Alaaye Abdulai Abdulrahman
18/ENG06/002
Mechanical
ENG 214

1 Real flow rate $= 10 dm^3/min$, $T = 12.5 Nm$

$= \frac{10\times10^{-3}}{60} = 1.67\times10^{-4} m^3/s$

Pressure $= 12bar = 12\times10^5 N/m$

Speed $= 1500 rev/min = 25 rev/sec$

Nominal displacement $= 10cm^3/rev = 1\times10^{-5} m^3/rev$

Ideal flowrate $= 2.5\times10^{-4} m^3/sec$

i Volumetric efficiency $= \frac{\text{Real flowrate}}{\text{Ideal flowrate}}\times100$

$= \frac{1.67\times10^{-4}}{2.5\times10^{-4}}\times100 = 66.8\%$

ii Fluid power $= (Q\times\Delta P)$

$= 1.67\times10^{-4}\times12\times10^5 = 200.4 Watts$

iii Shaft power $= T\times\omega$

$\omega = 2\pi N = 2\times\pi\times25$

$\simeq 157.08$

$\therefore$ Shaft power $= 12.5\times157.08$

$= 1963.5 Watts$

iv Overall efficiency $= \frac{\text{Fluid power}}{\text{Shaft power}}\times100$

$= \frac{200.4}{1963.5}\times100 = 10.206$

$\simeq 10.21\%$

2 Pump Delivery $= 35dm^3/min$

$= \frac{35\times10^{-3}}{60} = 5.83\times10^{-4}$

$P = 100bar = 100\times10^5 Nm^{-2}$

Overall efficiency $= 87\%$

Fluid Power $= (Q\times\Delta P)$

$= 5.83\times10^{-4}\times100\times10^5$

$= 5830 Watts$

i) Overall efficiency $= \frac{\text{Fluid power}}{\text{Shaft power}}\times100$

$\therefore$ Shaft power $= \frac{\text{Fluid power}}{\text{Overall efficiency}}\times100$

Shaft power $= \frac{5830}{87}\times100$

$= 6701.149 Watts$

3) Nominal displacement $50cm^3/rev = 50\times10^{-5} m^3/rev$

Pressure $= 100bar = 100\times10^5 N/m^2$

Shaft power $= 15kW = 15000 Watts$

Actual flowrate $= 35dm^3/min$

$= \frac{35\times10^{-3} m^3}{60} = 5.83\times10^{-4} m^3$

Speed $= 850 rev/min = \frac{850}{60}$

$= 14.17 rev/sec$

Ideal flowrate $=$ Nominal displacement $\times$ speed

$= 50\times10^{-6} m^3/rev \times 14.7 rev/sec$

$= 7.085\times10^{-4} m^3/sec$

i) Volumetric efficiency $= \frac{\text{Real flowrate}}{\text{Ideal flowrate}}\times100$

$= \frac{5.83\times10^{-4}}{7.083\times10^{-4}}\times100\%$

$= 82.29\%$

Fluid power $= (Q\times\Delta P)$

$= \cancel{5.83\times10^{-4}}\ 5.83\times10^{-4}\times100\times10^5$

$= 5830 Watts$

ii) Overall Efficiency = $\frac{\text{Fluid power}}{\text{Shaft power}} \times 100$

$= \frac{5830}{15000} \times 100 = 38.87\%$

$\simeq 38.9\%$

4 $z = 2400cm = 24m$

Volumetric flowrate; $Q = 13litres/sec$

$= 0.013m^3/sec$

Velocity $= 66m/sec$

$P = \rho g Q\left(\frac{P}{\rho g} + \frac{V^2}{2g} + z\right)$

$P = QP + \frac{\rho Q V^2}{2} + \rho g Q z$

i) Introducing for Jet power

Pressure head $= 0$

$z = 0$

$\therefore P = \frac{\rho Q V^2}{2}$

$Q = 0.013$, $\rho = 1000$, $V = 66m/s$

$\therefore P = \frac{1000 \times 0.013 \times 66^2}{2}$

$P = 28314 Watts$

ii) Power supplied from reservoir at $P = 0$ & $V = 0$

$\therefore P = \rho g Q z$

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

$= 30607.2 Watts$

iii) Power loss in transmission

= Power of reservoir − Power of Jet

$= (30607.2 - 28314)$

$= 2293.2 Watts$

Head loss in pipeline

$= 2293.2 Watts$

iv) $h = \frac{\text{Power loss in transmission}}{\rho g Q}$

$h = \frac{2293.2}{1000 \times 9.81 \times 0.013}$

$h = \frac{2293.2}{127.53} = 17.98m$

v) Efficiency $= \frac{\text{Power of Jet}}{\text{Power of reservoir}} \times 100$

$= \frac{28314}{30607.2} \times 100 = 92.51\%$

5) Specific gravity of oil $= 0.89$

$z = 30,000cm = 300m$

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

$V = 7m/sec$

Introducing, $z = 0$, Pressure $= 0$

i) $P = \frac{\rho Q V^2}{2}$ (Jet power)

