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1.) Length = 2.0 m

Velocity flow at smaller end = V_1 = 5m/s

Velocity flow at lower end V_2 = 2m/s

Pressure head at smaller end P_s = 2.5m of liquid

Let the loss of head $H_2 = \frac{0.35 (V_1 - V_2)^2}{2g}$

$= \frac{0.35 ((5-2)^2}{2 \times 9.81} = 0.161 m$

Pressure head at lower end P_L = ?

* Applying Bernoulli's Equation

$$\frac{P_1}{\rho g} + \frac{V_1^2}{2g} + Z_1 = \frac{P_2}{\rho g} + \frac{V_2^2}{2g} + Z_2 + H_2$$

where $P_s = P_1/\rho g$ & $P_L = P_2/\rho g$

$Z_1 = 2.0$ and $Z_2 = 0$

$\therefore 2.5 + \frac{5^2}{2 \times 9.81} + 2.0 = P_L + \frac{2^2}{2 \times 9.81} + 0 + 0.161$

$2.5 + \frac{25}{19.62} + 2 = P_L + \frac{4}{19.62} + 0.161$

$P_L = \left(2.5 + \frac{25}{19.62} + 2\right) - \left(\frac{4}{19.62} + 0.161\right)$

$P_L = 5.774 - 0.365$

$P_L = 5.409$m of fluid

2) Inlet diameter D_1 = 20cm

throat diameter D_2 = 10cm

let inlet area $A_1 = \frac{\pi D_1^2}{4} = \frac{\pi (20)^2}{4} = 314.16 cm^2$

Throat area $A_2 = \frac{\pi D_2^2}{4} = \frac{\pi (10)^2}{4} = 78.54 cm^2$

Density of water $\rho = 1000 Kg/m^3$

Pressure at inlet $= 17.658 \times 10^4 N/m^2$

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

$\frac{P_2}{\rho g} = -30 cm$ of mercury,

$S.g\ Hg = 13.6$

$\frac{P_2}{\rho g} = -30 \times 10^{-2} m \times 13.6 = -4.08m$

Differential Head $= \frac{P_1}{\rho g} - \frac{P_2}{\rho g}$

$= (18 - (-4.08))$

$= 18 + 4.08 = 22.08m \times 100$

$H = 2208 cm$

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

$= \frac{0.98 \times \sqrt{2 \times 981 \times 2208} \times 314.16 \times 78.54}{\sqrt{(314.16)^2 - (78.54)^2}}$

$= \frac{0.98 \times 2081.37 \times 24674.1264}{304.184112}$

$= 165455.3 \ cm^3/s$

$= \frac{165455.3}{1000} = 165.455$ Lit/sec

3) Diameter of pipe = 30cm

$A_1 = \frac{\pi d_1^2}{4} = \frac{\pi (30)^2}{4} = 706.86$

Diameter of orifice, $d_2 = 15cm$

$$A_2 = \frac{\pi d_2^2}{4} = \frac{\pi (15)^2}{4} = 176.72 cm$$

Specific gravity of oil $S_o = 0.9$

" " of mercury $S_{hg} = 13.6$

Differential manometer reading $x = 50cm$ of mercury

Coefficient of discharge $C_d = 0.64$

Differential head $h = x\left(\frac{S_{hg}}{S_o} - 1\right)$

$$h = 50\left(\frac{13.6}{0.9} - 1\right)$$

$$h = 705.56 \text{ cm of oil}$$

∴ The rate of flow of oil is

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

$$Q = \frac{0.64 \times \sqrt{2 \times 981 \times 705.56} \times 706.86 \times 176.72}{\sqrt{(706.86)^2 - (176.72)^2}}$$

$Q = 137443.29 \ cm^3/s$

$Q = 137443.29 \div 1000 = 137.44 \ lit/s$

4) Difference of mercury level, $x = 170mm \times 10^{-3} = 0.17$

Specific gravity of mercury $S_g = 13.6$

" " " sea water $S_o = 1.026$

Speed $v = ?$

$v = \sqrt{2gh}$ $h = ?$

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

∴ $v = 2 \times 9.81 \times 2.0834 = 6.393 \ m/s$

Km

$$v = \frac{6.393 \times 60^2}{1000} = 23.01 \ Km/hr$$

5) $Q = 0.05 m^3/min = 50 dm^3/min$

$P_o = 15 bar = 15 \times 100000 = 15 \times 10^5 N/m^2$

speed = 1700 rev/min

T = 15Nm, ND = 10 cm/rev

i) Volumetric Efficiency = $\frac{\text{Actual flow rate}}{\text{Ideal flow rate}}$

Ideal flow rate = Nominal flow rate x Speed

= $10 cm^3/rev \times 1700 rev/min$

= $17000 cm^3/min$

~~Ideal flow rate = Nominal flow rate x Speed / = 10 cm³ /rev/ x 1700 rev/min~~

Ideal flow rate = $\frac{17000}{1000000} = 0.017 m^3/min$

Actual flow rate = $0.05 m^3/min$

∴ Volumetric Efficiency = 0.05 ÷ 0.017 = 2.94 = 294%

ii) Fluid power = P x Q

$P = 15 \times 10^5 N/m^2$ $Q = 0.05 m^3/min = \frac{0.05}{60} = 8.33 \times 10^{-4} /s$

fluid power = $15 \times 10^5 \times 8.33 \times 10^{-4}$

= $15 \times 10^5 \times 83.3 \times 10^{-5} = 1249.5 \times 10^{5-5}$

" = 1249.5 watts

iii) Shaft power = $\frac{2\pi NT}{60} = \frac{2\pi \times 1700 \times 15}{60}$ = 2670.35 watts

iv) Overall Efficiency = $\frac{\text{Fluid Power}}{\text{Shaft Power}}$

$\frac{\text{Fluid power}}{\text{Shaft power}} = \frac{1249.5}{2670.35} = 0.468$

Overall Efficiency = 0.468 x 100 = 46.8 %