18/ENG04/008

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Assignment

No 1

Actual flowrate = $10 dm^3/min$

$= \frac{10 \times 10^{-3}}{60}$

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

Change in pressure, δP = 12 bar

Speed of rotation, N = 1500 rev/min

$= \frac{1500}{60}$

= 25 rev/s

= 25 r.p.s

Normial displacement = $10 cm^3/rev$

$= \frac{10}{10^6} m^3/rev$

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

Torque input, T = 12.5 Nm

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

Actual flowrate = $1.67 \times 10^{-4} m^3/min.$

Ideal flowrate = Speed of rotation × normal disp

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

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

∴ Volumetric Efficiency = $\frac{1.67 \times 10^{-4}}{2.5 \times 10^{-4}} \times 100\%$

$= 0.668 \times 100\%$

$= 66.8\%$

ii. Fluid Power, $P_F = Q \times \delta P$

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

$= 200.4$ Watts.

iii. Shaft Power $= T \cdot \omega$

$T = 12.5$ Nm.

$\omega = 2\pi N$ rad/s

$= 2 \times \frac{22}{7} \times 25$

$= 157.08$ rad/sec

$\therefore$ Shaft Power $= 12.5 \times 157.08$

$= 1963.5$ watts

iv. Overall efficiency.

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

$= \frac{200.4}{1963.5} \times 100$

$= 0.102 \times 100$

$= 10.21\%$

No. 2.

Actual flow rate, $Q = 35 dm^3/min$.

$= \frac{35 \times 10^{-3}}{60}$

$= 5.83 \times 10^{-4} m^3/sec$.

change in pressure, $\delta P = 100$ bar

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

Overall change in efficiency $= 87\%$.

Shaft power = ?

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.

$\therefore$ Shaft power $= \frac{\text{fluid Power}}{\text{Overall efficiency}} \times 100\%$

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

$= 6701.15$ Watts.

NO 3

Normal displacement $= 50 cm^3/rev$

$= \frac{50}{10^6}$

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

change in pressure, $\delta P = 100$ bar

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

Shaft Power = 15 kilowatts

$= 15{,}000$ watts.

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

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

Speed of rotation $= 850$ rev/min.

$= \frac{850}{60}$

$= 14.17$ rev/sec

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

Actual flow rate $= 5.83 \times 10^{-4} m^3/secs.$

~~Ideal flowrate = Normal displacement x change in pressure~~

Ideal flowrate = speed of rotation x Normal disp.

$= 14.17 \times 5 \times 10^{-5}$

$= 7.083 \times 10^{-4} m^3/sec.$

Volumetric Efficiency = $\frac{5.83\times10^{-4}}{7.083\times10^{-4}} \times 100\%$

$= 0.823 \times 100\%$

$= 82.3\%$

ii. Overall Efficiency = $\frac{\text{fluid power}}{\text{shaft power}} \times 100\%$

Fluid power, $P_f = Q \cdot \delta P$

$= 5.83\times10^{-4} \times 100\times10^{5}$

$= 5830$ watts.

Shaft power = 15,000 watts.

∴ Overall Efficiency = $\frac{5830}{15,000} \times 100$

$= 0.389 \times 100\%$

$= 38.9\%$

No. 4.

$z = 24,000 \text{ cm}$

$= \frac{24,000}{100}$

$= 240 \text{ m}.$

Rate of flow, $Q = 13 \text{ litres/sec}$

$= \frac{13}{1000} \text{ m}^3/\text{sec}$

$= 1.3 \times 10^{-2} \text{ m}^3/\text{sec}.$

The velocity of the jet = 66 m/s.

i) Power of jet:

i) At atmospheric pressure, $P = 0$

At datum level, $z = 0$

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

$P = 0 \cdot Q + \frac{\rho Q v^2}{2} + \rho g Q \cdot 0$

$\therefore P = \frac{\rho Q v^2}{2}$ $\quad \rho = 1000 \text{ kg/m}^3)$

$= \frac{1000 \times 1.3 \times 10^{-2} \times 66^2}{2}$

$= \frac{56628}{2} = 28314 \text{ Watts}$

$\therefore P = 28314 \text{ Watts}$

$P = 28.314 \text{ KW}.$

ii) Power supplied from reservoir

At atmospheric pressure, $P = 0$ & $v = 0$.

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

$= 0 \cdot Q + \frac{\rho Q (0)^2}{2} + \rho Q g z.$

$\therefore P = \rho Q g z$

$P = \rho g Q z$

$= 1000 \times 9.81 \times 1.3 \times 10^{-2} \times 240$

$= 30607.2$ watts.

$P = 30.6072$ kW.

iii) Head used to overcome losses

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

Power lost in transmission = Power supplied from reservoir - Power of jet

$= 30607.2 - 28314$

$= 2293.2$ watts

$$\therefore h = \frac{2293.2}{1000 \times 9.81 \times 1.3 \times 10^{-2}}$$

$h = 17.98$ m

iv) Efficiency of the pipeline and nozzle in transmitting operation.

$$\text{Efficiency} = \frac{\text{Power of jet}}{\text{Power supplied from reservoir}} \times 100\%$$

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

$= 0.925 \times 100\%$

$= 92.5\%$

$\therefore$ Efficiency $= 92.5\%$

No.5

S.G of Oil = 0.89.

$z = 30{,}000\,cm$

$= \frac{30000}{100}$

$= 300m.$

Rate of flow, $Q = 220\,litres/sec$

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

$= 0.22\,m^3/sec$

velocity of the jet = 4m/s.

i) Power of jet

At atmospheric pressure P = 0

At datum level, z = 0.

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

$$P = 0.Q + \frac{\rho Q v^2}{2} + \rho g v(0)$$

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

$$P = \frac{0.89 \times 1000 \times 0.22 \times 4^2}{2}$$

$$= \frac{9594.2}{2}$$

$$= 4797.1\ \text{Watts}$$

ii) Power supplied from reservoir

At atmosphere pressure, P = 0 & v = 0.

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

$$P = 0Q + \frac{\rho Q (0)^2}{2} + \rho Q g z$$

$$P = \rho Q g z$$

$P = -Q$ or $P = \rho g Q z$

$P = 0.89 \times 1000 \times 9.81 \times 300 \times 0.22$

$= 576239.4$ Watts

$= 576.6239$ KW.

iii) Head used to overcome losses

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

Power lost in transmission = Power supplied from reservoir − Power of jet.

$= 576239.4 - 4797.1$

$= 571442.3$ watts.

$$\therefore h = \frac{571442.3}{0.89 \times 1000 \times 9.81 \times 0.22}$$

$= 297.5$ m

iv) Efficiency of the pipeline and nozzle in transmitting operation

$$\text{Efficiency} = \frac{\text{Power of jet}}{\text{Power supplied from reservoir}} \times 100\%$$

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

$= 0.00832 \times 100\%$

$= 0.832\%$

No. 6

6 $h = 20m$

$d = 10cm = \frac{10}{100}$

$= 0.1m.$

$\therefore A = \frac{\pi d^2}{4} = 0.00785 m^2$

$=$

$= 7.85 \times 10^{-5} m^2$

$P = \rho g Q h.$

$Q = vA$

The final speed of the water is 0, before &

$\therefore v_f = 0$

$\therefore$ from

$v_f^2 = v_i^2 - 2gh$

$v_i^2 = v_f^2 + 2gh$

$v_i = \sqrt{v_f^2 + 2gh}$

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

$v_i = \sqrt{392.4}$

$\therefore v_i = 19.81 m/s$

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

$= 0.1555 m^3/sec$

$\therefore$ The power required, P

$P = \rho g Q h$

$= 1000 \times 9.81 \times 0.1555 \times 20$

$= 30509.36$ Watts

$= 30.51 KW.$

No. 7.

$d_1 = 0.3m$

$d_2 = 0.2m.$

$$A_1 = \frac{\pi d^2}{4} = \frac{\pi \times (0.5)^2}{4}$$

$$= 0.0707 m^2$$

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

$$= 0.0314 m^2$$

Coefficient of discharge, $C_d = 0.96$

Specific weight of the gas, $\rho_g = 19.62 N/m^2$

$\therefore Q = AV.$

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

$\therefore V_1 = \frac{Q}{0.0707}$

$V_2 = \frac{Q}{0.0314}$

For the manometer.

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

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

For the venturimeter

$$\frac{P_1}{\rho_g g} + \frac{V_1^2}{2g} + z_1 = \frac{P_2}{\rho_g g} + \frac{V^2}{2g} + z_2$$

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

$$\frac{1}{19.62}(P_1 - P_2) = \frac{V_2^2}{2g} - \frac{V_1^2}{2g} + (Z_2 - Z_1)$$

$$\therefore P_1 - P_2 = 19.62(Z_2 - Z_1) + 0.803V_2^2 \quad - (2)$$

Sub

from eqn (i) & eqn (ii)

$$0.803V_2^2 = 587.423$$

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

$$V_2^2 = 720.328$$

$$V_2 = \sqrt{720.328}$$

$$V_2 = 26.84 \text{ m/s.}$$

∴ To get Q

$$Q = A_2 V_2$$

$$V_2 = \frac{Q}{0.0314}$$

Ideal flow rate, $Q = 26.84 \times 0.0314$

$$= 0.843 \text{ m}^3/\text{sec}$$

$$\therefore Q = Cd \times Q_{ideal}$$

$$= 0.96 \times 0.843$$

$$= 0.809 \text{ m}^3/\text{sec}$$

$$= 0.81 \text{ m}^3/\text{sec}$$

No 8.

