Question 1

Emmanuel peter wonighan
18/Eng06/071

Actual flowrate $= 10dm^3/min$

$10dm = 1m$

dm^3 to m^3

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

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

$= m^3/min$ to m^3/sec

$60 sec = 1 min$

$(a) = \frac{0.01}{60} = 1.67 \times 10^{-4} m^3/sec$

speed, $N = 1500 rev/min$

$= \frac{1500}{60} = 25 rev/sec$ or $25 rps$

$\Delta P = 12 bar$ or $12 \times 10^5 Nm^{-2}$

Norminal displacement $= 10cm^3/rev$

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

ideal flowrate = norminal displacement × speed

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

~~i) Ideal flowrate =~~ Question 1 contd | 18/Eng05/071

i) Volumetric Efficiency = $\frac{\text{Actual flowrate}}{\text{Ideal flowrate}} \times 100\%$

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

$= 66.8\%$

(ii) Fluid power $= Q \cdot \Delta p$

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

(iii) Shaft power $= T \cdot \omega$

$T = 12.5$ Nm

$\omega = \frac{2\pi N}{60}$

$= 2 \times \frac{22}{7} \times 25 = 157.14$ rad/sec

∴ Shaft power $= 12.5 \times 157.14$

$= 1964.25$ watts

(iv) Overall Efficiency $= \frac{\text{fluid power}}{\text{shaft power}} \times 100\%$

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

$= 10.2\%$

Question 2) (18/Eng06/071)

Change in Pressure Δp = 100 bar ≃ $100 \times 10^5 Nm^{-2}$

flowrate = $35 dm^3 min^{-1}$

$= \frac{35}{1000 \times 60} = 5.83 \times 10^{-4} m^3 sec^{-1}$

~~Shaft~~ fluid power = flowrate × change in pressure

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

= 5830 watts

b) recall overall Efficiency = $\frac{\text{fluid power}}{\text{shaft power}} \times 100$

∴ Shaftpower = $\frac{\text{fluid power} \times 100\%}{\text{overall Efficiency}}$

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

= 6701.15 watts

Question 3 | 18/Eng06/071

Nominal displacement = $50 cm^3/rev$

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

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

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

$$\Delta p = 100 bar \triangleq 100 \times 10^5 Nm^{-2}$$

Shaft power = 15 kW = 15 × 1000 = 15000 watts

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

$$\therefore O.E = \frac{5830}{15,000} \times 100 = 38.67\%$$

Ideal flowrate = Nominal Displacement × speed

Speed N = 850 rpm

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

$\therefore$ Ideal flowrate $= 50 \times 10^{-6} \times 14.17$
$= 7.085 \times 10^{-4} m^3/sec$

(ii) Volumetric Efficiency 18/Eng06/071

$$= \frac{\text{Actual flowrate}}{\text{Ideal flowrate}} \times 100\%$$

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

Question 4 | 18/ENG06/011

$Z = 24000cm$

$100cm = 1m$

$\therefore Z = 240m$

Volumetric flow rate $Q = 13 Litres/sec$

$1000 Litres = 1m^3$

$Q = \frac{13}{1000}$

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

velocity at jet $= 66m/sec$

At datum level

$P = 0$ and $Z = 0$

i) Power at jet

Since its at datum level

$P = 0, Z = 0$

substitute into equation

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

$$= \frac{\rho Q v^2}{2}$$

$$= \frac{1000 \times 13 \times 10^{-3} \times (66)^2}{2} = 28314 \text{ Watts}$$

Questions cont'd

18/ENG06/071

Power from reservoir

here $P = 0$ and $v = 0$

substitute into equation

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

$$= \rho g Q z$$

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

$$= 30607.2 \text{ watts}$$

(ii) Head loss in pipeline (h)

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

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

$$= 30607.2 - 28314 = 2293.2 \text{ watts}$$

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

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

$$= \frac{28314}{30607.2} \times 100$$

$$= 92.5\%$$

$Z = 50{,}000$ (Question 5) 18/ENG06/071

$100cm = 1m$

$\therefore Z = 500m$

Volumetric flow rate (Q) = 220 Litres/sec

1000 Litres = $1m^3$

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

Velocity of jet = 7m/sec

S.G = 0.89

Recall S.G = $\frac{\text{density of fluid}}{\text{density of the water}}$

$\therefore \rho = SG \times 1000 = 0.89 \times 1000 = 890 Nm^{-3}$

At datum level

(i) Power of jet

$P = 0$ and $Z = 0$

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

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

$= 4797.1$ watts

~~(ii) Power from reservoir~~

(ii) Power from reservoir

Here $P = 0$ and $v = 0$

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

Question 5 contd   18/EN306/021

(i) ... = ρgQH

= 890 × 9.81 × 0.22 × 300

= 576239.4 watts

(ii) Head Loss in pipeline ...

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

But Power lost in transmission

= Power at reservoir − Power at jet

= 576239.4 − 4797.1

= 571442.3 watts

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

$h = 297.5\,m$

(iii) Efficiency = $\frac{\text{Power at Jet}}{\text{Power at reservoir}} \times 100$

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

= 0.832%

Question 6) ~~18/Eng06/071~~ 18/Eng06/071

(6) $h = 20m$

$d = 10cm = 0.1m$

$A = \frac{\pi d^2}{4} = 7.85 \times 10^{-3}$

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

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

$v = \sqrt{0^2 + 2(9.81)(20)}$

$= 19.81 ms^{-1}$

$Q = vA = (19.80)(7.854 \times 10^{-3})$

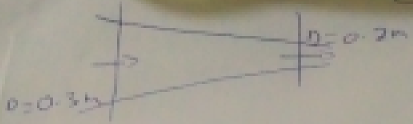
$= 0.155 m^3/s$

$W = \rho g Q h$

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

$= 30411 W$

Question 7 | 18/ENG06071



$D_E = 0.3m$

$A_E = \frac{\pi d^2}{4} = \frac{\pi (0.3)^2}{4} = 0.0707m^2$

$D_T = 0.2m$

$A_T = \frac{\pi d^2}{4} = \frac{\pi (0.2)^2}{4} = 0.0314m^2$

$\Delta p = 0.06m$

$Cd = 0.96 \qquad w = 17.62$

$h = \frac{\Delta p}{w} = \frac{0.06}{17.62} = \frac{1}{327}$

$Q = \frac{C_d A_E A_T \sqrt{2gh}}{\sqrt{(A_E - A_T)^2}}$

$= \frac{0.96 \times 0.0707 \times 0.0314 \sqrt{2 \times 9.81 \times \frac{1}{327}}}{\sqrt{(0.0707^2 - 0.0314^2)^2}}$

$= \frac{2.13 \times 10^{-3} \times \sqrt{0.06}}{\sqrt{4.01 \times 10^{-3}}} = 8.24 \times 10^{-3}$

$\therefore Q = 8.24 \times 10^{-3} = 0.00824$

Question 8 | 18/ENG05/073

(8) $d_1 = 0.152\,m = 0.01814\,m^2$

$d_2 = 0.076\,m = 0.00454\,m^2$

$\rho = 500\,kg\,m^{-3}$

$cd = 0.97$

$$\frac{P_1}{\rho g} + \frac{v_1^2}{2g} + z_1 = \frac{P_2}{\rho g} + \frac{v_2^2}{2g} + z_2$$

$P_1 = P_2$

$$\therefore \frac{v_1^2}{2g} + z_1 = \frac{v_2^2}{2g} + z_2$$

$$Q = v_1 A_1 = v_2 A_2$$

$$v_2 = \frac{v_1 A_1}{A_2} = 0.4$$

$$v_1 = \sqrt{\frac{0.914 \times 2 \times 9.81}{15}}$$

$$= 1.0934\,m\,s^{-1}$$

$$Q = Cd\,A_1 v_1$$

$$Q = 0.96 \times 0.01814 \times 1.0934$$

$$= 0.019\,m^3/s$$

$P_1 - P_2 = 15170$

$$\frac{P_1 - P_2}{\rho g} = \frac{v_2^2 - v_1^2}{2g} - 0.914$$

$$\frac{15170}{P3} = \frac{Q_2 (220.43^2 - 55.11^2)}{2g} - 0.914$$

$Q = 0.035 m^3/s$

18/EMS06/071

Question 9 | 18/Eng[illegible]/011

$D_1 = 300mm \triangleq 0.3m$

$A_1 = \frac{\pi d^2}{4} = \frac{\pi (0.3)^2}{4} = 0.071m^2$

$D_2 = 150mm \triangleq 0.15m$

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

$Q = 40 lit/sec \triangleq 0.04 m^3/sec$

$Z_1 = 10m$

$Z_2 = 6m$

$P_2 = ??$

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

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

recall $Q = V_1 A_1$

$\therefore V = \frac{Q}{A}$

$V_1 = \frac{0.04}{0.071} = 0.563ms^{-1}$

$V_2 = \frac{0.04}{0.0177} = 2.26ms^{-1}$

$w = \rho g = 1000 \times 9.81$

$= 9810$

$$\therefore \frac{400\times10^3}{9810} + 10 + \frac{(0.563)^2}{2\times9.81} = \frac{x}{9810} + 6 + \frac{(2.26)^2}{2\times9.81}$$

$$50.791 = \frac{x}{9810} + 6.26$$

$$\therefore P_2 = x = \frac{50.791 - 6.26}{9810}$$

$$P_2 = 4.50\times10^{-3}\ Nm^2$$

18/Eng06/071

Question 10) 18/Eng06/071)

$v = \sqrt{2gh}$

where $h = y \left\{ \frac{s.g \text{ of mercury}}{s.g \text{ of Liquid}} - 1 \right\}$

$y = 170mmHg$ or $0.17mHg$

$s.g$ of $Hg = 13.6$

$s.g$ of Liquid {seawater} $= 1.026$

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

$h = 2.083$

$v = \sqrt{2gh}$

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

$= 6.34ms^{-1}$