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18/ENG06/024
Mechanical Engineering

1. flow rate $= 10\ dm^3/min = 0.01\ m^3/min$

$Q = 1.67 \times 10^{-4}\ m^3/sec$

Speed $= 1500$ rev/min

$= 25$ rev/sec

$dP = 12$ bar $= 12 \times 10^5\ N/m^2$

Normal displacement $= 10\ cm^3/rev$

$= 1 \times 10^{-5}\ m^3/rev$

Ideal flow rate = nominal displacement × speed

$= 25 \times 1 \times 10^{-5}$

$= 2.5 \times 10^{-4}\ m^3/sec$

i) vol. efficiency $= \frac{\text{actual flow rate}}{\text{ideal flow rate}} \times 100 = \frac{1.67 \times 10^{-4}}{2.5 \times 10^{-4}} \times 100$

$= 66.8\%$

Fluid power $= Q \cdot dp$

$= 1.67 \times 10^{-4} \times 12 \times 10^5$

$= 200.4$ Nm/sec

shaft power $= T\omega_c$

↳ angular speed

$\omega_c = 2\pi N_c$ speed of rotation

$= 2 \times 22/7 \times 25 = 157.14$ rads/sec

∴ shaft power $= 12.5 \times 157.14$

$= 1964.25W$

Overall efficiency $= \frac{\text{fluid power}}{\text{shaft power}} \times 100$

$= \frac{200.4}{1964.25} \times 100$

$= 10.2\%$

18/ENG06/024

2) $dp = 100 \times 10^5 \, N/m^2$

$Q = 35 \, dm^3/min$

$= \frac{0.035}{60} = 5.83 \times 10^{-4} \, m^3/sec$

fluid power $= Q \cdot dp$

$= 5.83 \times 10^{-4} \times 100 \times 10^5$

$= 5830 \, kJ$

Shaft power $= \frac{\text{fluid power}}{\text{overall eff.}} \times 100$

$= \frac{5830}{87} \times 100$

$= 6701.15 \, kJ$

Nominal displacement $= 50 \, cm^3/rev = 5 \times 10^{-5} \, m^3/rev$

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

Shaft power $= 15 \, kW$

Actual flow rate $[Q_a] = \frac{0.035}{60} = 5.83 \times 10^{-4} \, m^3/sec$

$P_f = Q \cdot dP$

$5.83 \times 10^{-4} \times 100 \times 10^5$

$= 5830 \, W$

Overall efficiency $= \frac{5830}{15000} \times 100$

$= 38.87\%$

Ideal flow rate = nominal displacement $\times$ Speed

$\frac{5 \times 10^{-5} \times 850}{60} = 7.08 \times 10^{-4} \, m^3/sec$

Vol efficiency $= \frac{\text{actual flow rate}}{\text{Ideal flow rate}} \times 100$

$= \frac{5.83 \times 10^{-4}}{7.08 \times 10^{-4}} \times 100$

$= 82.34\%$

4 $Z = 240m$

$Q = 0.013 m^3/sec$ $\rho = 1000 kg/m^3$ for water

$V_{jet} = 66 m/sec$; $P = 0$ and $Z_1 = 0$

power $= PQ + \frac{\rho Q v^2}{2} + \rho g Q z_1$

$= \frac{\rho Q v^2}{2} = \frac{1000 \times 13 \times 10^{-3} \times (66)^2}{2}$

$P = 28.314 kW$

ii) power supplied from reservoir

Since reservoir operates at atmospheric pressure ; $P = 0, v = 0$

$P = 0 \cdot Q + \rho Q 0^2 + \rho g Q z_2$

$P = \rho g Q z_2 = 1000 \times 9.81 \times 0.013 \times 240$

$= 30.61 kW$

power loss in transmission = Reservoir power − Jet power

$= 30.61 - 28.314$

$= 2.296 kW$

Head loss (H) $= \frac{\text{power loss}}{\rho g Q} = \frac{2.29 \times 10^3}{1000 \times 9.81 \times 0.013}$

$= 18m$

iv) $\varepsilon = \frac{\text{power of jet}}{\text{power of reservoir}} \times 100$

