(1) Volumetric flow rate, $Q = 10 dm^3/min = 10 \times \frac{1}{1000 \times 60}$

$= \frac{10}{\cancel{1000 \times 60}} =$ $= 1.67 \times 10^{-4} m^3 s^{-1}$.

Speed $= 1500$ rev/min $= 1500 \times \frac{1}{60} =$

$= 25 rps$

Pressure change; $\Delta P = 12 bar$

$= 12 \times 10^5 Nm^{-2}$.

Nominal displacement $= 10 cm^3/rev$

$= 10/100^3 = 1 \times 10^{-5} m^3 rev^{-1}$.

Ideal flow rate = Nominal displacement $\times$ speed.

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

$= 2.5 \times 10^{-4} m^3 s^{-1}$.

(2) Volumetric efficiency $= \frac{\text{Actual flow rate}}{\text{Ideal flow rate}} \times 100$

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

$= 66.8\%$

(3) Fluid power = Flow rate $\times$ change in pressure

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

$= 200.4 W$.

(4) Shaft power = Torque input $\times$ angular speed

Torque input $= 12.5 Nm$

Angular speed, $\omega = \cancel{25 rps} = \frac{2\pi N}{60}$

$= \frac{2 \times \pi \times 25}{60} = 157.14 rad/s$

Shaft power $= 12.5 \times 157.14 = 1964.25 W$.

Scanned with CamScanner

④ Overall efficiency $= \frac{\text{Fluid power}}{\text{Shaft power}} \times 100$

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

$= 10.2\%$

② Pressure change, $\Delta P = 100 \text{ bar}$

$= 100 \times 10^5 \text{ Nm}^{-2}$

$= 10^7 \text{ Nm}^{-2}$

Actual flow rate, $Q = 35 \text{ dm}^3/\text{min}$

$= 35 \times \frac{1}{1000 \times 60}$

$= 5.83 \times 10^{-4} \text{ m}^3\text{s}^{-1}$

Fluid power $= \Delta P \cdot Q$

$= 10^7 \times 5.83 \times 10^{-4}$

$= 5830 \text{ W}$

Efficiency $= \frac{\text{Fluid power}}{\text{shaft power}} \times 100$

Shaft power $= \frac{\text{Fluid power}}{E} \times 100$

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

$= 6701.15 \text{ W}$

③ Nominal displacement $= 50 \text{ cm}^3\text{rev}^{-1}$

~~$= 50 \times \frac{1}{10^6 \times}$~~ $= 50 \times \frac{1}{10^6} = 5 \times 10^{-5} \text{ m}^3\text{rev}^{-1}$

Actual flow rate; $Q = 35 \text{ dm}^3/\text{min}$

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

Pressure change, $\Delta P = 100 \text{ bar} = 100 \times 10^5$

$= 10^7 \text{ Nm}^{-2}$

Scanned with CamScanner

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

$$= 28.314 \text{ kW}.$$

(ii) For power supplied from a reservoir;

$P = 0$; $V = 0$

$$\text{Power} = PQ + \frac{\rho Q V^2}{2} + \rho g Q z$$

$$P = \rho g Q z$$

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

$$= 30.6072 \text{ kW}.$$

(iii) Power loss = Reservoir power − Jet power

$$= 30.6072 - 28.314$$

$$= 2.293 \text{ kW}.$$

$$\text{Head loss} = \frac{\text{Power loss}}{\rho g Q}$$

$$= \frac{2293.2}{1000 \times 9.81 \times 13 \times 10^{-3}}$$

$$= 17.982 \text{ m}$$

(iv) $$\text{Efficiency} = \frac{\text{Jet power}}{\text{Reservoir power}} \times 100$$

$$= \frac{28.314}{30.6072} \times 100$$

$$= 92.5\%.$$

Scanned with CamScanner

(5) Power $= PQ + \frac{\rho q v^2}{2} + \rho g Q z$

$Z = 30000\,cm = 300\,m$

Specific gravity $= 0.89$

$Q = 220\,litres/sec = 2.2 \times 10^{-1}\,m^3 s^{-1}$

velocity of jet $= 7\,ms^{-1}$

(i) Power of jet $= \frac{\rho q v^2}{2}$

$= \frac{(0.89 \times 1000) \times 0.22 \times 7^2}{2}$

$= 4797.1\,W.$

(ii) Power supplied from reservoir

$= \rho g Q z$

$= (0.89 \times 1000) \times 9.81 \times 0.22 \times 300$

$= 576239\,W$

(iii) Power loss in transmission $= 576239 - 4797.1$

$= 571441.9\,W$

Head loss $= \frac{\text{Power loss}}{\rho g Q} = \frac{571441.9}{(0.89 \times 1000) \times 9.81 \times 0.22}$