$d_1 = 0.152m$ $\qquad z_1 = 0.914$

θ = $\qquad z_2 = 0.$

$d_2 = 0.076m.$

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

$$= 0.0181 m^2$$

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

$$= 0.00454 m^2$$

Relative density = 0.8

Coefficient of mete, $C_d = 0.97$

Applying Bernoulli's.

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

a) Pressure guage reads the same

$P_1 = P_2$

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

from Continuity Equation.

$$Q = A_1 v_1 = A_2 v_2.$$

$$A_1 v_1 = A_2 v_2.$$

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

$$v_2 = \frac{0.0181}{0.0045} \times v_1$$

$$v_2 = 4v_1$$

$\therefore$

$$\frac{v_1^2}{2g} + 0.914 = \frac{(4v_1)^2}{2g} + 0$$

$$\frac{V_1^2}{2g} + 0.914 = \frac{16V_1^2}{2g}$$

$$\frac{16V_1^2}{2g} - \frac{V_1^2}{2g} = 0.914$$

$$\frac{15V_1^2}{2g} = 0.914$$

$$15V_1^2 = 0.914 \times 2 \times 9.81$$

$$V_1^2 = \frac{0.914 \times 2 \times 9.81}{15}$$

$$V_1^2 = 1.1955$$

$$V_1 = \sqrt{1.1955}$$

$$V_1 = 1.0934 \, m/s.$$

$\therefore$

~~$Q = C_d A_1 V_1$~~

flow rate $Q_{ideal} = A_1 \cdot V_1$

$$= 0.0181 \times 1.0934$$

$$= 0.01979 \, m^3/sec.$$

$\therefore$ Discharge, $Q = C_d \cdot Q_{ideal}$

$$= 0.96 \times 0.01979$$

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

b.

~~New~~

$P_1 - P_2 = 15170.$

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

$$\frac{15170}{1000 \times 9.81} = \frac{V_2^2 - V_1^2}{2g} - 0.914$$

Recall $V_2 = 4V_1$.

$$1.55 = \frac{16v_1^2 - v_1^2}{2g} - 0.914$$

$$\frac{15v_1^2}{2g} = 2.46$$

$$15v_1^2 = 2.46 \times 2 \times 9.81$$

$$v_1^2 = \frac{48.27}{15}$$

$$v_1^2 = 3.218$$

$$v_1 = \sqrt{3.218}$$

$$v_1 = 1.79 m/s.$$

flow rate, $Q = A_1 v_1$

$= 0.0181 \times 1.79$

$= 0.0324 m^3/s.$

$\therefore$ Discharge, $Q = 0.96 \times 0.0324$

$= 0.031 m^3/secs.$

No. 9

$Q = 40$ litres/sec

$Q = \frac{40}{1000}$

$= 0.04 m^3/sec$

$d_1 = 300mm$

$= \frac{300}{1000}$

$= 0.3m.$

$d_2 = 150mm$

$= \frac{150}{1000}$

$= 0.15m$

$\therefore A_1 = \frac{\pi d_1^2}{4} = \frac{\pi \times (0.3)^2}{4}$

$= 0.0707m^2$

$$A_2 = \frac{\pi d_2^2}{4}$$

$$= \frac{\pi \times (0.15)^2}{4}$$

$$= 0.01767 \ m^2$$

$Z_1 = 10m$ $\quad V_1 = ?$

$Z_2 = 6m$ $\quad V_2 = ?$

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

$P_2 = ?$

$$Q = A_1 V_1 = A_2 V_2.$$

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

$$V_1 = \frac{Q}{A_1} = \frac{0.04}{0.0707}$$

$$= 0.566 \ m/sec$$

$$= 0.566 m/s$$

$$V_2 = \frac{Q}{A_2} = \frac{0.04}{0.01767}$$

$$= 2.264 m/s$$

Applying Bernoulli's Equation

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

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

$$= \frac{400 \times 10^3}{1000 \times 9.81} + \frac{0.566^2}{2 \times 9.81} + 10 - \frac{2.204^2}{2 \times 9.81} - 6$$

$$\frac{P_2}{w} = 44.529$$

$\frac{P_2}{w} = 44.529$

$P_2 = 44529(1000 \times 9.81)$

$P_2 = 436.839.33\ N/m^2$

$P_2 = 436.83\ KN/m^2$

No. 10.

Difference of mercury level = 170mm

$= \frac{170}{100}$

$y = 0.17m$

S.G of mercury = 13.6

S.G of Sea water = 1.026

∴

$h = y\left(\frac{S.G\ of\ Hg}{S.G\ of\ water} - 1\right)$

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

$= y(12.255)$

$= 0.17(12.255)$

$= 2.08m.$

velocity $= \sqrt{2g\Delta h}$

$= \sqrt{2gh}$

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

$V = 6.39m/s$

$V = \frac{6.39 \times 60 \times 60}{1000}$

$= 23km/hr.$