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1. i. $Q = 10 dm^3/min$

$Q_t = 1500 rev/min \times 0.01 dm^3/rev$

$= 15 dm^3/min$

$\eta_v = \frac{Q}{Q_t} \times 100 = \frac{10}{15} \times 100 = 66.667\%$ ans

ii. Fluid power $= \Delta P Q$ $\Delta P = 12 bar = 12 \times 10^5 Pa$

$Q = \frac{10 dm^3}{min} = \frac{0.01}{60} m^3/s$

Fluid power $= 12 \times 10^5 \times \frac{0.01}{60} = 200 W$ ans

iii. Shaft power $= \tau \omega$ $\tau = 12.5 Nm$ $\omega = 1500 rev/min$

$= \frac{1500 \times 2\pi}{60} = 50\pi / s$

Shaft power $= 12.5 Nm \times 50\pi / s$

$= 625\pi W = 1963.495 W$ ans

iv. Overall Efficiency $= \frac{\text{Fluid power}}{\text{Shaft power}} \times 100$

$= \frac{200}{1963.495} \times 100 = 10.186\%$ ans

2. Fluid power $= \Delta P \times Q$

$= 100 \times 10^5 \times \frac{0.035}{60}$

$= 5833.333 W$

$Q = 35 dm^3/min = \frac{0.035}{60} m^3/s$

$\Delta P = 100 bar = 100 \times 10^5 Pa$

Shaft power $= \frac{5833.333}{0.87} = 6704.981 W$ ans

3. Nominal flow rate (Q_n) = $50 cm^3/rev \times 850 rev/min$

$= 42500 cm^3/min = \underline{42.5}\ dm^3/min$

Fluid power $= \Delta P \times Q$ $\quad \Delta P = 100 \times 10^5 Pa$

$Q = 35 dm^3/min = \frac{0.035}{60} m^3/s$

$= 100 \times 10^5 \times \frac{0.035}{60}$

$= 5833.333 W$

i. Overall Efficiency $= \frac{5833.333 W}{15000 W} \times 100 = 38.887\%$ ans

ii. Volumetric Efficiency $= \frac{35}{42.5} \times 100 = 82.353\%$ ans

4. $z = 240m$, $Q = 13 dm^3/s = 0.013 m^3/s$ $\quad v = 66 m/s$

at the jet, $\Delta P = 0$, $z = 0$, $v = 66 m/s$

i. $P = \rho \times g \times Q \times \left(\frac{\Delta P}{\rho g} + z + \frac{v^2}{2g}\right)$

$= 1000 kg/m^3 \times 9.81 m/s^2 \times 0.013 m^3/s \times \left(0 + 0 + \frac{66^2}{2g}\right) m$

$= 9810 \times 0.013 \left(4356/2(9.81)\right)$

$= 28314$ W ans

ii. in the reservoir, $z = 240m$, $P = 0 Pa$, $v = 0 m$

$P = \rho g Q (0 + 0 + z)$

$= \rho g Q z$

$= 1000 \times 9.81 \times 0.013 \times 240m = 30607.2 W$ ans

iii. Head lost $= \frac{(30607.2 - 28314) W}{1000 \times 9.81 \times 0.013} = \frac{2293.200}{9810 \times 0.013} = 17.982 m$ ans

iv. $\eta = \frac{28314}{30607.2} \times 100 = 92.508\%$ ans

5. P in the jet... $\Delta P = 0$, $z = 0$, $v = 7 m/s$, $Q = 220 dm^3/s = 0.22 m^3/s$

i. $P = \frac{\rho g Q v^2}{2g} = \frac{\rho Q v^2}{2} \times 1000$

$= \frac{0.89 \times 0.22 \times 7^2}{2} \times 1000 = 4.7971 W \times 1000$

$= 4797.1 W$ ans

ii. in the reservoir, $\Delta P = 0$, $z = 30000 cm = 300 m$, $v = 0$

$\therefore P = \rho g Q z$

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

$= 576239.4 W$ ans

iii. Head lost $= \frac{576239.4 - 4797.1}{0.89 \times 1000 \times 9.81} = \frac{642.07}{9.81} = 65.451 m$ ans

iv. $\eta = \frac{65.451 m}{571}$ $\frac{576239.4}{}$ $\frac{4797.1}{576239.4} \times 100 = 0.83\%$

