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18/ENG06/064
MECHANICAL ENGINEERING
ENG 214

Solution

(1) $v_1 = 5ms^{-1}$, $v_2 = 2ms^{-1}$ $P_1/w = 2.5m$ of Liquid
$L = z_1 - z_2 = 2.0m$; $h_f = 0.3\frac{(v_1 - v_2)^2}{2g}$

considering loss of head
$$h_f = 0.3\frac{(v_1 - v_2)^2}{2g}$$

Applying Bernoulli's equation b/w points 1 & 2 we have:
$$P_2/w = P_1/w + \frac{1}{2g}(v_1^2 - v_2^2) + (z_1 - z_2) - h_f$$
$$= 2.5 + \frac{1}{2 \times 9.8}(5^2 - 2^2) + 2.0 - 0.3\frac{(5-2)^2}{2 \times 9.81}$$
$$= 2.5 + 1.07 + 2.0 - 0.138$$
$$P_2 = 5.57 \text{ bar}$$

2.) $d_1 = 20\,cm = 0.2\,m$; $dt = 10\,cm = 0.1\,m$

$P_1 = 17.658\,N/cm^2 = \left(\frac{17.658}{10^{-4}}\right) N/m^2$

$= 17.658 \times 10^4\,N\,m^{-2}$; $P_t = 30\,cm\,Hg$

$Cd = 0.98$

$A_1 = \frac{\pi d^2}{4} = \frac{\pi (0.2)^2}{4} = 0.0031\,m^2$

$A_2 = \frac{\pi d^2}{4} = \frac{\pi (0.1)^2}{4} = 7.85 \times 10^{-3}\,m^2$

Specific gravity of mercury = 13.6

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

Vacuum pressure $= \frac{P_2}{\omega} = 30\,cm\,Hg$

$= -0.30 \times 13.6$

$P_2 = -4.08\,m$

$h = \frac{P_1 - P_2}{\omega} = \frac{P_1}{\omega} - \frac{P_2}{\omega} = 18 - (-4.08)$

$= 22.08$

$Q_A = \frac{Cd \cdot A_1 A_2 \sqrt{2gh}}{\sqrt{A_1^2 - A_2^2}}$

$Q_{actual} = \frac{0.98 \times 0.031 \times 7.85 \times 10^{-3} \sqrt{2 \times 9.8 \times 22}}{\sqrt{(0.031)^2 - (7.85 \times 10^{-3})^2}}$

$\therefore Q = 0.1654\,m^3/s$

(3) Orifice diameter = 15 cm = 15×10^{-2} m

Pipe diameter = 30 cm = 30×10^{-2} m

50 cm of mercury = (50 cm Hg) - Pressure

Sgr of oil = 0.9; Cd = 0.64

$A_0 = \frac{\pi (15 \times 10^{-2})^2}{4}$ $= 0.017$

$A_1 = \frac{\pi (30 \times 10^{-2})}{4}$ $= 0.071$

$y = 0.5$ m of Hg

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

$= 7.05$ m of oil

$$Q = Cd \times \frac{A_0 \cdot A_1 \cdot \sqrt{2gh}}{\sqrt{A_1^2 - A_0^2}}$$

$$= 0.64\left(\frac{0.017 \times 0.071 \times \sqrt{2 \times 9.81 \times 7.05}}{\sqrt{0.071^2 - 0.017^2}}\right)$$

$$= 0.64\left(\frac{0.0142}{0.069}\right) = 0.132 \text{ m}^3/\text{s}$$

(4) Reading the manometer, $y = 170 mm$

$= 0.17 m$ of mercury

Sp. gr of mercury $= 13.6$ (S_{hl})

Sp. gr of sea water $= 1.026$ (S_l)

To find the head, (h) using the relation.

$\because y = 0.17 m$ of Hg

$$h = y\left(\frac{S_{hl}}{S_l} - 1\right),$$

$$h = 0.17\left(\frac{13.6}{1.026} - 1\right) = 0.17 \times 12.26$$

$$= 2.084$$

Velocity of Submarine:

$$v = \sqrt{2gh} = \sqrt{2 \times 9.81 \times 2.084}$$

$$= \underline{6.39} \; ms^{-1}$$

⑤ i) Volumetric efficiency: $\frac{\text{actual flow}}{\text{theoritical flow}}$

actual flow = 0.05 m^3/min

Theoritical flow = Pump displacement per revolution × driven speed

10 cm^3/rev × 1700 rev/min

0.1 m^3/rev × 1700 rev/min

= 170 m^3/min

Volumetric efficiency = $\frac{0.05\ m^3/min}{170\ m^3/min}$

= 2.94×10^{-4} %

ii) Fluid Power: