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CIVIL ENGINEERING

flowrate (Q) = 10 dm³/min
Pressure change (ΔP) = 12 bar
speed (N) = 1500 rpm
Normal displacement = 10 cm³/rev
Torque input (T) = 12.5 N-m

(i) Ideal flow rate = Normal displacement × speed
= 10 cm³/rev × 1500 rpm
= 15000 cm³/min = 15 dm³/min

volumetric efficiency = Actual flow / Ideal flow
= 10/15 = 0.6667 or 66.67%

(ii) $Q = \frac{10 \times 10^{-3}}{60}$ m³/sec = 16.7×10^{-3} m³/sec

$\Delta P = 12 \times 10^5$ N/m²

fluid Power = ΔP × Q = 16.7×10^{-3} m³/sec × 12×10^5 N/m² = 200 watts

shaft Power = $\frac{2\pi NT}{60}$ = $\frac{2\pi \times 1500 \times 12.5}{60}$ = 1963.5 watts

overall efficiency = F.P/S.P = 200/1963.5 = 0.102 or 10.2%

Summary: Here we can see that shaft power almost 10 times of fluid Power. fluid Power can be either inverse by the change in Pressure or discharge.

(3)
Normal displacement = 50 cm³/rev
Pressure change (ΔP) = 100 bar
shaft Power = 15 kilowatts = 15000
overall efficiency = ??
volumetric efficiency = ??
flowrate (Q) = 35 dm³/min
speed (N) = 850 rpm

(i) Ideal flow rate = Normal displacement × speed
= 50 cm³/rev × 850 rpm
= 42500 cm³/min
= 42.5 dm³/min

volumetric efficiency = Actual flow / Ideal flow
= 35/42.5 = 0.8235 or 82.35%

(ii) $Q = \frac{35 \times 10^{-3}}{60}$ m³/sec = 58.3×10^{-5} m³/sec
= 5830 watt

shaft Power = 15000 watts
overall efficiency = fluid Power / Shaft Power
= $\frac{5830}{15000}$ = 0.3886 or 38.86%

(4)

$H = 240m$ $Q = 0.013 m^3/s$
$v = 66 m/sec$

(a) Power of jet (P_{jet}) $= \frac{1}{2} mv^2 jet$
$= \frac{1}{2} \rho Q v^2 jet$
$= \frac{1}{2} \times 1000 \times 0.013 \times 66^2$ watt
$= 28314$
$= 28.314$ kilowatt

(b) Power supplied by reservoir (P_{res}) $= mgh$
$= \rho Q g h$
$= 1000 \times 0.013 \times 9.81 \times 240$ watt
$= 30607.2$
$= 30.6072$ kilowatt

(c) Head used to overcome losses (H_L) $= H - \frac{v^2 jet}{2g}$
$= 240 - \frac{66^2}{2 \times 9.81}$
$= 17.98 m$

(d) Efficiency of pipeline & nozzle
$= \frac{P_{jet}}{P_{res}} \times 100$
$= \frac{28.314}{30.6072} \times 100$ $= 92.51\%$

(5)

$Z_1 = 30,000 cm = 300m$
$Q_1 = 220$ litres/s $= (220 \times 10^{-3}) m^3/s$
$v_2 = 7 m/s$
Power of jet $= \rho g Q H$
where $\rho = 0.89 \times 1000 = 890 kg/m^3$
$g = 9.81 m/s^2$
$Q = (220 \times 10^{-3}) m^3/s$
$H = Z_2 + \frac{P}{\rho g} + \frac{v^2}{2g}$
$H = 0 + \frac{0}{\rho g} + \frac{(7)^2}{2 \times 9.81}$

$H = 49/19.62 = 2.4972$
Power $= 890 \times 9.81 \times 220 \times 10^{-3} \times 2.497$
$= 4797.1$ watts
Power supplied from reservoir
$H = Z_1 + \frac{P}{\rho g} + \frac{v^2}{2g} = 300 + \frac{0}{\rho g} + \frac{0}{2g}$
$= 300 J$
Power $= 890 \times 9.81 \times 220 \times 10^{-3} \times 300$
$= 576239.4$ kgm/sec

(iii) Head used to overcome the loss
$=$ Power loss $/ \rho g Q$
$= (576239.4 - 4797.1) / 1000 \times 9.81 \times 220 \times 10^{-3}$
$= 571442.3 / 2158.2$
$= 264.7772681$

(iv) Efficiency $= \frac{\text{Power of Jet}}{\text{Power of reservoir}} \times 100$
$= \frac{4797.1}{576239.4} \times 100$
$= 0.832485886\%$

(6)

Power $= \frac{\text{work done}}{\text{time}}$
workdone $= \frac{mgh}{\text{time}}$
v = velocity of stream
ρ = density of water ($1000 kg/m^3$)
$\dot{m} = \rho \times v$
$v = \sqrt{2gh} = \sqrt{2 \times 9.8 \times 20}$
$= 19.7989 m/s$
$P = \rho \pi r^2 \frac{vgh}{t}$

$Power = \frac{1000kg}{m^3} \times \left(\frac{10\times10^{-2}}{2}\right) \times 19.7989 m/s \times 9.8 m/s^2 \times 20m$

$= 1000 \times \pi \times 2.5 \times 10^{-3} \times 19.79899 \times 20$

Power = 30478.03 W

(7)

Diameter $(D_1) = 0.3m$

$A_1 = \frac{\pi}{4} \times 0.3^2$

$A_1 = 0.070685 m^2$

Throat diameter $(D_2) = 0.2m$

$\therefore A_2 = \frac{\pi}{4} \times (0.2)^2$

$A_2 = 0.031416 m^2$, coefficient of discharge $(C_d) = 0.96$

specific weight of gas $(\gamma) = 19.62 N/m^3$

$\therefore$ density of gas $(S_g) = \frac{19.62}{9.81}$

$S_g = 2kg/m^3$

Piezometric head difference $(h) =$

$x\left(\frac{S_m}{S_g} - 1\right)$

$= 0.06 \times \left(\frac{1000}{2} - 1\right)$

$h = 29.94m$

$\therefore$ value flow rate $(\dot{Q}) = \frac{C_d A_1 A_2 \sqrt{2gh}}{\sqrt{A_1^2 - A_2^2}}$

$= \frac{0.96 \times 0.070685 \times 0.031416 \sqrt{2 \times 9.81 \times 29.94}}{\sqrt{(0.070685)^2 - (0.031416)^2}}$

$Q = 0.81599 m^3/s$

(8)

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

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

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

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

$Q = 0.01924 m^3/s$

(ii) $h = \left(\frac{P_1 - P_2}{\rho g}\right) = \frac{15170}{0.8 \times 10^3 \times 9.81} = 1.933m$

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

$Q = \frac{0.97 \times 0.018146 \times 4.53 \times 10^{-3} \times \sqrt{2 \times 9.81 \times 1.933}}{\sqrt{(0.018146)^2 - (4.5365 \times 10^{-3})^2}}$

$Q = 0.02798 m^3/s$

(9)

$d_1 = 300mm = 0.3m$

$A_1 = \pi d^2/4 = \pi(0.3)^2/4 = 0.0707 m^2$

$d_2 = 150mm = 0.15m$

$A_2 = \frac{\pi d^2}{4} = \frac{\pi(0.15)^2}{4} = 0.0177 m^2$

$Q = 40 l/s = (40 \times 10^{-3}) m^3/s$

$Z_1 = 10m, Z_2 = 6m, P_1 = ??, P_2 = 400kN/m^2 = 400{,}000 N/m^2$

$Q = VA$

$V_1 A_1 = Q \therefore (V_1)(0.0707) = (40 \times 10^{-3})$

$V_1 = (40 \times 10^{-3}) / 0.0707$

$V_1 = 0.5658 m/s$

$Q = V_2 A_2$

$V_2 (0.0177) = 40 \times 10^{-3}$

$V_2 = \frac{40 \times 10^{-3}}{0.0177} = 2.2599 m/s$

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

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

$$10 + \frac{400000}{9.81 \times 1000} + \frac{(0.5658)^2}{2(9.81)} = 6 + \frac{P_2}{9.81 \times 1000} + \frac{(2.259)}{2 \times 9.81}$$

$$50.79 = \frac{P_2}{9.81 \times 1000} = 6.260303$$

$$\frac{P_2}{9.81 \times 1000} = 50.79 - 6.26$$

$$P_2 = (9.81 \times 1000)(44.53)$$

$$P_2 = 436836.326 \, N/m^2$$

$$P_2 = 436.836 \, kN/m^2$$

(1b)

Calculate the head

$$h = y \left[\frac{\rho_m}{\rho_f} - 1\right]$$

ρ_m = density of mercury

ρ_f = density of flowing fluid

$y \rightarrow$ manometer reading

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

$$h = 2.0834$$

Calculate the velocity of the submarine

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

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

$$= 6.393 \, m/sec$$