$S_g = 0.89$

$S_g = \frac{x}{1000}$

$\therefore x = 0.89 \times 1000 = 890$

$\rho = x = 890$

$P = \frac{890 \times 0.22 \times 7^2}{2}$

$= 4797.1 Watts$

ii) Power supplied from reservoir

$P = \rho g Q z$

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

$P = 576239.4 Watts$

iii. Power loss in transmission

$= \text{Reservoir power} - \text{Jet power}$

$= 576239.4 - 4797.1$

$= 571442.31 \text{ Watts}$

Head used to overcome losses

$= \dfrac{\text{Power loss in transmission}}{\rho g Q}$

$= \dfrac{571442.3}{890 \times 9.81 \times 0.22} = 297.51 m$

iv. $\text{Efficiency} = \dfrac{\text{Jet power}}{\text{Reservoir power}} \times 100$

$\dfrac{4797.1}{576239.4} \times 100$

6 $P = \rho g Q z \quad Q = vA$

$z = 20m = h \quad d = 10cm = 10 \times 10^{-2} m$

$\rho = 1000$

$g = 9.81$

$A = \dfrac{\pi d^2}{4} = \dfrac{\pi \times (10 \times 10^{-2})^2}{4} = 7.85 \times 10^{-3} m^2$

Applying eqn of motion,

Velocity of height of initial velocity

$v = 0$

$v^2 = u^2 - 2gh$

$u = \sqrt{v^2 + 2gh}$

$u = \sqrt{0^2 + 2 \times 9.81 \times 20}$

$u = \sqrt{392.4}$

$u = 19.809 \simeq 19.81 m/s$

$Q = vA$

$= 19.81 \times 7.85 \times 10^{-3}$

$= 0.15558 m^3/sec$

$\simeq 0.156 m^3/sec$

$P = \rho g Q z$

$= 1000 \times 9.81 \times 0.156 \times 20$

$P = 30510.767 \text{ Watts},$

7) $d_1 = 0.3m$

$A_1 = \dfrac{\pi d_1^2}{4} = \dfrac{\pi \times (0.3)^2}{4} = 0.0707 m^2$

$d_2 = 0.2 m$

$A_2 = \dfrac{\pi d_2^2}{4} = \dfrac{\pi \times (0.2)^2}{4} = 0.0314 m^2$

$C_d = 0.96$

Specific weight of gas $= 19.62 N/m^{-2}$

$\gamma = \dfrac{mg}{V} = \rho g$

$= \dfrac{19.62}{9.81} = \dfrac{\rho \times \cancel{9.81}}{\cancel{9.81}}$

$\rho g = 19.62$

$\rho = 2 kg m^2$

$Q_1 = A_1 V_1 \quad ; \quad Q_2 = A_2 V_2$

$V_1 = \dfrac{Q}{A_1} \qquad V_2 = \dfrac{Q}{A_2}$

$V_1 = \dfrac{Q}{0.0707} \qquad V_2 = \dfrac{Q}{0.0314}$

For manometer;

$P_1 + \rho_g g z_1 = P_2 + \rho_g g (z_2 - R_p) + \rho_w g R_p$

$P_1 - P_2 = \rho_g g (z_2 - R_p) + \rho_w g R_p - \rho_g g z_1$

$\therefore P_1 - P_2 = 19.62 (z_2 - z_1) + 587.423$ ①

For venturimeter;

$\dfrac{P_1}{\rho_g g} + \dfrac{V_1^2}{2g} + z_1 = \dfrac{P_2}{\rho_g g} + \dfrac{V_2^2}{2g} + z_2$

$P_1 - P_2 = 19.62 (z_2 - z_1) + 0.803 v_2^2$ ②

$z_2 - z_1 = 0.06 m.$

$0.803V_2^2 = 587.423$

$V_2^2 = \frac{587.423}{0.803}$

$V_2^2 = 731.535$

$V_2 = \sqrt{731.535}$

$V_2 = 27.0469$

$\simeq 27.05 m/s$

~~Ideal flowrate~~ $= Q_{ideal} = A_2 V_2$

$= 27.047 \times 0.0314$

$= 0.85 m^3/s$

$Q_{real} = Cd \times Q_{ideal}$

$= 0.96 \times 0.85$

$= 0.816 m^3/s$

8 Throat diameter $= 0.076 m$ d_2

Initial diameter $= 0.152 m$ d_1

Relative density $= 0.8$

Throat being $= 0.914 m$

$Cd = 0.91$

Bernoulli's eqn

$$\frac{P_1}{\rho g} + \frac{V_1^2}{2g} + z_1 = \frac{P_2}{\rho g} + \frac{V_2^2}{2g} + z_2$$

