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1) The small end is (1) and lower end is (2)

$V_1 = 5m/s$ $L = 2.0m$ $P_1/\rho g = 2.5m$ of liquid

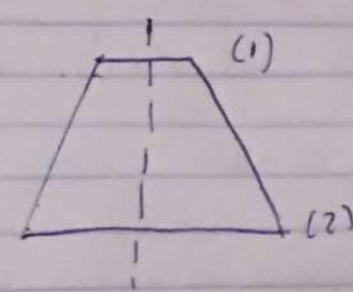
$V_2 = 2m/s$

$$\text{Loss of head} = \frac{0.35(V_1 - V_2)^2}{2g}$$

$$= \frac{0.35(5-2)^2}{2 \times 9.81} = 0.16m$$

Using Bernoulli's equation

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



Letting the line pass through the section, $Z_1 = 2.0$, $Z_2 = 0$

$$2.5 + \frac{5^2}{2 \times 9.81} + 2.0 = \frac{P_2}{\rho g} + \frac{2^2}{2 \times 9.81} + 0 + 0.16$$

$$5.77 = \frac{P_2}{\rho g} + 0.364$$

$$\frac{P_2}{\rho g} = 5.77 - 0.364 = 5.406m \text{ of liquid}$$

2) $D_{inlet} = \frac{20cm}{100} = 0.2m$

$A_{inlet} = \frac{\pi d^2}{4} = \frac{\pi \times (0.2)^2}{4} = 0.0314 m^2$

$D_{throat} = \frac{10cm}{100} = 0.1m$

$A_{throat} = \pi d^2/4 = \pi \times (0.1)^2 \div 4 = 7.85 \times 10^{-3} m^2$

$P_1 = 17.658\ N/cm^2 = 17.658 \times 10^4\ N/m^2$

$\frac{P_1}{\rho g} = \frac{17.658 \times 10^4}{1000 \times 9.81} = 18m$ of water

$\frac{P_2}{\rho g} = -30cm = -0.3m$ of mercury
$= -0.3 \times 13.6 = -4.08m$ of H_2O

Differential head $(h) = \frac{P_1}{\rho g} - \frac{P_2}{\rho g} = 18.0 + 4.08 = 22.08m$

Using discharge equation

$$Q = C_d \frac{a_1 \times a_2}{\sqrt{a_1^2 - a_2^2}} \times \sqrt{2gh}$$

$$= 0.98 \times \frac{0.0314 \times 7.85 \times 10^{-3}}{\sqrt{(0.0314)^2 - (7.85 \times 10^{-3})^2}} \times \sqrt{2 \times 9.81 \times 22.08}$$

$$= 0.98 \times 8.107 \times 10^{-3} \times 20.81$$

$= 0.1653\ m^3/s = 165.3$ litres/seconds

3) $A_{orifice} = \pi d^2/4 = \frac{\pi \times (15)^2}{4} = 176.714\ cm^2$

$A_{pipe} = \pi d^2/4 = \frac{\pi \times (30)^2}{4} = 706.858$

Differential head $(h) = \left[\frac{13.6}{0.9} - 1\right] \times 50$ cm of oil

$= 705.556$ cm of oil

$$Q = \frac{C_d \times A_{orifice} \times A_{pipe}}{\sqrt{A_{pipe}^2 - A_{orifice}^2}} \times \sqrt{2gh}$$

$$= 0.64 \times \frac{176.714 - 706.858}{\sqrt{706.858^2 - 176.714}} \times \sqrt{2 \times 9.81 \times 705.556}$$

$$= 0.64 \times 182.5094 \times 117.656$$

$= 13742.96\ cm^3/sec = 13.742$ litres/sec

4) ~~Differ~~ Specific gravity of mercury, $S_g = 13.6$
" " " water, $S_w = 1.026$
Difference of mercury level $x = 170\,mm = 0.17\,m$

$$h = x\left[\frac{S_g}{S_w} - 1\right] = 0.17\left[\frac{13.6}{1.026} - 1\right] = 2.0834\,m$$

Using $V = \sqrt{2gh}$

$$= \sqrt{2 \times 9.81 \times 2.0834} = 6.393\,m/s$$

$$= 23.01\,Km/hr$$

5) Volumetric flow rate $= 5\,dm^3$

$$= 0.005\,m^3/min$$

Actual flow rate $= \frac{0.005}{60} = 8.33 \times 10^{-5}\,m^3/sec$

If the speed is 1700 rpm
Conversion to rps

$1700/60 = 28.33$ rev/second

With the Pressure as 15 bars

$1\,bar = 1 \times 10^5\,N/m^2$

$\therefore\ 15\,bars = 15 \times 10^5\,N/m^2$

Nominal displacement $= 10\,cm^3/rev$

If $100^3\,cm^3 = 1\,m^3$

$10\,cm^3 = x$

$$x = \frac{10}{100^3} = 1 \times 10^{-5}\,m^3/rev$$

Ideal flowrate = Nominal displacement × Speed

$$= 28.33 \times 1.0 \times 10^{-5}$$

$$= 2.833 \times 10^{-4}$$

a) Volume Efficiency $= \frac{\text{Actual flowrate}}{\text{Ideal flowrate}} \times 100\%$

$= \frac{8.33 \times 10^{-5}}{2.833 \times 10^{-4}} \times 100 = 29.4\%$

b T, Fluid Power $= Q \times P$

$= 8.33 \times 10^{-5} \times 15 \times 10^{5}$

$= 124.95$ Nm/sec

c) Shaft Power $= T \cdot W$

$W = 2\pi \times 28.33 = 178.07$ rad/sec

$\therefore$ Shaft Power $= 15 \times 178.07 = 2671.05$ Watts

d) Overall Efficiency $= \frac{\text{Fluid Power}}{\text{Shaft Power}} \times 100\%$

$= \frac{124.95}{2671.05} \times 100 = 4.67\%$