18/ENG05/036
Mechanical engineering
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ENG214

i) Actual flow rate = 10 dm^3/min

10 dm = 1m

$dm^3 = 10m^3$

$= 10^3 dm^3 = 1m^3$

$\therefore$ 10 dm^3/min = 0.01 m^3/min

0.01 m^3/min = $1.67 \times 10^{-4} m^3/s$

Speed, N = 1500 rev/min = $\frac{1500}{60}$ = 25 rev/sec Ω 25 rps

ΔP = 12 bar Ω $12 \times 10^5 Nm^{-2}$

nominal displacement = 10 cm^3/rev

$\Omega = \frac{10}{1 \times 10^6} = 10 \times 10^{-6} m^3/rev$

Ideal flow rate = nominal displacement $\times$ speed

$= 25 \times 10 \times 10^{-6} = 2.5 \times 10^{-4} m^3/sec$

i) volumetric efficiency = $\frac{\text{Actual flow rate}}{\text{ideal flow rate}} \times 100$

$= \frac{1.67 \times 10^{-4}}{2.5 \times 10^{-4}} \times 100 = 66.8\%$

ii) fluid power = $Q\Delta P$

$= 1.67 \times 10^{-4} \times 12 \times 10^5 = 200.4$ watts

iii) shaft power = T.w

T = 12.5Nm

$w = (2\pi N)/60 = 2 \times 22/7 \times 25 = 157.14$ rad/sec

$\therefore$ shaft power = $12.5 \times 157.14 = 1964.25$ watts.

iv) overall efficiency = $\frac{\text{fluid power}}{\text{Shaft power}} \times 100$

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

$= 10.2\%$

2) change in pressure $\Delta P = 100 bars \approx 100 \times 10^5 NM^{-2}$

flowrate = $35 dm^3/min$

$= \frac{35}{1000 \times 60} = 5.83 \times 10^{-4} m^3/sec$

fluid power = flow rate × change in pressure

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

= 5830 watts

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

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

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

= 6701.15 watts

3) Nominal displacement = $50 cm^3/rev$

$x = \frac{50}{1000000} = 50 \times 10^{-6} m^3/rev$

Actual flow rate = $35 dm^3/min$

$= \frac{35}{1000 \times 60} = 5.83 \times 10^{-4} m^3/sec$

$\Delta P = 100 \times 10^5 NM^{-2}$

shaft power = 15kw = 15000 watts

i) overall efficiency = $\frac{\text{fluid power}}{\text{shaft power}} \times 100$

fluid power = $Q \times \Delta P = 5.83 \times 10^{-4} \times 100 \times 10^5$

= 5830 watts

$\therefore$ O.E = $\frac{5830}{15000} \times 100$ = 38.67%

Continuation of number 3.

Ideal flow rate = nominal × speed

Speed = 850 rpm

$= \frac{850}{60} = 14.17$ rps

∴ Ideal flow rate $= 50 \times 10^{-6} \times 14.17$

$= 7.085 \times 10^{-4}$ m^3/sec

ii) Volumetric efficiency

$= \frac{\text{Actual flow rate}}{\text{ideal flow rate}} \times 100\%$

$= \frac{5.83 \times 10^{-4}}{7.085 \times 10^{-4}} \times 100 = 82.3\%$

4. Z = 2660cm

Z = 26.6m

Volumetric flow rate = 13 liter/sec

$Q = \frac{13}{1000}$ $\quad Q = 13 \times 10^{-3}$ m^3/sec

velocity of jet = 66m/sec

At datum level P = 0 and Z = 0

i) power of Jet

P = 0 Z = 0

$P = PQ + \frac{\rho Q v^2}{2} + \rho g Q Z$

$= \frac{\rho Q v^2}{2} = \frac{1000 \times 13 \times 10^{-3} \times (66)^2}{2} = 28314$ watts

ii) power from reservoir

P = 0 and V = 0

$P = PQ + \frac{\rho Q v^2}{2} + \rho g Q Z$

$= \rho g Q Z$

continuation of 4

$= 1000 \times 9.81 \times 13 \times 10^{-3} \times 240$

$= 30607.2$ watts

ii) head loss in pipe line (h)

$h = \frac{\text{power lost in transmission}}{\rho g Q}$

power lost in transmission = power of reservoir − power of Jet

$= 30607.2 - 28314 = 2293.2$ watts

$\therefore h = \frac{2293.2}{1000 \times 9.81 \times 13 \times 10^{-3}} = 17.98\,m$

iii) Efficiency $= \frac{\text{power of Jet}}{\text{power of reservoir}} \times 100$

$= \frac{28314}{30607.2} \times 100 = 92.5\,\%$

5. $Z = 30000\,cm$

$Z = 300\,m$

volumetric flow rate (Q) = 220 litres/sec

1000 litres = $1\,m^3$

$Q = \frac{220}{1000} = 0.22\,m^3/sec$

velocity of Jet (V) = 7m/sec

S.g = 0.89

recall $S.g = \frac{\text{density of fluid}}{\text{density of pure water}}$

$\rho = S.g \times 1000 = 0.89 \times 1000 = 890\,Nm^{-2}$

At datum level

i) Power of jet $P = 0$ and $Z = 0$

$P = PQ + \frac{\rho Q \cdot V^2}{2} + \rho g \cdot QZ$

$= \frac{\rho Q \cdot V^2}{2} = \frac{890 \times 0.22 \times (7)^2}{2} = 4797.1$ watts

