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18/ENG08/009
BIOMEDICAL ENGINEERING

1) $L = 2.0m$

$V_1 = 5m/s$

$P_1/\rho g = 2.5m$

$V_2 = 2m/s$

loss of head $= h_l = \frac{0.35(V_1 - V_2)^2}{2g}$

$= \frac{0.35(5-2)^2}{2g} = \frac{0.35(3)^2}{2\times9.81} = \frac{0.35\times9}{2\times9.81}$

$= 0.16m$

Pressure head $P_2/\rho g = ?$ applying Bernoulli's equation ...

$$P_1/\rho g + P_1/2g + z_1 = P_2/\rho g + V_2/2g + Z_2 + h_L$$

$Z_2 = 0, \quad Z_1 = 2.0$

$$2.5 + \frac{(5)^2}{2\times9.81} + 2.0 = \frac{P_2}{\rho g} + \frac{(2^2)}{2\times9.81} + 0.016$$

$$2.5 + 1.27 + 2.0 = \frac{P_2}{\rho g} + 0.203 + 0.16$$

$$P_2/\rho g = (2.5 + 1.27 + 2.0) - (0.203 + 0.16)$$

$= 5.77 - 0.363 = 5.407 = 5.4m$ of fluid

2. Inlet diameter (D_1) = 20cm = 0.2m

Throat diameter (D_2) = 100 = 0.10m

Area of inlet = $\pi/4 \times (0.2)^2$ = $0.0346m^2$

Area of throat = $\pi/4 \times (0.1)^2$ = $0.07854 m^2$

cd = 0.98, Pressure (P_1) = 17.685×10^4 N/m^2, ρ = 1000kg/m^3

$$P_1/\rho g = \frac{17.653 \times 10^4}{9.81 \times 1000} = 18m$$

$P_2/\rho g$ = 30cm of mercury = $-0.3 \times 13.6 = -4$

differential head

$$h = P_1/\rho g - P_2/\rho g = 18 - (-4)$$

$$= 22.08 m \text{ of water}$$

$$Q = \frac{cd \times a_1 \times a_2 \sqrt{2gh}}{(a_1)^2 - (a_2)^2}$$

$$= \frac{0.98 \times 314.16 \times 0.007854}{\sqrt{(314.16)^2 - (0.007854)}} \times \sqrt{2 \times 9.81 \times 22.08}$$

$$= \frac{50328837.21 \times 165555}{304} = 0.165m$$

= 165.56 litres/s

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3. Orifice diameter = 15cm

Pipe diameter = 30cm

Co-efficient of discharge of the metre is 0.64

flow of oil of specific gravity = 0.9

$A_0 = \pi/4 (15)^2 = 176.714\ cm^2$

$A_p = \pi/4 (30)^2 = 706.858\ cm^2$

$H = \left[\frac{13.6}{0.9} - 1\right] \times 50cm$ of oil

$= (15.1 - 1) \times 50 cm = 14.1 \times 50$

$= 705.50$

$$Q_1 = \frac{c_d A_0 A_p \sqrt{2gh}}{\sqrt{(A_p^2)(A_0)^2}}$$

$$Q = \frac{C\,0.64 \times 176.71 \times 706.86 \times \sqrt{2 \times 9.81 \times 7.05 \times 100}}{\sqrt{(706.85)^2 - (176.74)^2}}$$

$$= \frac{0.64 \times 176.71 \times 706.85 \times \sqrt{2 \times 9.81 \times 7.05 \times 100}}{\sqrt{(706.858)^2 \cdot (176.74)^2}}\ m^3/sec$$

$Q = 137414.25\ cm^3/sec$

Litres = 137414. 137.41425 lit/sec

Rate of flow of oil = 137.414 lit/sec

4. Diff of mercury level, x = 170mm = 0.17m

specific gravity of mercury = 13.6

specific gravity (sp) = 1.026

$$H = x\left[\frac{S_g}{S_o} - 1\right] = 0.17\left[\frac{13.6}{1.026} - 1\right]$$

$$= 2.0834\text{m}$$

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

$$= 2 \times 9.81 \times 2.08$$

$$= 6.39\text{m/s}$$

$$= \frac{6.39 \times 60 \times 60}{1000} = \frac{23004}{1000} = 23.004$$

speed of submarine = ~~23.004 Km/r~~ 23.004Km/hr

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5) Rate of Pump = 5 dm^3/min

pressure change = 15 bar

speed rotation = 1700 rev/min

normal displacement = 10 cm^3 / rev

torque input = 15N/m

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Ideal flow rate = Normal displacement × speed

= 15 × 1700 = 25,500 cm^3 / min

= 25 500 dm^3 / min

= 1231.5

Volumetric efficiency

$\frac{\text{Actual flow}}{\text{Ideal flow}} = \frac{500}{25.5} = 19.60$

$Q = \frac{(500 \times 10^{-4})}{60 m^3/s} = 8.33 \times 10^{-6} m^3/s$

Fluid power

$\Delta P = 100 \times 10^5 N/m^2$

fluid power = $Q\Delta P = 8.33 \times 10^{-6} \times 1000 \times 10^5$

" = 833 W

Shaft Power

$2\pi NT/60 = \frac{2\pi \times 1700 \times 25.5}{60} = 4541.4 N/m$

Overall efficiency

$\frac{\text{fluid power}}{\text{shaft power}} = \frac{833}{4541.4} = 0.18342$

overall efficiency = 18.342%