$= 297.5\,m$

(iv) Efficiency $= \frac{4797.1}{578239} \times 100 = 0.83\%$

(6) $h = 20\,m$

$d = 10\,cm = \cancel{0.01}\ 0.1\,m$

$g = 9.81\,ms^{-2}$

According to law of conservation of energy

$\frac{1}{2}mv^2 = mgh$

$\frac{v^2}{2} = gh \quad , \quad v^2 = 2gh$

$$v = \sqrt{2(9.8)(20)}$$
$$= 19.8 ms^{-1}$$

This is the velocity of the stream at its base.

$$\text{Flow rate} = A \cdot V$$
$$= \frac{\pi d^2}{4} \cdot v$$
$$= \frac{\pi (0.1)^2}{4} \times 19.8$$
$$= 0.156 m^3 s^{-1}$$

$$\text{mass flow rate} = \rho \cdot Q$$
$$= 1000 \times 0.156$$
$$= 156 kgs^{-1}$$

$$\text{Power} = \frac{\text{Work done}}{\text{time}} = \frac{mgh}{t}$$
$$= m/t \cdot g \cdot h$$
$$= 156 \times 9.81 \times 20$$
$$= 30607.2 W$$
$$= 30.6 kW.$$

7.

$d_1 = 0.3m$

$d_2 = 0.2m$

$C_d = 0.96$

$\rho g = 19.62 Nm^{-3}$

$$A_1 = \frac{\pi d_1^2}{4} = 0.0707 m^2$$

$$A_2 = \frac{\pi d_2^2}{4} = 0.0314 m^2$$

$$Q = A \cdot V$$
$$V_1 = Q/A_1 = Q/0.707$$

$V_2 = Q/A_2 = Q/0.0314$

For the manometer,

~~$P_1 + \rho g z = P_2 + \rho g(R$~~

$$P_1 + \rho g z = P_2 + \rho g(z_2 - R) + \rho_w g R$$

$$P_1 - P_2 = 19.62(z_2 - z_1) + 587.423 \quad \ldots (i)$$

For the venturimeter

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

$$P_1 - P_2 = 19.62(z_2 - z_1) + 0.803V_2^2 \quad \ldots (2)$$

Combining (i) and (ii)

$$0.803V_2^2 = 587.423$$

$$V_{2\,ideal} = 24.047\,ms^{-1}$$

$$Q_{ideal} = A_2 \cdot V_2 = 0.0314 \times 24.047$$
$$= 0.85\,m^3s^{-1}$$

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

(9) $D_1 = 300mm = 0.3m$

$$A_1 = \frac{\pi d^2}{4} = \frac{\pi(0.3)^2}{4} = 0.07707\,m^2$$

$P_1 = 400kNm^{-2}$

$z_1 = 10m$

$D_2 = 150mm = 0.15m$

$$A_2 = \frac{\pi d^2}{4} = \frac{\pi(0.15)^2}{4} = 0.01767\,m^2$$

$z_2 = 6m$

$Q = 40 \text{ litres/sec} = \frac{40 \times 1}{10^3} = 0.04 m^3 s^{-1}$

$Q = A_1 V_1 = A_2 V_2$

$V_1 = Q/A_1 = \frac{0.04}{0.0707} = 0.566 ms^{-1}$

$V_2 = Q/A_2 = \frac{0.04}{0.01767} = 2.264 ms^{-1}$

Applying Bernoulli's equation, you get,

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

$$P_2/w = P_1/w + \left[\frac{V_1^2 - V_2^2}{2g}\right] + \left[Z_1 - Z_2\right]$$

$$= \frac{400}{9.81} + \left[\frac{0.566^2 - 2.264^2}{2(9.81)}\right] + \left[10 - 6\right]$$

$$= 44.525 m$$

$$P_2 = w \times 44.525$$

$$= 9.81 \times 44.525$$

$$= 436.8 kNm^{-2}$$

(10) Manometer reading, y = 200mm = 0.2m Hg.
Specific gravity of mercury, S_{Hg} = 13.6
Specific gravity of sea water, S_l = 1.025

$$h = y\left[\frac{S_{Hg}}{S_l} - 1\right]$$

$$h = 0.2\left[\frac{13.6}{1.025} - 1\right]$$

$$= 2.45$$

$$V = \sqrt{2gh} = \sqrt{2(9.81)(2.45)}$$

$$= 6.93 ms^{-1}$$