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Number 1

$Q = 100 dm^3/min = 1.67 \times 10^{-4} m^3/sec$

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

Speed of rotation = 1500 rev/min = 25 rev/sec

Nominal disp = $10 cm^3/rev = 10^{-5} m^3/rev$

Torque input = 12.5 Nm

Ideal flowrate = $10^{-5} \times 25 = 2.5 \times 10^{-4} m^3/s$

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

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

$= 66.8\%$

b Fluid power = $Q \times \Delta P$

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

$= 200.4 Nm/sec$

c shaft power P = Torque × 2π × Speed

$= 12.5 \times 2 \times \frac{22}{7} \times 25$

$= 1964.29$ watts

d overall Efficiency = $\frac{\text{Fluid Power}}{\text{Shaft Power}} \times 100$

$= \frac{200.4}{1964.29} \times 100$

$= 10.2\%$

Number 2

$Q = 350 dm^3/min = 5.83 \times 10^{-4} m^3/sec$,

$\Delta P = 10 bar = 10^{4} N/m^2$, overall eff = 87%

$\frac{87}{100} = \frac{\text{Fluid power}}{\text{shaft power}}$

But fluid power = $Q \times \Delta P$

$\frac{87}{100} = \frac{5.83 \times 10^{-4} \times 10^{7}}{\text{shaft power}}$

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

Shaft power = 6701.15 watts

Number 3

Nominal disp = $5 \times 10^{-5} m^3/sec$

$\Delta P = 10^7 N/m^2$, ~~shaft power~~

shaft power = $15 \times 10^3 W$

Actual flow rate = 5.83×10^{-4}

speed of rotation = 14.17 rev/sec

Ideal flowrate = Nominal Disp × speed

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

$= 7.08 \times 10^{-8} m^3/sec$

Volumetric eff = $\frac{5.83 \times 10^{-4}}{7.08 \times 10^{-8}} \times 100$

$= 82.34\%$

Overall eff = $\frac{5.83 \times 10^{-4} \times 10^{-7}}{15 \times 10^3}$

$= 38.87\%$

Number 4

$Z = 240m$, $Q = 13 \times 10^{-3} m/sec$, $V = 66m/sec$

$\rho = 1000 kgm^{-3}$

a) Power of jett, $P = \frac{\rho \times Q \times V^2}{2}$

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

$= 28314$ watts (28.3KW)

b) Power supplied from reservior $= \rho \times Q \times g \times Z$

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

$= 30607.2$ watts $= 30.6$ KW

c) Power lost = Power of reservior − Power of jett

$= 30607.2 - 28314$

$= 2293.2$ Watts

Head used to overcome losses $= \frac{\text{Power lost}}{\rho \times g \times Q}$

$= \frac{2293.2}{1000 \times 9.8 \times 13 \times 10^{-3}}$

$= 17.98m$

Efficiency $= \frac{\text{Power of jett}}{\text{Power of reservior}} \times 100$

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

$= 92.5\%$

Number 5

$S.g = 0.89$, $\rho = 890 kg/m^3$, $Z = 300m$

$Q = 0.22 m^3/sec$, $V = 7 m/s$

a) Power of jett $P = \frac{\rho \times Q \times V^2}{2}$

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

$= 4797.1$ Watts

$= 4.8$ KW

b) Power of reservior $P = \rho \times Q \times g \times Z$

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

$= 576239.4$ watts

$= 576.2$ KW

c) Power lost $= 576239.4 - 4797.1$

$= 571442.3$ Watts

d) Head loss $= \frac{\text{Power lost}}{\rho \times g \times Q}$

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

$= 297.50m$

d) Efficiency $= \frac{\text{Power of jett}}{\text{Power of reservior}} \times 100\%$

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

$= 0.83\%$

Number 6

$Z = 20m$, $\delta = 0.1m$, $A = 7.85 \times 10^{-3} m^2$

$\rho = 1000 kg/m^3$

Applying equation of motion

$V = 0 m/s$, $h = 20m$, $g = 9.81 m/s^2$

$u = ?$

$V^2 = u^2 - 2gh$

$0^2 = u^2 - 2 \times 9.81 \times 20$

$392.4 = u^2$

$u = \sqrt{392.4}$

$u = 19.8 m/s$

The velocity at the height (Z)

