(b) when $P_1 - P_2 = 15170$,

$w = \rho g$

$= 800 \times 9.81 = 7848\ kN/m^3$

$h = \frac{15170}{7.848}$

$h = 1.933m + 0.914m$

$\therefore h = 2.847m$

$\therefore$ Discharge (Q)

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

$Q = \frac{0.97 \times 0.0781 \times 4.54 \times 10^{-3}}{\sqrt{0.078^2 - (4.54 \times 10^{-3})^2}} \times \sqrt{2 \times 9.81 \times 2.847}$

$Q = 0.034 m^3/sec.$

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

$P = 400 kN/m^2$

$z = 10m$, $A_1 = \frac{\pi d^2}{4} = 0.0707 m^2$

$D_2 = 150mm = 0.15m$

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

$= A_2$

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

$Q = A_1 V_1 = A_2 V_2$

$\therefore V_1 = \frac{Q}{A_1} = \frac{0.04}{0.0707} = 0.566 m/s$

$V_2 = \frac{Q}{A_2} = \frac{0.04}{0.01767} = 2.264 m/s.$

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

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

~~$(400/9.81) + 1/2 \times 9.81$~~

$= (400/9.81) + \frac{1}{(2 \times 9.81)}(0.566^2 - 2.264^2) + (10 - 5)$

$= 40.77 - 0.24584$

$\frac{P_2}{w} = 44.525\ m$

$P_2 = 44.525 \times 9.81$

$= 436.8\ kN/m^2$

(10) Specific gravity of mercury

$= 13.6$

S.G of water $= 1.026$

$h = y\left[\frac{\text{S.G of mercury}}{\text{S.G of water}} - 1\right]$

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

$= 2.083$

$V = \sqrt{2gh}$

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

$= 6.393 m/s.$

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ASSIGNMENT.

1) Actual flow rate = 10 dm³/min

$= 0.01 m^3/min$

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

Speed, N = 1500 rev/min

$= \frac{1500}{60}$

= 25 rev/sec.

Pressure change, ∂P = 12 bar

$\partial P = 12 \times 10^5 N/m^2$

Nominal disp. = 10 cm³/rev

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

(i) Volumetric Efficiency

$\frac{\text{Actual flow rate}}{\text{Ideal flow rate}} \times \frac{100}{1}$

~~Not~~ Ideal flow rate = Nominal × speed disp.

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

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

$V.E = \frac{1.67 \times 10^{-4}}{2.5 \times 10^{-4}} \times \frac{100}{1}$

= 66.8%.

(ii) Fluid Power

$P_F = Q \cdot \partial P$

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

= 200.4 Watts.

(iii) Shaft Power.

$= T \cdot \omega$

$\omega = 2\pi N$

$= 2 \times \frac{22}{7} \times 25 = 157.14$ rad/s

Shaft power = 12.5 × 157.14

= 1964.25 watts.

(2) Actual flow rate = 35 dm³/min.

$= 0.035 m^3/min$

$= 5.833 \times 10^{-4} m^3/sec$.

∂P = 100 bar

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

Overall Efficiency = 87%

Fluid power = Q · ∂P

$= 5.833 \times 10^{-4} \times 100 \times 10^5$

= 5,833 watts.

$87 = \frac{5,833}{\text{Shaft power}} \times \frac{100}{1}$

Shaft power = 6,701.2 watts

(3) Nominal disp. = 50 cm³/rev

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

Pressure Change = 100 bar

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

Shaft Power = 15 kW

Actual flow rate = 35 dm³/min

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

Speed of rotation = 850 rpm.

Ideal Flow rate

$= ~~5 \times 10^{-5}~~ \; 5 \times 10^{-5} \times 14.167$

$= 7.0835 \times 10^{-4} m^3/sec$.

Overall Efficiency

$= \frac{\text{Actual flow rate}}{\text{Ideal flow rate}} \times \frac{100}{1}$

$= \frac{5.83 \times 10^{4}}{7.0835 \times 10^{4}} \times \frac{100}{1}$

$= 82.4\%$.

