 5.409bar \simeq 5.41bar$

2 Inlet diameter = 0.2m

Throat diameter = 0.1m

$Cd = 0.98$

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

$$A_2 = \frac{\pi d^2}{4} = \frac{\pi \times 0.1^2}{4} = 7.85 \times 10^{-3} m^2$$

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

$$\frac{P_1}{w} = \frac{1.765 \times 10^{-2} N/m}{9.81}$$

$$= 1.799 \times 10^{-3}$$

$$\frac{P_2}{w} = 0.3 \times 13.6 = -4.08$$

$$h = \frac{P_1}{w} - \frac{P_2}{w} = 1.799 \times 10^{-3} - (-4.08) = 4.082m$$

3

4

$\therefore Q = \frac{0.98 \times 0.0314 \times 7.85 \times 10^{-3}}{\sqrt{(0.0314)^2 - (7.85 \times 10^{-3})^2}} \times \sqrt{2 \times 9.81} \times 4.082$

$Q = \frac{0.0002415 \times 8.949}{\sqrt{0.000922}}$

$Q = \frac{0.00216}{0.0303} = 0.0713 m^3/s$

3 $D_1 = 0.15m$; $D_2 = 0.3m$

$= 0.9$, $Cd = 0.64$

$A_1 = \frac{\pi d^2}{4} = \frac{\pi \times 0.15^2}{4} = 0.0176m^2$

$A_2 = \frac{\pi d^2}{4} = \frac{\pi \times 0.3^2}{4} = 0.07069m^2$

$h = 0.5\left(\frac{13.6}{0.9} - 1\right) = 7.05m$

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

$= \frac{0.64 \times 0.0176 \times 0.07069}{\sqrt{(0.0176)^2 - (0.07069)^2}} \times \sqrt{2 \times 9.81 \times 7.05}$

$= \frac{0.000796 \times 11.7609}{\sqrt{0.000309 - 0.00499}} = 2.03 \times 10^{-3} ms^{-3}$

4 $\Delta x_0 = 15m$

170mmHg (0.17m)

$S_g Hg = 13.6$

S_g of sea water $= 1.026$

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

$h = 2.083m$

$V = \sqrt{2gh}$

$V = \sqrt{2 \times 9.81 \times 2.083}$

$= 6.39 m/s$

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

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

$V = 1700 rev/min = 28.33 rev/sec$

$T = 15 N/m$ Normal displacement $= 100 cm^3/rev = 1 \times 10^{-5} m^3/rev$

Volumetric efficiency

$\frac{\text{Actual flowrate}}{\text{Ideal flowrate}} \times 100$; ~~Ideal flowrate = displacement × speed~~

Ideal flowrate = displacement × speed

$Q = 1 \times 10^{-5} \times 28.33 = 2.833 \times 10^{-4} m^3/sec$

i Volumetric efficiency $= \frac{8.33 \times 10^{-5}}{2.833 \times 10^{-4}} \times 100 = 29.4\%$

ii Fluid power $(Q \times \Delta P)$

$= 8.33 \times 10^{-5} \times 15 \times 10^5 = 124.95$ Watts

iii Shaft power $= T \times \omega$

$\omega = 2 \times \pi \times V = 2 \times \pi \times 28.33 = 178 rad/sec$

$T \times \omega = 15 \times 178 = 2670$ Watts

iv Overall efficiency

$\frac{\text{Fluid power}}{\text{Shaft power}} \times 100\%$

$= \frac{124.95}{2670} \times 100 = 4.68\%$