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18/ENG08/020

BIOMEDICAL ENGINEERING

ANSWER

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 =

$$L = z_1 - z_2 = z_h$$

$$\frac{P_1}{w} + \frac{V_1^2}{2g} + z_1 = P_2 + \frac{V_2^2}{2g} + z_2 + h_f$$

$$\frac{P_2}{w} = \frac{P_1}{w} + \frac{1}{2g}(V_1^2 + V_2^2) + (z_1 - z_2)h_f$$

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

$$2.5 + 1.07 + 2 - 0.16055$$

$$P_2 = 5.4096 bar.$$

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

d_{12} 20cm = 0.2m

$A_1 = \frac{3.142 \times (0.2)^2}{4} = 0.03142 m^2$

$d_2 = 10cm = 0.1m$

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

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

Specific gravity of mercury = 13.6

$\frac{P_1 - P_2}{w} = \frac{176580}{1000 \times 9.81}$

$= 18m$

Vacuum Pressure $= P_2 = -300mmHg$

$w = 0.80 \times 13.6$

$P_2 = -4.08m$

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

$= 18 + 4.08$

$= 22.08m$

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

$Q = 0.165 \approx 0.17 m^3/s$

3.] $D_1 = 15cm = 0.15m$

$D_2 = 30cm = 0.3m$

$50cmHg = 500mmHg = 0.5m$

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

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

$= 0.017 m^2$

$= 0.0176 m^2$

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

$= 0.0706 m^2$

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

$= 7.05m$

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

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

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

40.12

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

4.] Axis = 15m

170mmHg = 0.17m

S.G of mercury = 13.6

S.G of seawater = 1.026

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

$h = 2.08m$

$V = \sqrt{2gh}$

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

$V = 6.39 m/s$

5.] 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, $\delta P = 15 bar$

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

15 bar $= x$

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

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

Nominal displacement $= 10 cm^3/rev$

100 cm = 1 m

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

$10 cm^3 = x$

$x = \frac{10}{1000000} = 1 \times 10^{-5} m^3/rev.$

Ideal flowrate = nominal x 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 $= Q \cdot \delta P$

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

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

c.] Shaft Power

$T \cdot w$

$T = 15 Nm$

$w = 2\pi N$

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

$= 178.07 rad/sec$

Shaft power $= 15 \times 178.07$

$= 2.67 \times 10^3$

d.] Overall Efficiency

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

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

$= 4.67 \times 10^{-11}\%$.

4.] Axis = 15m, 170mmHg = 0.17m

S.G of Hg = 13.6, S.G of seawater

$= 1.026$.

$h = 0.17 \left[\frac{13.6}{1.026} - 1\right] = 2.08m$

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

$V = 6.39 m/s$

$\frac{6.39 \times 60 \times 60}{1000} = \frac{23004}{100}$

$= 23.004$

Speed of submarine $= 23.004 km/hr$