(4) $Z = 24000cm = 240m$ [water level]

Volumetric flow rate,

$Q = 13 litre/sec = 13 \times 10^{-3} m^3/sec$

velocity of the jet

$= 66 m/sec$

(i) Power of jet.

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

At $p = 0$, $z = 0$

$P = \frac{\rho Q \cdot v^2}{2} = \frac{1000 \times 13 \times 10^{-3} \times 66^2}{2}$

$P = 28314$ KW.

(ii) Power supplied from reservoir

At $p = 0, v = 0$

$P = \rho g Q z$

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

$P = 30607.2$ KW.

(iii) Head used to overcome losses.

Power loss in transmission

: Power of reservoir − Power of jet

$= 30607.2 - 28314$

$= 2,293.2$ Watts.

Head loss in pipeline

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

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

$h = 17.982m$

(iv) Efficiency

$= \frac{\text{Power of jet}}{\text{power of reservoir}} \times \frac{100}{1}$

$= \frac{28.314}{30607.2} \times \frac{100}{1}$

(5) $z = 300m$

$Q = 220 litres/sec$

$= 220 \times 10^{-3} m^3/sec$

velocity of jet = $7m/sec$

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

At $p = 0$, $z = 0$

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

$= \frac{0.89 \times 10^3 \times 220 \times 10^{-3} \times 7^2}{2}$

$= 4.7971 kW$

(ii) Power supplied from the reservoir

$P = \rho g Q z$

$= 0.89 \times 10^3 \times 981 \times 220 \times 10^3 \times 30$

$= 576239.4$ kw

(iii) Head used to overcome losses

$h = \dfrac{\text{power lost in transmission}}{\rho g Q}$

$= \dfrac{576239.4 - 4797.1}{0.89 \times 10^3 \times 9.81 \times 220 \times 10^{-3}}$

$h = 297.5$ m.

(iv) Efficiency

$= \dfrac{4797.1}{576239.4} \times \dfrac{100}{1}$

$= 0.836$

(6) Power = pressure × flow rate.

pressure of water $= \rho g h$

$= 1000 \times 9.81 \times 20$

$= 196200\ Nm^{-2}$

Area $= \pi \times (0.05)^2$

$= 7.854 \times 10^{-3} m^2$

Volume $= 7.854 \times 10^{-3} \times 20$

$= 0.1571 m^3$

Q = flow rate

$= \dfrac{0.1571}{60} = 2.62 m^3/s$

Power $= 196200 \times 2.62$

$= 514.044$ kw.

(7) Entrance d. = 0.3m

Throat d = 0.2m

Cd = 0.94

$S_w = 19.62\ N/m^3$

$v = ?$

h = pressure difference = 0.06m

$h = y\left[\dfrac{S_m}{S_p} - 1\right]$

$Q = A_1 V_1$

$Q = \dfrac{Cd.\ A_1 A_2 . \sqrt{2gh}}{\sqrt{A_1^2 - A_2^2}}$

$Q = \dfrac{0.94 \times 0.07 \times 0.03 \sqrt{2 \times 9.81 \times 0.06}}{\sqrt{0.07^2 - 0.03^2}}$

$= 0.035 m^3/s$

$Q = A_1 V_1$

$\therefore 0.035 = 0.07 V_1$

$V = \dfrac{0.035}{0.07}$

$= 0.49 m^3$

(8) Throat diameter (d) = 0.076m

Throat area $= 4.54 \times 10^{-3} m^2$

(a) when $P_1 = P_2$

$\therefore h = 0$

Discharge (Q) = ~~Cd~~ ×

$Cd \times \dfrac{A_1 A_2}{\sqrt{A_1^2 - A_2^2}} \times \sqrt{2gh}$

Since h = 0

$\therefore Q = 0$

(b)