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Mechanical Engineering

1) Flowrate (Q) = $10 dm^3/min$
Pressure Change (ΔP) = 12bar
Speed = 1500rpm
Normінal displacement = $10 cm^3/rev$
Torque input = 12.5Nm

(i) Ideal flow rate = Normінal Displacement × Speed
= $10 cm^3/rev \times 1500rpm$
= $15000 cm^3/min = 15 dm^3/min$
Volumetric efficiency = Actual flow / Ideal flow
$= \frac{10}{15} = 0.6667$ or 66.67%

(ii) $Q = \frac{10 \times 10^{-3}}{60} = 16.7 \times 10^{-5} m^3/sec$

$\Delta P = 12 \times 10^5 N/m^2$

Fluid power = $\Delta p \times Q = 16.7 \times 10^{-5} \times 12 \times 10^5$ = 200 watts

Shaft power = $\frac{2\pi NT}{60} = \frac{2\pi \times 1500 \times 12.5}{60}$ = 1963.5 watts

Over all Efficiency = $\frac{F.P}{S.P} = \frac{200}{1963.5}$ = 0.102 or 10.2%

8.314 Kwatt 2) Flowrate (Q) = $35 dm^3/min$ = $58.3 \times 10^{-5} m^3/sec$
Pressure change (ΔP) = 100bar = $100 \times 10^5 N/m^2$
Overall efficiency = 87%
Shaft power = $\frac{2\pi NT}{60}$
Fluid power = $58.3 \times 10^{-5} \times 100 \times 10^5 N/m^2$
= 5830 watts.

Overall efficiency = $\frac{\text{Fluid power}}{\text{Shaft power}}$

$0.87 = \frac{5830}{x}$

~~x~~ = Shaft power = 6701.14 watt.

3) Nominal displacement = 500 cm³/rev

Pressure change (Δp) = 100 bar = $100 \times 10^5 \, N/m^2$

Shaft power = 15000 watt.

Flow rate (Q) = 35 dm³/min = $58.3 \times 10^{-5} \, m^3/sec$

Speed = 850 rpm

i) Ideal flow rate = $50 \, cm^3/rev \times 850 \, rpm$

$= 42500 \, cm^3/min = 42.5 \, dm^3/min$

Volumetric efficiency = $\frac{\text{Actual}}{\text{Ideal}} = \frac{35}{42.5} = 82.35\%$

ii) ~~Q~~ Fluid power = $\Delta p \times Q$

$= 100 \times 10^5 \times 58.3 \times 10^{-5} \, m^3/sec$

$= 5830$ watt

Overall Eff. = $\frac{\text{Fluid power}}{\text{Shaft power}} = \frac{5830}{15000} = 38.86\%$

4) $H = 240m$ $\quad v = 66 \, m/sec$

$Q = 0.013 \, m^3/s$

i) Power of Jet = $\frac{1}{2} m v^2$.

$= \frac{1}{2} \rho Q v^2 = \frac{1}{2} \times 1000 \times 0.013 \times 66^2 = 28.314$ Kwatt $\quad$ 2)

ii) Power supplied by reservoir = $mgh = \rho Q g h$

$= 1000 \times 0.013 \times 9.81 \times 240$

$= 30.6072$ Kwatt

(iii) $H_f = H - \frac{V^2_{jet}}{2g}$

$= 240 - \frac{66^2}{2 \times 9.81}$

$= 17.98m$

(iv) Efficiency of pipeline and nozzle $= \frac{P_{jet}}{P_{res}} \times 100$

$= \frac{28.314}{30.6072} \times 100 = 92.51\%$

5) $Z_1 = 300m$

$Q = 220 \times 10^{-3}\ m^3/s$

$V_2 = 7m/s$

i) Jet power $= \rho g Q H$

$\rho = 890 kg/m^3$

$g = 9.81 m/s^2$

$H = Z_2 + \frac{P}{\rho g} + \frac{v^2}{2g}$

$H = 0 + \frac{0}{\rho g} + \frac{(7)^2}{2 \times 9.81}$

$H = 2.497 J$

Power $= 890 \times 9.81 \times 220 \times 10^{-3} \times 2.497$

$= 4797.1$ watts

ii) $H = Z_1 + \frac{P}{\rho g} + \frac{v^2}{2g}$

$= 300 + \frac{0}{\rho g} + \frac{0}{2g}$

$= 300 J$

Power $= 890 \times 9.81 \times 220 \times 10^{-3} \times 300$

$= 576239.4$ Kgm/sec

$\times 20m$

iii) Head used to overcome the loss

$= \frac{576239.4 - 4797.1}{1000 \times 9.81 \times 220 \times 10^{-3}}$

$= 264.777$

iv) Efficiency $= \frac{\text{Jet power}}{\text{Reservoir power}} \times 100$

$= \frac{4797.1}{576239.4} \times 100$

$= 0.83248\ \%$

6) Power $= \frac{\text{Workdone}}{\text{Time}}$

workdone $= mgh \div$ time

$v =$ Velocity of steam

$\rho =$ density of water ($1000 kg/m^3$)

$m = \rho \times v$

$v = \sqrt{2gh} = \sqrt{2 \times 9.81 \times 20}$

$v = 19.7989 m/s$

Power $= \frac{1000}{m^3} \times \left(\frac{10 \times 10^{-2}}{2}\right) \times 19.7989 m/s \times 9.8 m/s^2 \times 20 m$

$= 30478.03$ watts

8) $A_1 = \frac{\pi}{4}(0.152)^2 = 0.018146 m^2$

$A_2 = \frac{\pi}{4}(0.076)^2 = 4.5365 \times 10^{-3} m^2$

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

$= \frac{0.97 \times 0.018146 \times 4.5363 \times 10^{-3} \times \sqrt{2 \times 9.81 \times 0.914}}{\sqrt{(0.018146)^2 - (4.5365 \times 10^{-3})^2}}$

$Q = 0.01924 m^3/s$

ii) $h = \left(\frac{P_1 - P_2}{\rho g}\right) = \frac{15120}{0.8 \times 10^3 \times 9.81} = 1.933m$

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

$Q = \frac{0.97 \times 0.018146 \times 4.5365 \times 10^{-3} \times \sqrt{2 \times 9.81 \times 1.933}}{\sqrt{(0.018146)^2 - (4.5365 \times 10^{-3})^2}}$

$Q = 0.02798 m^3/s$

(iv) $h = y\left(\frac{\rho_m}{\rho_f} - 1\right)$

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

$h = 2.0834$

velocity of submarine

$v = \sqrt{2gh}$

$v = \sqrt{2 \times 9.81 \times 2.0834}$

$v = 6.393 m/sec$