$= \frac{28314}{30610} \times 100$

$= 92.45\%$

18/ENG06/024

5) $Z_2 = 300m$

$Q = 220 l/sec = 0.22 m^3/s$

$V_{jet} = 7 m/sec$; $P = 0$; $Z = 0$

power of jet $= PQ + \frac{\rho Q v^2}{2} + \rho g Q Z_1$

$$P = \frac{\rho Q v^2}{2} = \frac{890 \times 0.22 \times (7)^2}{2}$$

$= 4797.1 W$

$= 4.7971 kW$

ii) Power supplied from reservoir

$P = 0$; $V = 0$

$P = \rho g Q z$

$= 890 \times 9.81 \times 0.22 \times 300$

$= 576.239 kW$

Power loss in transmission $= 576.239 - 4.7971$

$= 571.442 kW$

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$= 571.442 kW$

Head loss (h) $= \frac{\text{power loss}}{\rho g Q} = \frac{571.442}{890 \times 9.81 \times 0.22} = 297.50m$

Efficiency $= \frac{4797.1}{576239} \times 100$

$= 0.83\%$

18/ENG06/024

(6) $h_1 = 20m$

$d = 10cm = 0.1m$

$r = 0.05m$

$g = 9.81m/s^2$

Using conservation of energy

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

$= \sqrt{392.4}$

$v = 19.8 m/s$ at the base

$\rho = 1000 kg/m^3$

$Q_{base} = \pi r^2 v$

$= 22/7 \times 0.05^2 \times 19.81$

$= 0.156 m^3/sec$

∴ 155.6 kg of water leaves the fountain every sec

$P = \frac{W}{t} = \frac{mgh}{t}$

$= \frac{\rho \pi r^2 v g h}{t} = 155.6 \times 9.81 \times 20$

$= 30528.72W$

$\approx 30.53kW$

7) $C_d = 0.96$

$d_1 = 0.3m$

$d_2 = 0.2m$

$\rho g = 19.62 N/m^2$

$A_1 = \frac{\pi d^2}{4} = \frac{\pi \times 0.3^2}{4} = 0.0707 m^2$

$A_2 = \frac{\pi \times 0.2^2}{4} = 0.0314 m^2$

$Q = U_1 A_1 = U_2 A_2$

$U_1 = \frac{Q}{0.0707}$ $U_2 = \frac{Q}{0.0314}$

For manometer,

$P_1 + \rho_g g z = P_2 + \rho_2 + \rho_g g (z_2 - R_1) + \rho_w g R_2$

$P_1 - P_2 = 19.62(Z_2 - Z_1) + 587.423$

For ventrimeter;

$P_1 - P_2 = 19.62(Z_2 - Z_1) + 0.803U_2^2$

Combining:

$0.803U_2^2 = 587.423$

$U_{2ideal} = 27.047 m/s$

$Q_{ideal} = 27.047 \times \pi \left(\frac{0.2}{2}\right)^2 = 0.85 m^3/s$

$Q_{actual} = Cd \cdot Q_{ideal}$

$= 0.96 \times 0.85$

$= 0.816 m^3/sec$

9) $d_1 = 300mm = 0.3m$

$A_1 = \pi/4 \times 0.3^2 = 0.0707m^2$

$P_1 = 400kN/m^2$

Height above datum $Z_1 = 10m$

$d_2 = 0.15m$

$A_2 = \frac{\pi \times 0.15^2}{4} = 0.01767m^2$

height of tower and above datum. $Z_2 = 6m$

$Q = 40 l/sec = \frac{40 \times 10^2}{10^6} = 0.04 m^3/s$

$Q = A_1V_1 = A_2V_2$

$V_1 = \frac{Q}{A_1} = 0.566 m/s$

$V_2 = \frac{0.04}{0.01767} = 2.264 m/s$

Using Bernoullis eqn:

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

$$\frac{P_2}{w} = \frac{400}{9.81} + \frac{1}{2 \times 9.81}(0.566^2 - 2.264^2) + (10 - 6)$$

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$\frac{P_2}{w} = 44.525m$

$P_2 = 44.525 \times 9.81 = 436.8 kN/m^2$

(10) Manomete reading (y) = 170mm Hg = 0.17 m Hg
Speific gravity of heavie liquid (mercury) = 13.6
Sg of Sea water (Sw) = 1.026

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

Velocity of the resistance

$v = \sqrt{2gh}$

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

$= 6.39 m/s$