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18/ENG07/010
Petroleum Engineering
ENG 214: Fluid Mechanics

Question 1:

Length of Tube = 2.0 m

$V_1 = 5 m/s$

$P_g = 2.5 m$

$V_2 = 2 m/s$

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

$$= \frac{0.35(5-2)^2}{2g} = \frac{0.35 \times 9}{2 \times 9.81}$$

$$= 0.16 m$$

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

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

$$2.51 + 1.27 + 2.0 = \frac{P_2}{\rho g} + 0.203 + 1.6$$

$$\frac{P_2}{\rho g} = ((2.5) + (1.27) + (2.0)) - (0.203 + 0.16)$$

$$= \underline{5.407 m}$$

→

Question 3:

Diameter of Orifice = 15cm

Area of the orifice = $a_0 = \frac{\pi}{4}(15)^2$

$= 176.7 cm^2$

Diameter of Pipe = $d_1 = 30cm$

Area of the Pipe = $a_1 = \frac{\pi \times 30^2}{4} = 706.85 cm^2$

Specific Gravity = 0.9

differential manometer Length = 50cm of mercury

$\therefore$ Differential Head $= x\left(\frac{S_g}{S_o} - 1\right) = 50\left(\frac{13.6}{0.9} - 1\right)$

$= 50 \times 14.11$

$= 705.5cm$ of oil

$\therefore$ The rate of flow $Q = C_d \times \frac{a_0 a_1}{\sqrt{a_1^2 - a_0^2}} \times \sqrt{2gh}$

$= \frac{0.64}{1} \times \frac{176.7 \times 706.85}{\sqrt{(706.85)^2 - (176.7)^2}} \times \sqrt{2 \times 9.81 \times 705.5}$

$= \frac{94046317.78}{684.4}$

$= 137414.25 cm^3/s$

$\simeq 137.414$ litres/seconds

Question 2

Diameter at Inlet; $d_1 = 20cm$

$$a_1 = \frac{\pi}{4} \times d_1$$

$$= \frac{\pi \times 20^2}{4} = 314.16cm^2$$

Diameter at Outlet; $d_2 = 10cm$

$$a_2 = \frac{\pi \times 10^2}{4} = 78.74cm^2$$

$$P_1 = 17.658 N/cm^2$$

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

density of water = 1000 kg/m³

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

$$\frac{P_2}{\rho g} = -30cm \text{ of mecury}$$

$$= -0.30 \times 13.6$$

$$= -4.08 \text{ of water}$$

$$h_L = \frac{P_1}{\rho g} - \frac{P_2}{\rho g} = 18 - (-4.08)$$

$$= 18 + 4.08$$

$$= 2208cm \text{ of water}$$

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

$$= \frac{0.98 \times 314.16 \times 78.54}{\sqrt{(314.16)^2 - (78.74)^2}} \times \sqrt{2 \times 9.81 \times 2208}$$

$$= \frac{50328837.21}{304} \times 165555 cm^3/s$$

= 165.5555 litres/seconds

Question 4:

Differential of mercury, $x = 170mm$
$= 0.17m$

Specific gravity of mercury $= 13.6$; S_g
Specific gravity of Sea-water $= 1.026$; S_o

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

$= 0.17\left(\frac{13.6}{1.026} - 1\right)$

$= 2.0834m$

$\therefore V = \sqrt{2gh} = \sqrt{2 \times 9.81 \times 2.0834}$

$= 6.393 m/s$

$= \frac{6.393 \times 60 \times 60}{1000}$

$= 23.07 \text{ km/hr}$

Question 5:

Actual flow rate $= 5dm^3/min$

$5 dm = 1m$

$5dm^3 = x$

Volumetric flow rate $= x = \frac{5}{1000}$

$= 0.005 m^3/min$

Actual flow rate $= \frac{0.005}{60 seconds}$

$Q = 8.33 \times 10^{-4} m^3/seconds$

Speed, N = 1700 rev/min

$= \frac{1700}{60} = 28.33$ rev/seconds

$= 28.33$ rps

Pressure, $\delta p = 15$ bar

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

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

Normal displacement = $10 cm^3/rev$

$100 cm = 1 m$

$10 cm^3 = x$

$x = 10/1000000$

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

ideal flow rate = normal × speed displacement

$= 28.33 \times 1 \times 10^{-5}$

$= 2.833 \times 10^{-4} m^3/sec$

(a) Volumetric Efficiency = $\frac{\text{Actual flow rate}}{\text{Ideal flow rate}} \times 100\%$

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

$= 29.4\%$

(b) fluid power $P_f = Q \times \delta p$

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

$= 1249.5$ Nm/seconds

(c) Shaft Power = T = 15 Nm

$W = \frac{2\pi N}{60} = 2 \times \frac{22}{7} \times 28.33$

$= 178.02$ rad/seconds

$\therefore$ Shaft power $= 15 \times 178.02$

$= 2670.3$ watts

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

$= \frac{1249.5 \times 100\%}{2670.3} = \underline{46.79\%}$