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1) Length, $L = 2.0m$

The velocity flow at smaller end $= v_1 = 5m/s$

The velocity flow at large end $= v_2 = 2m/s$

Let the pressure head at smaller end $= P_S = 2.5m$ of liquid

Let the loss of head $= H_L = \frac{0.35(v_1 - v_2)^2}{2g}$

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

Let the pressure head at the lower end $= P_L = ?$

By Applying Bernoulli's equation

$$\frac{P_1}{\rho g} + \frac{v_1^2}{2g} + z_1 = \frac{P_2}{\rho g} + \frac{v_2^2}{2g} + z_2 + H$$

where $P_S = \frac{P_1}{\rho g}$ and $P_L = \frac{P_2}{\rho g}$

$z_1 = 2.0$ and $z_2 = 0$ (datum line passes through section 2)

Inputting values into the equation

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

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

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

$5.774 - 0.365 = P_L$

$P_L = 5.409m$ of fluid

2) let Inlet diameter $= D_1 = 20cm$

let throat diameter $= D_2 = 10cm$

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

$= 314.16cm^2$

let throat area $= A_2 = \frac{\pi D_2^2}{4} = \frac{\pi (10)^2}{4}$

$= 78.54cm^2$

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

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

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

$\frac{P_2}{\rho g} = -30cm$ of mercury, sg Hg $= 13.6$

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

$= -4.08m$

Let differential head $= \frac{P_1}{\rho g} - \frac{P_2}{\rho g}$

$= 18 - (-4.08)$

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

$H = 2208cm$

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

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

$= \frac{0.98 \times 2081.37 \times 24674.1264}{304.184113}$

$= 165455.3cm$

$= \frac{165455.3}{1000} = 165.4551 lit/sec$

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3) Diameter of pipe = 30cm

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

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_0 = 0.9

Specific gravity of mercury, S_{Hg} = 13.6

Differential manometer reading, x = 50cm of mercury

Coefficient of discharge, C_d = 0.64

Differential head, $h = x\left(\frac{S_{Hg}}{S_0} - 1\right)$

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

h = 705.56 cm of oil

∴ The rate of flow of oil is

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

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

Q = 137443.29 cm^3/s

$$Q = \frac{137443.29}{1000} = 137.44 \text{ lt/s}$$

4) The difference of mercury load, x = 170mm = 170×10^{-3} = 0.17

The specific gravity of mercury, S_g = 13.6

The specific gravity of sea water, S_0 = 1.026

The speed, v = ?

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

$$h = x\left[\frac{S_g}{S_0} - 1\right] = 0.17\left[\frac{13.6}{1.026} - 1\right]$$

= ~~28~~ 2.0834m

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

in km/hr

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

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5)

$Q = 0.05 m^3/mn = 50 dm^3/mn$

$P_0 = 15 bar = 15 \times 100000 = 15 \times 10^5 N/m^2$

Speed = 1700 rev/min

T = 15 Nm, NO: 10 cm^3/rev

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

Ideal flow rate = Nominal flow rate × speed

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

$= 17000 cm^3/mn$

Ideal flow rate $= \frac{17000}{1000000} = 0.617 m^3/min$

∴ Volumetric efficiency $= \frac{0.05}{0.017} = 2.94\%$

$= 294\%$

ii) Fluid power = P × Q

$P = 15 \times 10^5 N/m^2$

$Q = 0.05 m^3/mm = \frac{0.05}{60}$

$= 8.33 \times 10^{-4} m/s$

Fluid power $= 15 \times 105 \times 8.33 \times 10^{-4}$

$= 15 \times 105 \times 83.3 \times 10^{-5}$

$= 1249.5 \times 105^{-5}$

Fluid power = 1249.5 watts

iii) Shaft power $= \frac{2\pi N T}{60} = \frac{2\pi \times 1700 \times 15}{60}$

Shaft power = 2670.35 watts

iv) Overal 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 × 100 = 46.8%