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18/ENG04/029
Elect - Elect

ENG 214

Fluid Mechanics

1) $Z_1 = 2m$, $Z_2 = 0m$, $l = 2m$, $V_1 = 5m/s$, $V_2 = 2m/s$

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

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

(h_L) Head loss $= 0.1601m$.

Applying Bernoulli's equation

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

$$2.5 + \frac{(5)^2}{2 \times 9.81} + 2 = \frac{P_2}{W} + \frac{(2)^2}{2 \times 9.81} + 0 + 0.1601$$

$$2.5 + 1.2742 + 2 = \frac{P_2}{W} + 0.2039 + 0.1601$$

$$5.7742 = \frac{P_2}{W} + 0.3640$$

$$\frac{P_2}{W} = 5.7742 - 0.3640$$

$$\frac{P_2}{W} = 5.4102\,m$$

(2) $d_1 = 20cm = 0.2m$, $C_d = 0.98$

$$A_1 = \frac{\pi (d_1)^2}{4} = \frac{\pi \times (0.2)^2}{4} = 0.03142 m^2$$

$d_2 = 10cm = 0.1m$

$$A_2 = \frac{\pi (d_2)^2}{4} = \frac{\pi \times (0.1)^3}{4} = 0.007855 m^2$$

$P_1 = 17.658 N/cm^2 = 176580 N/m^2$

$$\frac{P_1}{W} = \frac{P_1}{\rho \times g} = \frac{176580}{1000 \times 9.81} = 18m$$

Vaccum pressure = 30cm of Hg mercury (Hg)
= −0.3m mercury (Hg)

$P_2 = -0.3 \times 13.6$

$$\frac{P_2}{w} = -4.08m$$

$$h = \frac{P_1 - P_2}{w}$$

$h = 18 - (-4.08) = 22.08m$

$$Q_{actual} = \frac{C_d A_1 A_2 \times \sqrt{2gh}}{\sqrt{A_1^2 - A_2^3}}$$

$$Q_{actual} = \frac{0.98 \times 0.03142 \times 0.007855 \times \sqrt{2 \times 9.81 \times 22.08}}{\sqrt{0.03142^2 - 0.007855^2}}$$

$$Q_{actual} = \frac{5.03497 \times 10^{-3}}{0.03042}$$

$Q_{actual} = 0.1655 m^3/s$

(3) $d_0 = 15cm = 0.15m$

$A_0 = \frac{\pi (d_0)^3}{4} = \frac{\pi \times (0.15)^2}{4} = 0.0177 m^3$

$d_1 = 30cm = 0.3m$

$A_1 = \frac{\pi (d_1)^3}{4} = \frac{\pi \times (0.3)^3}{4} = 0.0707 m^3$

$C_d = 0.64$

differential reading $(y) = 50cm = 0.5m$

(S_{Hg}) Specific gravity of mercury $= 13.6$

Specific gravity of oil $(S_{oil}) = 0.9$

Differential head $(h) = y\left[\frac{S_{Hg}}{S_{oil}} - 1\right]$

$= 0.5\left[\frac{13.6}{0.9} - 1\right]$

$= 0.5(14.11)$

$= 7.055m$

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

$$Q = \frac{0.64 \times 0.0177 \times 0.0707 \times \sqrt{2 \times 9.81 \times 7.055}}{\sqrt{0.0707^2 - 0.0177^2}}$$

$$Q = \frac{9.4226 \times 10^{-3}}{0.0684}$$

$$Q = 0.1378 \, m^3/s$$

(A) depth = 15m

manometer reading = 170mm = 0.17m

Specific gravity mercury $S_{Hg} = 13.6$

Specific gravity seawater $S_{swater} = 1.026$

$$h = y\left[\frac{S_{Hg}}{S_{swater}} - 1\right]$$

$$h = 0.17\left[\frac{13.6}{1.026} - 1\right]$$

$$h = 0.17(12.255)$$

$$h = 2.08335 \, m$$

Velocity $V = \sqrt{2 \times g \times h}$

$$V = \sqrt{2 \times 9.81 \times 2.08335}$$

$$V = 6.3934 \, m/s$$

5 Actual flow rate = 0.05 m^3/min = 8.33×10^{-4} m^3/s
Pressure = 15bar = $15 \times 10^5 N/m^2$
Speed = 1700 rev/min = 28.33 rev/s
nominal displacement = 10 cm^3/rev = $1 \times 10^{-5} m^3/rev$
Torque input = 15Nm

Volumetric efficiency = $\frac{\text{Actual flow rate}}{\text{ideal flow rate}} \times 100\%$

Ideal flow rate = nominal displacement × speed
= $1 \times 10^{-5} \times 28.33$
= $2.833 \times 10^{-4} m^3/s$

Volumetric efficiency = $\frac{8.33 \times 10^{-4}}{2.833 \times 10^{-4}} \times 100\%$
= $2.94 \times 100\%$
= 294%

Fluid power = Actual rate × pressure
= $8.33 \times 10^{-4} \times 15 \times 10^5$
Fluid power = 1249.5 Watts

Shaft power = Torque × angular speed

Angular speed = $2 \times \pi \times$ speed

$= 2 \times \pi \times 28.33$

angular speed = 178.0026 rad/s

Shaft power = $15 \times 178.0026 = 2670.0039$ watts

Overall efficiency = $\frac{\text{Fluid power}}{\text{shaft power}} \times 100\%$

$= \frac{1249.5}{2670.0039} \times 100\%$

$= 0.468 \times 100$

$= 46.8\%$