$Q = V_1 A_1$, $Q = V_2 A_2$

$A_2 = \frac{\pi d^2}{4} = \frac{\pi \times 0.076^2}{4}$

$= 4.64 \times 10^{-3} m^2$

$A_1 = \frac{\pi d^2}{4} = \frac{\pi \times 0.152^2}{4}$

$= 0.0181 m^2$

$V_1 A_1 = V_2 A_2$

$V_1 = \frac{V_2 A_2}{A_1} = \frac{V_2 \times 4.54 \times 10^{-3}}{0.0181}$

$V_1 = 0.251 V_2$

For $P_1 = P_2$, $\rho = 800$

$$\frac{P_1}{\rho g} - \frac{P_2}{\rho g} + \frac{V_1^2}{2g} + z_1 - \frac{V_2^2}{2g} + z_2$$

$z_1 - z_2 + \frac{V_1^2}{2g} = \frac{V_2^2}{2g}$, $z_1 - z_2 = 0.914$

$0.914 + \frac{(0.251V_2)^2}{2 \times 9.81} = \frac{V_2^2}{2 \times 9.81}$

$0.914 = \frac{V_2^2 - 0.251V_2^2}{19.62}$

$V_2^2 - 0.063V_2^2 = 17.93$

$0.937V_2^2 = 17.93$

$V_2^2 = \frac{17.93}{0.937}$

$V_2^2 = 19.136$

$V_2 = \sqrt{19.136}$

$= 4.374$

$Q_{ideal} = A_2 V_2 = 4.37 \times 4.64 \times 10^{-3}$

$= 0.02027$

$Q_{real} = Cd \times Q_{ideal}$

$= 0.96 \times 0.02027$

$= 0.0195 m^3/s$

ii) $P_1 - P_2 = 15170$

$\left(\frac{P_1}{\rho g} + z_1\right) - \left(\frac{P_2}{\rho g} + z_2\right) = \frac{V_1^2}{2g} - \frac{V_2^2}{2g}$

$\frac{P_1 - P_2}{\rho g} + (z_1 - z_2) = \frac{V_2^2}{2g} - \frac{V_1^2}{2g}$

Recall, $z_1 - z_2 = 0.914$

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

Recall; $Q = VA$; $\frac{V}{\cancel{\ }} = \frac{Q}{A}$

$\rho = 800$, $g = 9.81$

$$\frac{15170}{800 \times 9.81} = \left(\frac{Q}{A_2}\right)^2 - \left(\frac{Q}{A_1}\right)^2 - 0.914/2g$$

$$\frac{15170}{7848} = \frac{Q^2\left[\left(\frac{1}{A_2}\right)^2 - \left(\frac{1}{A_1}\right)^2\right]}{2g} - 0.914$$

$$1.932 = Q^2\left(\frac{48516.36 - 3052.41}{2g}\right) - 0.914$$

$$(1.932 + 0.914)2g = Q^2(48516.36 - 3052.41)$$

$$56.3678 = Q^2 \, 45463.95$$

Divide through by 45463.95

$$Q^2 = 1.24 \times 10^{-3}$$

$$Q = \sqrt{1.24 \times 10^{-3}}$$

$$= 0.0352 \, m^3/s$$

9 $d_1 = 300mm = 0.3m$

$d_2 = 150mm = 0.15m$

$\therefore A_1 = 0.07069m^2 = \frac{\pi \times 0.3^2}{4}$

$A_2 = 0.0177m^2 = \frac{\pi \times 0.15^2}{4}$

$Q = 40$ litres/sec $= 0.04 m^3/sec$

$z_1 = 10m$; $Z_2 = 6m$

$P_1 = 400 kN/m^2$, $P_2 = ?$

$$\frac{P_1}{\rho g} + z_1 + \frac{V_1^2}{2g} = \frac{P_2}{\rho g} + z_2 + \frac{V_2^2}{2g}$$

But; $Q = A_1 V_1$

$$V_1 = \frac{Q}{A} = \frac{0.04}{0.07069} = 0.5658 m/s$$

$$\simeq 0.57 m/s$$

$$V_2 = \frac{Q}{A_2} = \frac{0.04}{0.0177} = 2.26 m/s$$

$$\frac{P_1}{\rho g} + (z_1 - z_2) + \left(\frac{V_1^2}{2g} - \frac{V_2^2}{2g}\right) = \frac{P_2}{\rho g}$$

$$\frac{400kN}{9.81kN} + (10-6) + \left(\frac{0.57^2 - 2.26^2}{2 \times 9.81}\right) = \frac{P_2}{9.81kN}$$

$$= 40.77 + 4 + (-0.2438) = \frac{P_2}{9.81kN}$$

$$44.52 \times 9.81 = P_2$$

$$\therefore P_2 = 436.74kN$$

10) Reading of manometer $= 170mm$

$= 0.17m$

S_g of Hg $= 13.6$

S_g of Sea water $= 1.026$

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

$$h = 2.083m$$

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

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

$$= 6.39 m/s$$