$= 19.8 m/s$

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Number 7

$C_d = 0.96$, $h = 0.06\,mHg$, $d = 0.3m$

$d_2 = 0.2m$, $A_1 = 0.070\,m^2$, $A_2 = 0.031\,m^2$

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

~~$= 0.96 \times 0.070 \times 0.031$~~

$$= \frac{0.96 \times 0.070 \times 0.031 \times \sqrt{2 \times 9.81 \times 0.06}}{\sqrt{0.070^2 - 0.031^2}}$$

$$= \frac{2.08 \times 10^{-3} \times 1.08}{0.063}$$

$Q = 0.036\,m^3/sec$

But $Q = A_1 V_1$

$$\frac{0.036}{0.070} = V_1$$

$V_1 = 0.5\,m^3/s$

Number 8

$A_2 = 4.54 \times 10^{-3}\,m^2$, $A_1 = 0.018\,m^2$

$z_1 - z_2 = 0.914$ $C_d = 0.97$

a) When $P_1 = P_2$

Applying Bernoulli's equation

$$\frac{P_1}{\rho g} + \frac{V^2}{2g} + z = \frac{P_2}{\rho g} + \frac{V_2^2}{2g} + z_2$$

But $Q = A_1 V_1 = A_2 V_2$

$$V_1 = \frac{4.54 \times 10^{-3} \times V_2}{0.018}$$

$V_1 = 0.025\,V_2$

$$\therefore \frac{P_1}{\rho g} - \frac{P_2}{\rho g} + \frac{(0.025 V_2)^2}{2 \times 9.81} = \frac{V_2^2}{2 \times 9.81} + z_1 - z_2$$

$$\frac{(0.025 V_2)^2}{19.62} - \frac{V_2^2}{19.62} = -0.914$$

$6.25 \times 10^{-4} V_2^2 = 17.93$

$V_2^2 - 6.25 \times 10^{-4} V_2^2 = 17.93$

$0.99 V_2^2 = 17.93$

$V_2^2 = 17.94$

$V_2 = 4.23\,m/s$

$\therefore Q = A_2 V_2$

$Q = 4.54 \times 10^{-3} \times 4.23$

$Q = 0.019\,m/sec$

When $P_1 - P_2 = 15170\,N/m^2$

$$h = \left[\frac{P_1 - P_2}{W}\right] + (z_1 - z_2)$$

$$= \left[\frac{15170}{860 \times 9.81}\right] - 0.914$$

$= 1.93 - 0.914$

$h = 1.02m$

$$Q = \frac{C_d \times A_1 \times A_2 \times \sqrt{2gh}}{\sqrt{A_1^2 - A_0^2}}$$

$$= \frac{0.97 \times 0.018 \times 4.54 \times 10^{-3} \sqrt{2 \times 9.81 \times 1}}{\sqrt{0.018 - (4.54 \times 10^{-3})^2}}$$

$$= \frac{7.93 \times 10^{-5} \times 4.47}{0.017}$$

$= 0.021\,m^3/sec$

Number 9

$A_1 = 0.070m^2$ $A_2 = 0.177m^2$, $Q = 0.04m^3/s$

$Z_1 = 20m$, $Z_2 = 6m$, $P_1 = 400 \times 10^3 N/m^2$

$P_2 = ?$

$Q = AV$

$V_1 = \frac{0.04}{0.070}$

$V_1 = 0.57 m/s$

$Q = A_2 V_2$

$V = \frac{0.04}{0.177}$

$V_2 = 0.226 m/s$

Applying Bernoulli's Equation

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

$20 + \frac{0.57^2}{2 \times 9.81} + \frac{400 \times 10^3}{1000 \times 9.81} = 6 + \frac{0.226}{2 \times 9.81} \times \frac{P_2}{9810}$

$50.79 = 6.002 + \frac{P_2}{9810}$

$P_2 = 44.788 \times 9810$

$P_2 = 439370.28 N/m$

$P_2 = 439.37 KN/m$

Number 10

$y = 170mm = 0.17m$ Hg

$S.g = 13.6$, S.g of oil = 1.026

$\Delta h = y\left(\frac{Sg\ Hg}{Sg\ oil} - 1\right)$

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

$= 0.17 (12.26)$

$= 2.08 m$

But $V = \sqrt{2g \cdot \Delta h}$

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

$V = 6.388 m/s$