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1) Actual flow rate = 10 dm^3/min = $1.667 \times 10^{-4} m^3/s$
Normal displacement = 10 cm^3/rev = $1 \times 10^{-5} m^3/rev$
speed rotation = 1500 rev/min = 25.05 rev/sec
Ideal flow rate = Normal displacement x speed rotation
= $1 \times 10^{-5} \times 25.05$
= $2.505 \times 10^{-4} m^3/s$

1) V.E = $\frac{\text{Actual flowrate}}{\text{Ideal flowrate}} \times 100$
= $\frac{1.667 \times 10^{-4}}{25.05 \times 10^{-4}}$ = 0.066546 91 ≈ 0.0665
= 0.0665 x 100 = 66.5%

2) Fluid power = Actual flow rate x pressure change
Pressure change = 12 bar = 12×10^5 KN/m^2
∴ $1.667 \times 10^{-4} \times 12 \times 10^5$
= 200.04 Nm/sec

3) Shaft power = Torque input x Angular speed
T.I = 12.5 Nm
Angular speed = 2 x π x speed of rotation
= 2 x π x 25.05
= 157.39 rev/sec
Shaft power = 12.5 x 157.39
= 1967.42 Nm/sec

4) Overall efficiency = $\frac{\text{fluid power}}{\text{Shaft power}} \times 100$
= $\frac{200.04}{1967.42} \times 100$ = 10.16 = 10%

$35 \times 1.667 \times 10^{-3}$

2) flow rate = 35 dm^3/min = 5.8345×10^{-4} m^3/sec
pressure change = 100 bar = 100×10^3 KN/m^2
fluid power = Actual flowrate × pressure change
$35 \times 1.667 \times 10^{-3} \times 100 \times 10^5$
= 5834.5 W
Overall efficiency = $\frac{\text{fluid power}}{\text{shaft power}} \times 100$

O.E = 87%
shaft power = x
$87 = \frac{5834.5}{x} \times 100$
$87x = 5834.5 \times 100$
$x = \frac{583450}{87}$
$x = 6706.32$ W

3) Actual flowrate = 35 dm^3/min = 5.8345×10^{-4} m^3/sec
Normal displacement = 50 m^3/rev = 5×10^{-5} m^3/rev
speed of rotation = 850 rpm = 14.155 rev/sec
fluid power = A.f × P.C
∴ P.C = 100 bar = 100×10^{-5} N/m^2
F.P = $5.8345 \times 10^{-4} \times 100 \times 10^{-5}$
= 5834.5 W
shaft power = 15 KN = 15000 N
i) overall efficiency = $\frac{5834.5 \times 100}{1500}$
$\frac{\text{fluid power} \times 100}{\text{shaft power}}$ = 38.89 ≈ 38.9%
ii) volumetric efficiency = $\frac{\text{Actual flowrate}}{\text{ideal flowrate}} \times 100$
= $\frac{5.8345 \times 10^{-4}}{7.0875 \times 10^{-4}} \times 100$
= 82.2%

NB: Ideal flowrate = Normal dis × speed of rotation
= $5 \times 10^{-5} \times 14.155$ = 7.0875×10^{-4} //

3) Water level (Z) = 24,000cm = 240m
Volumetric flowrate (Q) = 13×10^{-3} m³/sec
Velocity of jet = 66m/sec
P = 0, x = 0
Density for water = 1000kg/m³

i) Power of jet

$P = pQ + \frac{\rho \cdot Q V^2}{2} + \rho g Q_x$

recall p = 0, x = 0

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

$P = \frac{\rho Q V^2}{2} = 1000 \times 13 \times 10^{-3} \times 66^2$
$= 28314N$

P = 28.314 KN

ii) Power supplied from reservoir

p = 0, v = 0

$P = pQ = \frac{\rho Q V^2}{2} + \rho g Q_z$

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

$P = \rho g Q_z = 1000 \times 9.81 \times 13 \times 10^{-3} \times 240$
P = 30.6072 KN
= 30607.2N

