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Mechanical Engineering

(1) Length $L = 2.0m$

The velocity flow at smaller end $= V_1 = 5m/s$

The velocity flow at large end $= V_2 = 2m/s$

pressure head at the smaller end $= P_s = 2.5m$ of Liquid.

loss of head $= H_L = \dfrac{0.35(V_1 - V_2)^2}{2g}$

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

pressure head at lower end $= P_L = ?$

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

where $P_s = \dfrac{P_1}{\rho g}$ and $P_L = \dfrac{P_2}{\rho g}$

$Z_1 = 2.0$ and $Z_2 = 0$.

putting values into the equation.

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

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

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

$$5.774 - 0.365 = P_L$$

$P_L = 5.409$ m of fluid.

(2) let inlet diameter $= D_1 = 20$ cm

" throat " $= D_2 = 10$ cm

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

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

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

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

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

$= 18 - (-4.08m)$

~~differential Head = H =~~ $\cancel{\frac{P_1}{\rho g} - \frac{P_2}{\rho g}}$ $= 18 + 4.08 = 22.08m \times 100$

$= 2208$ cm

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

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

= 165.455 lit/sec

4.

(3) $d_1 = 30cm$

$$A_1 = \frac{\pi d_1^2}{4} = \frac{\pi (30)^3}{4} = 176.72cm$$

$d_2 = 15cm$

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

S gravity of oil = 0.9

" of mercury = 13.6

Diff 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 = 705.56cm of oil

∴ The rate of flow of soil is

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

$$Q = \frac{0.04 \times \sqrt{2 \times 981} \times 705.56 \times 706.86 \times 176.72}{\sqrt{(706.86)^2 - (176.72)}}$$

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

4) difference of mercury = 170mm = 170 mm = 170×10^{-3} = 0.17m

Specific gravity of mercury, S_g = 13.6

Specific gravity of sea water, S_o = 1.026

Speed, V = ?

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

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

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

In Km/hr

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

$a = (20 - 0.05s^2)(-0.1s)$
$= -2s + 5 \times 10^{-3} s^3$
$= -2(15) + 5 \times 10^{-3} (15)^3$
$= -13.13 \, m/s^2$

5) $Q = 0.05 m^3/min = 50 dm^3/min$
$P = 15 bar = 15 \times 10000 = 15 \times 10^5 \, N/m^2$
Speed $= 1700$ rev/min
$T = 15 Nm$, $ND = 10 cm^3/rev$

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

Ideal flow rate = Nominal flow rate × Speed
$= 10 cm^3/rev \times 1700 rev/min$
$= 17000 cm^3/min$

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

Actual flow rate $=$ ~~[illegible]~~ $0.05 m^3/min$

$\therefore$ volumetric efficiency $= \frac{0.05}{0.017} = 2.94 \% = 294 \%$

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

fluid power $= 15 \times 10^5 \times 8.33 \times 10^{-4}$
fluid power $= 1249.5$ watts

iii) shaft power

$= \frac{2\pi N T}{60} = \frac{2\pi \times 1700 \times 15}{60}$

$= 2670.35$ watts

iv) overall efficiency $= \frac{\text{fluid power}}{\text{shaft power}}$

$= \frac{1249.5}{2670.35} = 0.468$

Overall Efficiency $= 0.468 \times 100 = 46.8\%$