1. Flow rate = $10\,dm^3/min$ $\Delta P_{recorded}$ = 12 bar

Nominal displace = $10\,cm^3/rev$ Speed = 1500 rpm

Torque input = 12.5 N·m

Ideal flow rate = Nominal disp × speed = 10 × 1500 = $15000\,cm^3/min$

$= 15\,dm^3/min$

Volumetric efficiency = $\dfrac{\text{Actual flow}}{\text{Ideal flow}} = \dfrac{10}{15} = 0.667$ or 66.7%

ii

$Q = \dfrac{10 \times 10^{-3}}{60}\,m^3/sec = 16.7 \times 10^{-5}\,m^3/sec$

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

Fluid Power = $\Delta P \times Q = 16.7 \times 10^{-5}\,m^3/sec \times 12 \times 10^5$ = 200 watt

Shaft power = $\dfrac{2\pi NT}{60} = \dfrac{2\pi \times 1500 \times 12.5}{60}$ = 1963.5 watt

Overall efficiency = FP/SP = $\dfrac{200}{1963.5}$ = 0.102 or 10.2%

2. Overall efficiency = 87% = $\dfrac{F.P}{S.P}$

$S.P = \dfrac{F.P}{87\%} = \dfrac{\Delta P \times Q}{87\%} = \dfrac{100 \times 10^5 \times 5.833 \times 10^{-7}}{0.87}$

= 6.7 watt

3 nominal displacement = 50 cm^3/rev

ΔP = 100 bar

Shaft power = 15 KW = 15000 watt

Actual flow rate = 35 dm^3/min

Speed rotation = 850 r.p.m

Volumetric efficiency = $\frac{\text{Actual flow}}{\text{Ideal flow}} = \frac{\text{Actual flow}}{\text{nominal disp} \times \text{speed}}$

$= \frac{35 \; dm^3/min}{850 \times 50 \; cm^3/min}$

$= \frac{35}{42.5} = 0.82$ or 82%

Overall Efficiency $= \frac{FP}{SP} = \frac{\Delta P \times Q}{SP} = \frac{100 \times 10^5 \times 35 \times 10^{-3}}{60 \times 15000}$

$= 0.389$ or 38.9%

4 Power of jet $= \frac{1}{2} \rho v^2 Q$

$= \frac{1 \times 1000}{2 \times 9.81} \times 66^2 \times 0.13 = 28862$ kgm/sec

$= 28862 \times 9.81 = 283140$ watt

" At reservoir, pressure is atmospheric and velocity of jet surface equals zero; $P = 0$, $v = 0$

Power supplied from reservoir $= \rho Q g z = \gamma Q z$

$= 1000 \times 0.13 \times 240$

$= 31200$ kgm/sec

$= 31200 \times 9.81 = 306072$ W

$= 306.072$ KW

iii If H_T = Total head at the reservoir

H_j = Total head at the jet

h = head loss in transmission

a_1 = Power supplied from reservoir $= \gamma Q H_1 = 31200$ kgm/sec

b Power of issuing jet $= \gamma Q H_2 = 28862$ kgm/sec

Power lost in transmission $= \gamma Q h = a - b = 2338$ kgm/sec

Head loss in pipe $= h =$ Power lost$/\gamma Q$

$h = 2338/(1000 \times 0.13)$

$= 17.98m$

$40000 = 416.67Q + 0.0625\,Q^2$

$0.0625Q^2 + 416.67Q - 40000 = 0$

$Q^2 + 6666.72Q - 640{,}000 = 0$

$Q = 9445$ m/day

5 $\rho = 890 kg/m^3$

$H = 300m$

$Q = 220 l/s = 0.22 m^3/s$

$V = 7m/s$

i Power jet $= \frac{1}{2}\rho Q V^2 = \frac{1}{2} \times 890 \times 0.22 \times 7^2$

$= 4797.1$ watt

ii Power supplied from reservoir $= P = \rho g Q H$

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

$= 576229.4W$

Power supplied from reservoir = $\gamma Q H_1$

$= 890 \times 0.022 = 58740 \text{ kgm/sec}$

Power issuing jet = $\frac{1}{2}\rho v^2 Q = \frac{1}{2} \times \frac{890}{9.81} \times 7^2 \times 0.022 = 489 \text{ kgm/s}$

Power loss during transmission = $\gamma Q h = 58740 - 489 = 58251 \text{ kgm/s}$

$$\text{or } h = \frac{58251}{890 \cdot 022} = 297.38 \text{ m}$$

$$\eta = \frac{\text{Power of jet}}{\text{Power supplied}} = \frac{489}{58740} = 0.0083 = 0.8324 = 0.8324\%$$

6.

$$P = \frac{W}{t} = \frac{mgh}{t}$$

$$= \frac{\rho \times \pi r^2 v\, gh}{t}$$

$$v = \sqrt{2gh} = \sqrt{2 \times 9.8 \times 20} = 19.798 \text{ m/s}$$

$$(1000 \text{ kg/m}^3) \times \pi \times \left(\frac{10 \times 10^{-2}}{2}\right)^2 \times 19.798 \text{ m/s} \times 9.8 \times 20$$

$$= 1000 \times \pi \times 2.5 \times 10^{-3} \times 19.798 \times 9.8 \times 20$$

$$= 30475.03 \text{ W}$$

7.

