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MECHATRONICS ENGINEERING

18/ENG05/040

FLUID MECHANICS NUMBER1-5.

Question 1

$L = 2m$ $\qquad$ $Z_2 = 0m$

$\therefore Z_1 = 2m$

$v_1 = 5 m/s$

$v_2 = 2 m/s$

$\frac{P_1}{w} = 2.5m$

Loss of head $= 0.35 (v_1 - v_2)^2 / 2g$
(H_L)

$\Rightarrow 0.35 (5-2)^2 / 2 \times 9.81$

$= 0.35(9) / 19.62$

$\Rightarrow 3.15 / 19.62$

$\Rightarrow 0.1606 m$

Using Bernoulli's equation

$$Z_1 + \frac{P_1}{w} + \frac{v_1^2}{2g} \Rightarrow Z_2 + \frac{P_2}{w} + \frac{v_2^2}{2g} + H_L$$

$$\frac{P_1}{w} - \frac{P_2}{w} = (Z_2 - Z_1) + \left(\frac{v_2^2}{2g} - \frac{v_1^2}{2g}\right) + H_L$$

$$2.5 - \frac{P_2}{w} = (0 - 2) + \left(\frac{2^2 - 5^2}{2g}\right) + 0.1606$$

$$-\frac{P_2}{w} = -2 - 2.5 + \left(\frac{-21}{2 \times 9.81}\right) + 0.1606$$

$$-\frac{P_2}{w} = -4.3394 + \left(\frac{-21}{19.62}\right)$$

$$-\frac{P_2}{w} = -4.3394 - 1.070$$

$$-\frac{P_2}{w} = -5.4097\ m$$

$$\frac{P_2}{w} = 5.4097\ m$$

$\therefore$ Pressure head at lower end $= 5.4097\ m$

QUESTION 2.

Question 2.

$A_1 = \pi d^2/4 = \pi(0.2)^2/4 = 0.03 m^2$

$d_1 = 20cm = 0.2m$

$d_2 = 10cm = 0.1m$ $\quad A_2 = \pi d^2/4 = \pi(0.1)^2/4 = 7.85\times10^{-3} m^2$

$P_1 = 17.658 N/cm^2$

$\frac{17.658 N}{(1\times10^{-4})m^2} = 176580 N/m^2$

Vacuum Pressure = 30cm Hg
= -0.3m of Hg

$C_d = 0.98$

$\frac{P_1}{w} = 176580/\rho g = 176580/1000\times9.81 \Rightarrow 18m$

Note $Q = C_d . A_1 . A_2 . \sqrt{2gh} / \sqrt{A_1^2 - A_2^2}$

$\frac{P_2}{w} = 0.3\times13.6 = -4.08m$

$h = \frac{P_1 - P_2}{w} = 18 - (-4.08)$
$= 18 + 4.08$
$= 22.08m$

$\therefore Q = \frac{0.98\times0.03\times7.85\times10^{-3}\times\sqrt{2\times9.81\times22.08}}{\sqrt{0.03^2 - (7.85\times10^{-3})^2}} \Rightarrow \frac{4.8\times10^{-3}}{0.029}$

$Q \Rightarrow 0.1658 m^3/s$

Question 3.

$d_o = 15\,cm = 0.15\,m$

$A_o = \pi d_o^2 / 4 = \pi (0.15)^2 / 4$

$= 0.0177\,m^2$

$d_1 = 30\,cm = 0.3\,m$

$A_1 = \pi d^2 / 4 = \pi (0.3)^2 / 4$

$= 0.071\,m^2$

Pressure difference = 50cm of Hg

= 0.5m of Hg

$\therefore h = 0.5 \left(\frac{S_m}{S_{oil}} - 1 \right)$

$= 0.5 \left(\frac{13.6}{0.9} - 1 \right) = 0.5 (14.11)$

$\Rightarrow 7.06\,m$

$C_d = 0.64$

$Q = C_d . A_o . A_1 \times \sqrt{2gh} / \sqrt{A_1^2 - A_o^2}$

$$Q = \frac{0.64 \times 0.0177 \times 0.071 \times \sqrt{2 \times 9.81 \times 7.06}}{\sqrt{(0.071)^2 - (0.0177)^2}}$$

$Q = 9.466 \times 10^{-3} / 0.0688$

$Q = 0.1377\,m^3/s.$

Question 4.

Difference in mercury level = 170 mm = 0.17 m

$S_m = 13.6$

$S_s = 1.026$

$V = \sqrt{2gh}$

$h = 0.17 \times \left(\frac{S_m}{S_s} - 1\right) = \left(\frac{13.6}{1.026} - 1\right) \times 0.17$

$h = 12.255 \times 0.17$

$h = 2.083\ m$

$V = \sqrt{2 \times 9.81 \times 2.083}$

$V = \sqrt{40.877}$

$V = 6.39\ m/s$

QUESTION 5.

Question 5

$Q = 0.05 m^3 / min$

$= 0.05 m^3 / 60$ seconds

$= \frac{0.05 m^3}{60 \text{ seconds}} = 8.33 \times 10^{-4} \ m^3/s$

Speed of rotation = 1700 rev/min

$= \frac{1700 \text{ rev}}{60 \text{ seconds}}$

$= 28.33$ rev/s

Nominal displacement = $10 \ cm^3$/rev

$= (10 \times 10^{-6}) m^3$/rev

Torque input = 15Nm

(I) Volumetric Efficiency

= (fluid flow rate / Ideal flow rate) x100%

Ideal flow rate = Nominal displacement x speed of rotation

$= (10 \times 10^{-6}) \times (28.33)$

$\Rightarrow 2.833 \times 10^{-4} \ m^3/s$

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

2.940 × 100

= 294 %

(ii) Fluid power = Q × δP

δP = 15 bar = 15×10^5 N/m²

= $8.33 \times 10^{-4} \times 15 \times 10^5$ = 1249.5 watt.

(iii) Shaft Power = Torque Input × angular Speed of rev

angular speed = ~~1700 × 2 × π~~ 28.33 × 2 × π / s

= 178.00 rad/s.

= 15 × 178 => 2670 watt.

(iv) Overal Efficiency = $\frac{\text{fluid power}}{\text{shaft power}} \times 100$

= $\frac{1249.5}{2670} \times 100$

= 46.798 %

≃ 46.8 %