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CHEMICAL ENGINEERING
FLUID MECHANICS

1) $L = 2.0m$

V_1 (smaller end) = 5m/s

V_2 (lower end) = 2m/s

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

Ph at smaller head = 2.5m

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

$$= 2.5 + \frac{5^2 - 2^2}{2 \times 9.81} + 2 - \frac{(0.5 (5-2)^2)}{2 \times 9.81}$$

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

Pressure at lower head

$= 5.409 bar \simeq 5.41 bar$

2) Inlet diameter = 0.2m

Throat diameter = 0.1m

$Cd = 0.98$

$$A_1 = \frac{\pi d^2}{4} = \frac{\pi \times 0.2^2}{4} = 0.314 m^2$$

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

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

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

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

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

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

$= 4.082 m$

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

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

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

$= 0.0713 m^3/s$

3) $D_1 = 0.15 m$

$D_2 = 0.3 m$

$S.G = 0.9$

$Cd = 0.64$

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

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

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

$= 7.05 m$

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

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

$= \frac{0.000796 \times 11.7609}{\sqrt{0.000309 - 0.00499}}$

4) Axis = 15 m
170 mm of mercury (0.17 m)
Sg of mercury 13.6
Sg of sea water = 1.026

$h = 0.19 \left[\frac{15.6}{1.026} - 1\right]$

$h = 2.083 m$

$V = \sqrt{2gh}$

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

$V = 6.39 m/s$

5) $Q = 0.5 dm^3/min = 8.33 \times 10^{-5} m^3/sec$
Speed of Rotation = 1700 Rev/min = 28.3 Rev/sec
Normal displacement = $10 cm^3/rev = 10^{-5} m^3/rev$
Torque Input = 15 N/m
Pressure change = 15 bar = $15 \times 10^{-5} N/m^2$
Ideal flowrate = Nominal displacement × Speed Rotation
$= 10^{-5} \times 28.3 = 2.83 \times 10^{-4} m^3/sec$

a) Volumetric Efficiency = $\frac{\text{Actual flowrate}}{\text{Ideal flowrate}} \times 100$

$= \frac{8.33 \times 10^{-5} \times 100}{2.83 \times 10^{-4}}$

$= 29.45\%$

b) Fluid power, $PF = Q \times \Delta P$
$= 3.33 \times 10^{-5} \times 15 \times 10^{5} = 124.95$ watts

c) Shaft power, $= T \times w$
$w = 2 \times \pi \times$ Speed of Rotation
$W = 2 \times \pi \times 28.3$
$w = 177.81$ rad/sec
∴ Shaft Power = $15 \times 177.81 = 2667.2$ watts

d) Overall efficiency = $\frac{\text{fluid Power}}{\text{Shaft Power}} \times 100 = \frac{124.95}{2667.2} \times 100$

$= 4.68\%$