$P_g = 19.62 \text{ N/m}^2$

$C_d = 0.96$

$d_1 = 0.3 \text{m}$

$d_2 = 0.2 \text{m}$

We know that continuity equation

$a_1 v_1 = a_2 v_2$

$Q = a_1 v_1$ $\quad\quad$ $Q = a_2 v_2$

$a_1 = \frac{\pi}{4} d_1^2$ $\quad\quad$ $a_2 = \frac{\pi}{4} d_2^2$

$a_1 = \frac{\pi (0.3)^2}{4}$ $\quad\quad$ $a_2 = \frac{\pi}{4} \times (0.2)^2$

$a_1 = 0.0700$ $\quad\quad$ $a_2 = 0.0319$

$V_1 = \frac{Q}{0.07}$ $\quad\quad$ $V_2 = \frac{Q}{0.0314}$

For manometer

For the above fig

we get

$P_1 + \rho_g g z_1 = P_2 + \rho_g g (z_2 - R) + \rho_m g R$

We know that

$\rho_g g = 19.62 N/m^2$ $\quad$ for $\rho_w = 1000$ (water)

$= 9810 N/m^2$

By simplifying the eqn.

$P_1 - P_2 = 19.62(z_2 - z_1) + 589.422$

For venturimeter:

By Bernoullis equation.

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

We know that V_1

$V_1 = \frac{Q}{0.07}$

then $\frac{P_1}{19.6} + \frac{\left(\frac{Q}{0.07}\right)^2}{2 \times 9.81} + z_1 = \frac{P_2}{19.6} + \frac{V_2^2}{2 \times 9.81} + z_2$

$P_1 - P_2 = 1073 (z_2 - z_1) + 0.803 V_1$ —

Now comparing equation in ? (2)

$0.803 V_1^2 = 587.423$

$V_2 = 27.047 \, m/s$

$Q_{ideal} = a_2 V_2$

$= 27.047 \times \frac{\pi}{4} (d_2)^2$

$= 27.047 \times \frac{\pi}{4} (0.2)^2$

$= 0.85 \, m^3/sec$

$Q = C_d \, Q_{ideal}$

$= 0.96 \times 0.85$

$= 0.816 \, m^3/sec$

8. $d_1 = 0.152 \, m$ $\quad A_1 = \frac{\pi}{4} (0.152)^2 = 0.01814 \, m^2$

$d_2 = 0.076 \, m$

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

$\rho = 0.8 \times 1000 = 870 \, kg/m^3$

$C_d = 0.97$

Apply Bernoulli :-

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

$P_1 = P_2$

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

By continuity

$Q = V_1 A_1 = V_2 A_2$

$$V_2 = \frac{V_1 A_1}{A_2}$$

$$\frac{V_1^2}{2g} = 0.314 = \frac{1.6\,(V_1)^2}{2g}$$

$$V_1 = \sqrt{\frac{0.314 \times 2 \times 9.81}{1.5}} = 1.0934 \text{ m/s}$$

$$Q = C_d A_1 V_1 = 0.97 \times (0.01814) \times (1.0934)$$

$$Q = 0.0192 \text{ m}^3/\text{s}$$

(b)

$$P_1 - P_2 = 15170$$

$$\frac{P_1 - P_2}{\rho g} = \frac{V_2^2 - V_1^2}{2g} - 0.914$$

$$\frac{15170}{800 \times 9.81} = \frac{Q^2 (220.43^2 - 55.1^2)}{2 \times 9.81} - 0.914$$

$$1.933 = 2321.7\,Q^2 - 0.914$$

$$2.847 = 2321.7\,Q^2$$

$$0.001226256 = Q^2$$

$$Q = 0.035$$

9. At section 1

$D_1 = 300\text{mm} = 0.3\text{m}$ $A_1 = \frac{\pi}{4} \times 0.3^2 = 0.07065\text{m}^2$

Pressure $P_1 = 400\text{kN/m}^2$

Height of upper end above the datum $(Z_1) = 10\text{m}$

At section 2 -

$D_2 = 150\text{mm} = 0.15\text{m}$ $A_2 = \frac{\pi}{4} \times 0.15^2 = 0.01767\text{m}^2$

Height of lower end above the datum $(z_2) = 6m$

Rate of flow:

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

As the flow is continuous.

$Q = A_1 V_1 = A_2 V_2$

$V_1 = Q/A_1 = 0.04/0.07068 = 0.5658 m/s$

$V_2 = Q/A_2 = 0.04/0.01767 = 2.2635 m/s$

Apply Bernoulli's equation at section 1 & 2.

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

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

$$\frac{P_2}{\rho g} = \frac{400 \times 10^3}{1000 \times 9.81} + \frac{(0.5658^2 - 2.2635^2)}{2 \times 9.81} + 10 - 6$$

$$\frac{P_2}{\rho g} = 44.53$$

$P_2 = 44.53 \times 9.81 \times 1000 = 436.838 kN/m^2$

10- Specific gravity of mercury $(S_m) = 13.6$

Specific gravity of sea water $(S_{sw}) = 1.025$

Difference of Hg level, $x = 170mm = 0.17m$

$$h = x\left[\frac{S_m}{S_{sw}} - 1\right] = 0.17\left[\frac{13.6}{1.026} - 1\right]$$

$$h = 2.0534\ m$$

Speed of Submarine

$$v = \sqrt{2gh} = \sqrt{2 \times 9.81 \times 2.0534}$$

$$v = 6.39347\ m/s^2$$

$$v = 6.39347 \times \frac{3600}{100}\ Km/hr$$

$$v = 23.0163\ Km/hr$$