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Chemical Engineering

1. $V_1 = 5ms^{-1}$ $P_L = ?$

$V_2 = 2ms^{-1}$

$P_3 = 2.5m$ of liquid

$$H_L = \frac{0.35(V_1 - V_2)^2}{2g}$$

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

$$= 0.161m$$

Apply Bernoulli's Equation

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

$$P_3 = \frac{P_1}{\rho g} \quad P_L = \frac{P_2}{\rho g}$$

$Z_1 = 2$ and $Z_2 = 0$

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

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

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

$$\Rightarrow P_L = 5.41m$$

2. $D_1 = 20cm$

$D_2 = 10cm$

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

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

P

$\rho = 1000 kg/m^3$

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

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

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

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

$= -4.08m$

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

$= 18 - (-4.08)$

$= 22.08 m \times 100$

$= 2208 cm$

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

$\Rightarrow \frac{0.98 \times \sqrt{2 \times 9.81 \times 2208} \times 314.16 \times 78.54}{\sqrt{(314.16^2) - (78.54^2)}}$

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

$\Rightarrow 165455.3 cm^3/s$

$\Rightarrow \frac{165455.3}{1000} = 165.455$ lit/sec

3. $d_1 = 30cm$

$A_1 = \frac{\pi d^2}{4} = 1706.86cm^2$

$d_2 = 15cm$

$A_2 = 176.72cm^2$

S.g of oil, $S_o = 0.9$

$S_{Hg} = 13.6$

X = 50cm of mecury

$C_d = 0.64$

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

$= 50\left(\frac{13.6}{0.9} - 1\right) \Rightarrow 705.56cm$ of oil

rate of flow

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

$= \frac{0.64\sqrt{2 \times 9.81 \times 705.56} \times 1706.86 \times 176.72}{\sqrt{(1706.86^2) - (176.72^2)}}$

$= 137443.29 cm^3/sec$

$\Rightarrow \frac{137443.29}{1000} = 137.44$ litres/sec

4. X = 170mm = 0.17m

$S_{hg} = 13.6$

$S_o = 1.026$

V = ?

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

$h = x\left(\frac{S_g}{S_o} - 1\right) = 0.17\left(\frac{13.6}{1.020} - 1\right)$

$= 2.0834m$

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

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

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

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

Speed $= 1760 rev/min$

$T = 15Nm$

$ND = 10 cm^3/rev$

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

Ideal flow rate = Nominal flow rate x speed

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

$= 17000 cm^3/min$

$\Rightarrow \frac{17000}{1000000} = 0.017 m^3/min$

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

$\therefore$ Volumetric Efficiency $= \frac{0.05}{0.017} = 2.94 =$ ~~2.94~~ 294%

ii) Fluid power = $P \times Q$

$= 15 \times 10^5 \times \frac{0.05}{60}$

$= 12495$ watts

iii) Shaft Power $= \frac{2\pi NT}{60}$

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

$= 2670.35$ watts

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

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

$\Rightarrow 0.468 \times 100 = 46.8\%$