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ENG 214 (Fluid mechanics)

Solution

1) $L = 2.0m$

V_1 (smaller end) = 5m/s

V_2 (lower end) = 2m/s

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

P 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

$= 5.409 bar \simeq 5.41 bar$

2) Inlet diameter = 0.2m

Throat diameter = 0.1m

$C_d = 0.98$

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

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

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

$\frac{P_1}{w} = \frac{1.765 \times 10^{-2} N/m}{981}$

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

$\frac{P_2}{w} = 0.8 \times 13.6 = -4.08$

$h = \frac{P_1}{w} - \frac{P_2}{w} = 1.799 \times 10^{-5} - (-4.08)$

$= 4.082m$

$\therefore Q = \frac{0.98 \times 0.0314 \times 7.85 \times 10^{-5}}{\sqrt{(0.0514)^2 - (7.85 \times 10^{-5})^2}} \times$

$\Rightarrow \sqrt{2 \times 9.81 \times 4.082}$

$Q = \frac{0.0002415 \times 8.949}{\sqrt{0.00092}}$

$Q = \frac{0.00216}{0.0303}$

$= 0.0713 m^3/s$

3) $D_1 = 0.15m$, $D_2 = 0.3m$

$S.G = 0.9$, $C_d = 0.64$

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

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

$h = 0.5 \left[\frac{13.6}{0.9} - 1\right]$

$= 7.05m$

$Q = \frac{C_d A_1 A_2}{\sqrt{A_1^2 - A_2^2}} \times \sqrt{2gh}$ ×2.685

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

$= \frac{0.000796 \times 11.7609}{\sqrt{0.006309 - 0.00499}}$

$= 0.1374 m^3/s$

4) Axis = 15m, Sg of mercury = 13.6

Sg of seawater = 1.026

170mm of mercury (0.17m).

$h = 0.17\left[\frac{13.6}{1.026} - 1\right]$

$h = 2.083 m$

$V = \sqrt{2gh}$

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

$V = 6.39 m/s$

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

Torque Input = 15N/m.

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

Ideal flowrate = 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, $P_f = Q \times \Delta P$

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

$= 124.95$ watts

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

$\omega = 2 \times \pi \times$ speed of rotation

$\omega = 2 \times \pi \times 28.3$

$\omega = 177.81$ rad/sec

∴ Shaft power = 15×177.81

$= 2667.2$ watts

d) Overall efficiency = $\frac{\text{Fluid power}}{\text{Shaft power}} \times 100$

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

$= 4.68\%$