MIKE - OSARO NATHAN
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Petroleum Engineering

1) Ideal flow rate = Normal displacement × speed

$= 10 \times 1500 = 15 dm^3/min$

i) Volumetric efficiency $= \frac{\text{Actual flow}}{\text{Ideal flow}} = \frac{10}{15} = 0.67 = 67\%$

ii) Fluid power = ΔpQ

$\Delta p = 12 \times 10^5 = 1200000$

$Q = \frac{10 \times 10^{-3}}{60} = 1.67 \times 10^{-4}$

$= \Delta pQ = 200.4$ Watts

iii) Shaft power $= \frac{2\pi NT}{60} = 2 \times \pi \times 1500 \times 12.5 = 1964.3$ Nm

iv) Overall efficiency $= \frac{\text{Fluid power}}{\text{Shaft power}} = \frac{200.4}{1964.3} = 0.102 = 10.2\%$

2) $87\% = F.P/S.P$

Fluid power = ΔpQ

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

$Q = 35 \times 10^{-3} = 5.83 \times 10^{-4} = 5833.3$ Watts

$87\% = \frac{5833.3}{x}$, $0.87 = \frac{5833.3}{x}$

$x = \frac{5833.3}{0.87} = 6705$ Nm

3) Ideal flow rate = Normal displacement × speed

$= 50 \times 850 = 42.5 dm^3/min$

Volumetric efficiency $= \frac{\text{Actual flow}}{\text{Ideal flow}} = \frac{35}{42.5} = 0.82 = 82\%$

Fluid power $= \Delta pQ$, $\Delta p = 100 \times 10^5$, $Q = \frac{50 \times 10^{-3}}{60} = 8.3 \times 10^{-4}$

$\therefore \Delta pQ = 8300$

Shaft $= 15000$

Overall efficiency $= \frac{\text{Fluid power}}{\text{Shaft power}} = \frac{8300}{15000} = 0.553 = \underline{55.3\%}$

6) $h = 20m$

$d = 10cm = 0.1m$

$A = \frac{\pi}{4} \times d^2 = 0.7854$

$V_F = 0$

$W = P$

$V_F^2 = V_1^2 - 2gh$, $V_1 = \sqrt{V_F^2 + 2gh}$, $V_1 = \sqrt{0^2 + 2(9.8)(20)} = \underline{19.80m/s}$

The flow rate is equal to the speed through the area

$Q = VA = (19.80m/s)(7.854 \times 10^{-3} m^2) = \underline{0.155m^3/s}$

$W = \rho g Q h$

$= (1000) \times (9.8) \times (0.155) \times (20) = 30478 \, kg/m^2/s^3$

$= \underline{30 \times 10^3 w}$

7) $P_1 g = 19.62 N/m^2$

$Cd = 0.96$

$d_1 = 0.3m$

$d_2 = 0.2m$

$u_1 = Q_1 0.0707$ $\quad u_2 = Q_1 0.0314$

$P_1 + P_g gz = P_2 + \rho_g g (Z_2 - Z_1) + \rho_w g R_f$

$P_1 - P_2 = 19.62 (z_2 - z_1) + 587.423$ ---- Q_1

For the venturimeter, $\frac{P_1}{\rho g} + \frac{V_1^2}{2g} + z_1 = \frac{P_2}{\rho g} + \frac{V_2^2}{2g} + z_2$

$P_1 - P_2 = 19.62 (z_2 - z_1) + 0.803 V_2^2$ ---- Q_2

Combine Q_1 and Q_2

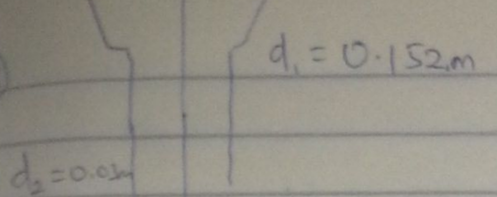
$0.803 V_2^2 = 587.423$

$V^2_{ideal} = 27.047 m/s$, $Q_{ideal} = 27.04 \times \pi \left(\frac{0.2}{2}\right)^2$

$= \underline{0.85m^3/s}$

$Q = cd \, Q_{ideal} = 0.96 \times 0.85 = \underline{0.816m^3/s}$

8)



$d_1 = 0.152m$ $\quad A_1 = 0.184m$

$d_2 = 0.076m$ $\quad A_2 = 0.0454m$

$\rho = 800kg/m^3$

$C_d = 0.97$

Applying Bernoulli's equation, $\frac{P_1}{\rho g} + \frac{V_1^2}{2g} + z_1 = \frac{P_2}{\rho g} + \frac{V_2^2}{2g} + z_2$

a) $P_1 = P_2$ $\quad \frac{V_1^2}{2g} + z_1 = \frac{V_2^2}{2g} + z_2$

$Q = A_1 V_1 = A_2 V_2$

$V_2 = V_1 \frac{A_1}{A_2} = V_1 4$

$V_1 = \sqrt{\frac{0.914 \times 2 \times 9.81}{15}} = 1.0934m/s$

$Q = C_d A_1 V_1 = 0.96 \times 0.01814 \times 1.0934$

$= 0.019m^3/s$

$P_1 - P_2 = 15170$

$\frac{P_1 - P_2}{\rho g} = \frac{V_2^2 - V_1^2}{2g} - 0.914$

$\frac{15170}{\rho g} = Q_2 \left(\frac{220.43^2 - 55.11^2}{2g} \right) - 0.914$

$Q = 0.035m^3/s$

9) At section 1,

$D = 0.3m$

$A = \frac{\pi}{4}(0.3)^2 = 0.707m^2$

$z_1 = 10m$

$V_1 = ?$

$P_1 = 400 \times 10^3 N/m^2$

At section 2

$D_2 = 0.15m$

$A_2 = \frac{\pi}{4}(0.15)^2 = 0.1767m^2$

$z_2 = 6m$

$V_2 = ?$

$P_2 = ?$

$A_1 V_1 = A_2 V_2 = 400\ l/s = 40 \times 10^{-3}\ m^3/s$

$V_1 = \frac{40 \times 10^{-3}}{0.707} = 0.566\ m/s$

$V_2 = \frac{40 \times 10^{-3}}{0.01767} = 2.264\ m/s$

Applying Bernoulli's equation

$$\frac{400 \times 10^3}{9800} + \frac{(0.556)^2}{2 \times 9.81} + 10 = \frac{P_2}{w} + \frac{(1.274)^2}{2 \times 7.81} + 6$$

$P_2 = 436.8\ kN/m^2$

10) Reading of the manometer = 170 mm

$S_{hl} = 13.6$ (mercury)

$S_p = \text{sea} = 1.026$

$$h = y\left[\frac{S_{hl}}{S_P} - 1\right]$$

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

$h = 2.085$

Velocity of submarine

$V = \sqrt{2gh} = \sqrt{2 \times 7.81 \times 2.083} = 6.39\ m/s$