Head used to overcome losses

Head loss = $\frac{\text{Power lost in transmission}}{\rho g Q_z}$

Power lost in transmission = power of reservoir − power of jet
= 30.6072 − 28314
= 2293.2 N

5. Head loss = $\frac{2293.2}{1000 \times 9.81 \times 13 \times 10^{-3}}$ = 17.98m

iv) Efficiency of the nozzle & pipeline

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

$$= \frac{28314}{30607.2} \times 100 = 92.5\%$$

Q) $Z = 80 \; 000 \times 10 = 800m$

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

$v = 7m/sec$

$Sg = 0.89 \quad \rho = 0.89 \times 1000 = 890 kg/m^3$

i) power of jet

$P = pQ + \frac{\rho Q v^2}{2} + \rho g Q z$ when $p = 0$, $z = 0$

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

$= \frac{890 \times 220 \times 10^{-3} \times (7)^2}{2} = 4797N$ ~~✓~~ $4.797KN$

ii) power supplied from reservoir

$p = 0, \; v = 0$

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

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

$= 890 \times 9.81 \times 220 \times 10^{-3} \times 800$

$= 576.24 \, kN$

Head used to overcome losses

$$\text{Head loss} = \frac{\text{power lost to transmission}}{\rho g Q}$$

Power lost to transmission =

power of reservoir − power of jet

$= 571442.3$

$$H_L = \frac{571442.3}{890 \times 9.81 \times 220 \times 10^{-3}} = 297.50m$$

iv) Efficiency of pipeline and nozzle

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

$\frac{4797.1}{577342} \; \frac{4797.1}{576234.4} \times 100$

$= 8.23 \times 10^{-3} \times 100 = 0.823\%$

5) $h = 20m$

$d = 10cm = 0.1m$

$r = 5cm = 0.05m$

$g = 9.8 ms^{-2}$

By conservation of energy $\frac{1}{2}mv^2 = mgh$

V as subject of formula

$v^2 = 2gh \quad v = \sqrt{2gh} \quad v = \sqrt{2 \times 9.81 \times 20}$

$v = 19.8 m/s$

flow rate of base,

$\pi r^2 v = \pi \times (0.05)^2 \times 19.8 = 0.1555 m^3/s$

To find the amount of water that emerges

$\frac{m}{t} = \rho \pi r^2 v$

$= 1000 \times \pi \times (0.05)^2 \times 19.8$

$= 155.5088 kg$

$P = \frac{W}{t} = mg\frac{h}{t} = (\rho \pi r^2 v) g \frac{h}{t}$

$= 155.5088 \times (9.81) \times (20/1)$

$P = 30479.72N, \; P = 30.47972 KN$

1) $\rho_f g = 19.62 N/m^2$

$C_d = 0.96, \; d_1 = 0.5m, \; d_2 = 0.2m$

$u_1 = \frac{Q}{0.1960}$ $\quad u_2 = \frac{Q}{0.6314}$

for the manometer:

$P_1 + \rho_f g z = P_2 + \rho_f g(z_2 - R_f) + \rho_w g R_f$

$P_1 - P_2 = 19.62(z_2 - z_1) + 587.4$ —— (1)

for the venturimeter

$$\frac{P_1}{\rho_w g} + \frac{u_1^2}{2g} + z_1 = \frac{P_2}{\rho_w g} + \frac{u_2^2}{2g} + z_2$$

$P_1 - P_2 = 13062(z_2 - z_1) + 0.503u_2^2$ ——— (11)

$0.503\, u_2^2 = 587.423$

$u_{ideal} = 27.047$ m/s

$q_{ideal} = 27.047 \times \pi \frac{(0.2)^2}{4} = 0.85 m^3/s$

$\phi = C_d\, \phi_{ideal} = 0.96 \times 0.85$

$\phi = 0.816 m^3/sec$