Continuation of 5

ii) Power from reservoir

$P=0 \quad v=0$

$P = PQ + \frac{\rho Q v^2}{2} + \rho g Q z$

$= \rho g Q z$

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

$= 576239.4$ watts

iii) Head loss in pipe line (h)

$h = \frac{\text{Power lost in transmission}}{\rho g Q}$

But power lost in transmission

= power of reservoir − power of jet

$= 576239.4 - 4797.1$

$= 571442.3$ watts

$h = \frac{571442.3}{890 \times 9.81 \times 0.22} = \frac{571442.3}{1920.798}$

$h = 297.5m$

iv) efficiency $= \frac{\text{Power of Jet}}{\text{Power of reservoir}} \times 100 = \frac{4797.1}{576239.4} \times 100$

$= 0.832\%$

6. $h = 20m \quad d = 10cm = 0.1m$

$A = \frac{\pi d^2}{4} = 0.7854 \quad v_f = 0$

$W = ?$

$v_f^2 = v_1^2 - 2gh$

$v_1 = \sqrt{v_F^2 + 2gh}$

$v_1 = \sqrt{0^2 + 2(9.8)(20m)} = 19.80ms^{-1}$

The flow rate is equal to the speed through the area

$Q = vA = (19.80)(7.834 \times 10^{-3}) = 0.155 m^3/s$

$W = \rho g Q h$

$= (1000) \times (9.81) \times (0.155) \times (20)$

$= 30478 \; kg\,m^2/s^3 = 30 \times 10^3 \; W$

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

$Cd = 0.96$

$d_1 = 0.3m$

$d_2 = 0.2m$

$v_1 = Q, 0.0707 \qquad u_2 = Q, 0.0314$

$P_1 + \rho_g g_z = P_2 + \rho_g g(Z_2 - P_1) + \rho_w g P_1 f$

$P_1 - P_2 = 19.62(Z_2 - Z_1) + 587.423 \quad --- Q_1$

for the venturimeter

$$\frac{P_1}{\rho g} + \frac{u_1^2}{2g} + Z_1 = \frac{P_2}{\rho g} + \frac{u_2^2}{2g} + Z_2$$

$P_1 - P_2 = 19.62(Z_2 - Z_1) + 0.803v^2 \quad -- Q_2$

Combine Q_1 and Q_2

$0.803v_2^2 = 587.423$

$v_{ideal}^2 = 27.047ms^{-1}$

$Q_{ideal} = 27.047 \times \pi(0.2)^2$

$= 0.85m^3s^{-1}$

$Q = Cd\ Q_{ideal} = 0.96 \times 0.85 = 0.816m^3s^{-1}$

8. $d_1 = 0.152m \quad d_2 = 0.076m \quad A_1 = 0.01814m \quad A_2 = 0.00454m$

$\rho = 800kgm^{-3} \qquad Cd = 0.97$

$$\frac{P_1}{\rho g} + \frac{v_1^2}{2g} + Z_1 = \frac{P_2}{\rho g} + \frac{v_2^2}{2g} + Z_2$$

a) $P_1 = P_2$

$$\frac{v_1^2}{2g} + Z_1 = \frac{v_2^2}{2g} + Z_2$$

$Q = v_1A_1 = v_2A_2$

$$V_2 = \sqrt{\frac{0.914 + 2 \times 9.81}{15}} = 1.0934ms^{-1}$$

$Q = CdA_1v_1$

$Q = 0.96 \times 0.01814 \times 1.0934$

$= 0.019m^3s^{-1}$

Continuation of 8.

$P_1 - P_2 = 15170$

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

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

$Q = 0.035\ m^3/s$

9. At section 1

$D_1 = 0.3m$

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

$Z_1 = 10m$

$V_1 = ?$ $P_1 = 400 \times 10^3\ Nm^{-2}$

At section 2

$D_2 = 0.15m$

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

$Z_2 = 6m$ $V_2 = ?$ $P_2 = ?$

$A_1V_1 = A_2V_2 = 40$ litre/sec $= 40 \times 10^{-3}$ m/sec

$$V_1 = \frac{40 \times 10^{-3}}{0.707} = 0.336ms^{-1}$$

$$V_2 = \frac{40 \times 10^{-3}}{0.01767} = 2.264ms^{-1}$$

$$\frac{400 \times 10^3}{9800} + \frac{(0.556)^2}{2 \times 9.8} + 10 = \frac{P_2}{w} + \frac{(1.274)^2}{2 \times 9.8} + 6$$

$P_2 = 436.8\ KN/m^2$

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(b) Reading of manometer = 170 mm

S.g of mercury (S_{h1}) = 13.6

S.g of water S_1 = 1.026

$$h = y\left[\frac{S_{h1}}{S_1} - 1\right]$$

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

$h = 2.083$

velocity of submarine

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

$$= \sqrt{2 \times 9.81 \times 2.083}$$

$= 6.39 ms^{-1}$.