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1) $V_1 = 5ms^{-1}$, $V_2 = 2ms^{-1}$

Smaller end = 2.5m

$L = 2.0m$

$$h_f = \frac{(0.35(v^1 - v^2))^2}{2g}$$

Lower end =

$L = Z_1 - Z_2 = Z_n$

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

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

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

$$2.5 + 1.07 + 2 - 0.16055$$

$$P_2 = 5.4096 \text{bar}$$

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

$d_1 = 20cm = 0.2m$

$$A_1 = \frac{3.143 \times (0.2)^2}{4} = 0.03142m^2$$

$d_2 = 10 cm = 0.1 m$

$$A_2 = \frac{3.142 \times (0.1)^2}{4} = 7.855 \times 10^{-3} m^2$$

$P_1 = 17.658 N/cm^2 = 176580 N/m^2$

Specific gravity of mecury = 13.6

$$\frac{P_1}{w} - \frac{P_1}{\rho g} = \frac{176580}{1000 \times 9.81}$$

$$= 18 m$$

$$\text{Vacuum Pressure} = \frac{P_2}{w} = \frac{-300 mmHg}{-0.30 \times 13.6}$$

$P_2 = -4.08 m$

$$h = \frac{P_1 - P_2}{w} = 18 - (-4.08)$$

$= 18 + 4.08$

$= 22.08 m$

$$Q = \frac{0.98 \times 0.03142 \times 7.855 \times 10^{-3} \sqrt{2 \times 9.81 \times 22.08}}{\sqrt{(0.03142)^2 - (7.855 \times 10^{-3})^2}}$$

$Q = 0.168$

$\simeq 0.17 m^3/s$

3) $D_1 = 15 cm = 0.15 m$

$D_2 = 30 cm = 0.3 m$

$50 cmHg = 500 mmHg = 0.5 m$

$Q = ?$, $S.G = 0.9$, $Cd = 0.64$

$$A_1 = \frac{\pi d_1^2}{4} = \frac{3.142 \times (0.15)^2}{4} = 0.0176\,m^2$$

$$A_2 = \frac{\pi d_2^2}{4} = \frac{3.142 \times (0.3)^2}{4} = 0.0706\,m^2$$

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

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

$$Q = \frac{0.64 \times 0.0176 \times 0.0706 \times \sqrt{2 \times 9.81 \times 7.05}}{\sqrt{(0.0176)^2 - (0.0706)^2}}$$

$$Q = \frac{9.35 \times 10^{-2}}{40.12}$$

$$Q = 2.33 \times 10^{-3}\,m^3/s$$

4) Axis = 15m

$170\,mmHg = 0.17\,m$

S.G of mecury = 13.6

S.G of sea water = 1.026

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

$$h = 2.08\,m$$

$$V = \sqrt{2gh}$$

$$V = \sqrt{2 \times 9.81 \times 2.08}$$

$$V = 6.39\,m/s$$

8) Actual flowrate $= 0.05\ m^3/min$

m^3/min to m^3/sec

60 sec = 1 min

$= \frac{0.05}{60}$

$Q = 8.33 \times 10^{-4}\ m^3/sec$

Speed = 1700 rev/min

$= \frac{1700}{60} = 28.33$ rev/sec

= 28.33 rps.

Pressure, S_p = 15 bar

$1 bar = 1 \times 10^5\ N/m^2$

$15 bar = x$

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

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

Nominal displacement $= 10\ cm^3/rev$

100 cm = 1 m

$100^3\ cm^3 = 1\ m^3$

$10\ cm^3 = x$

$x = \frac{10}{1,000,000} = 1 \times 10^{-3}\ m^3/rev.$

Ideal flowrate = nominal × Speed displacement

$= 1 \times 10^{-5} \times 28.33$

$= 2.833 \times 10^{-4}\ m^3/sec$

a) Volumetric Efficiency

$$\frac{\text{Actual flowrate}}{\text{Ideal flowrate}} \times 100\%$$

$$= \frac{8.33 \times 10^{-4}}{2.833 \times 10^{-4}} \times 100\%$$

$$= 2.94\%$$

b) Fluid power

$P_F = Q \cdot \delta p$

$8.33 \times 10^{-4} \times 15 \times 10^{-5}$

$= 1.2495 \times 10^{-7}$ watts

c) Shaft Power

$T \cdot w$

$T = 15Nm$

$w = 2\pi N$

$w = 2 \times \frac{22}{7} \times 28.33$

$= 178.07$ rad/sec

Shaft power $= 15 \times 178.07$

$= 2.67 \times 10^3$

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

$$\frac{1.2495 \times 10^{-7}}{2.67 \times 10^3} \times 100\% = 4.67 \times 10^{-10}\%$$