6. $\frac{v^2}{2g} = 20m$

$v^2 = 20 \times 2 \times 9.81 = 392.4$

$v = \sqrt{392.4} = 19.809 ms^{-1}$

$A = \frac{\pi d^2}{4} = \frac{\pi (3.14 \times 10 \times 10^{-2})}{4} = \frac{0.1^2 \pi}{4} = 0.0785 m^2$ $0.00785 m^2$ ans

$Q = Av = 0.00785 m^2 \times 19.809 ms^{-1} = 0.156 m^3/s$

$P = \frac{\rho g Q v^2}{2} = \frac{1000 \times 9.81 \times 0.156 \times 392.4}{2} = 300256.632 = 300.257 kW$ ans

$P = \rho g Q_2$

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

$= 30607.2\,W = 30.607\,kW$

7. $Q = C_d \times \frac{A_1 A_2}{\sqrt{A_1^2 - A_2^2}} \times \sqrt{2gh}$

$C_d = 0.96$

$A_1 = 0.3\,m$

$A_2 = 0.2\,m$

~~$h = 0.06\,m$~~

$Q = 0.96 \times \frac{0.3 \times 0.2}{\sqrt{0.3^2 - 0.2^2}} \times \sqrt{2 \times 9.81 \times 0.06}$

$Q = 0.279\,m^3/s$

$h = \frac{\Delta P}{\omega} = \frac{1000 \times 9.81 \times 0.06}{19.62} = 30\,m$

$Q = 0.96 \times \frac{0.3 \times 0.2}{\sqrt{0.3^2 - 0.2^2}} \times \sqrt{2 \times 9.81 \times 30}$

$= 6.2495\,m^3/s$ ans

8. $A_1 = \pi(0.152)^2/4 = 0.0181\,m^2$

$A_2 = \pi(0.076)^2/4 = 0.00454\,m^2$

$C_d = 0.97$

$\rho = 0.8 \times 1000 = 800\,kg/m^3$

$\Delta z = 0.914\,m$

$\omega = 800 \times 9.81 = 7848\,N/m^3$

a. $\frac{\Delta P}{\omega} = 0$

$\therefore h = 0 + 0.914\,m = 0.914\,m$

$Q = C_d \times \frac{A_1 A_2}{\sqrt{A_1^2 - A_2^2}} \times \sqrt{2gh} = 0.97 \times \frac{0.0181 \times 0.00454}{\sqrt{0.0181^2 - 0.00454^2}} \times \sqrt{2 \times 9.81 \times 0.914}$

$Q = 0.01926\ m^3/s$ ans

b. $h = \frac{\Delta P}{\omega} + 0.914 = \frac{15170}{7848} + 0.914 = 2.847\ m$

$Q = Cd \times \frac{A_1 A_2}{\sqrt{A_1^2 - A_2^2}} \times \sqrt{2gh}$

$= 0.97 \times \frac{0.0181 \times 0.00454}{\sqrt{0.0181^2 - 0.00454^2}} \times \sqrt{2 \times 9.81 \times 2.847} = 0.034\ m^3/s$ ans

3. $d_1 = 300mm = 0.3m$ $d_2 = 150mm = 0.15m$ $\Delta z = z_1 - z_2 = 10 - 6 = 4m$

$A_1 = \pi(0.3)^2/4 = 0.07069\ m^2$ $P_1 = 400 \times 10^3\ N/m^2$

$A_2 = \pi(0.15)^2/4 = 0.01767\ m^2$

$Q = 40 l/s = 0.04\ m^3/s$

$Q = A_1 v_1 = A_2 v_2$

$v_1 = \frac{Q}{A_1}$; $v_2 = \frac{Q}{A_2}$

$v_1 = \frac{0.04}{0.07069}$ $v_2 = \frac{0.04}{0.01767}$

$= 0.5659\ m/s$ $= 2.2634\ m/s$

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

$0 = P_1 - P_2 + \rho g(4) + \frac{\rho(0.5659^2 - 2.2634^2)}{2}$

$P_2 - P_1 = 1000 \times 9.81 \times 4 + \frac{1000(-4.8027)}{2}$

$P_2 - 400000 = 36838.65$

$P_2 = 436838.65\ N/m^2$ ans

0.914

10. $y = 0.17\,m$

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

$$= 0.17\left(\frac{13.6}{1.026} - 1\right) = 2.0834\,m$$

$$v = \sqrt{2gh} = \sqrt{2 \times 9.81 \times 2.0834}$$

$$= 6.3935\,ms^{-1}$$ ans