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18/ENG04/057
Electrical Engineering
Fluid Mechanics

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

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

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

Head Loss(hl) = 0.1606m

Applying bernoulli's equation

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

$$2.5 + \frac{(5)^2}{2 \times 9.81} + 2 = \frac{P_2}{w} + \frac{(2)^2}{2 \times 9.81} + 0 + 0.1606$$

$$2.5 + 1.2742 + 2 = \frac{P_2}{w} + 0.2039 + 0.1606$$

$$5.7742 = \frac{P_2}{w} + 0.3645$$

$$\frac{P_2}{w} = 5.7742 - 0.3645$$

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

2) $d_1 = 20cm = 0.2m$, $cd = 0.98$

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

$d_2 = 10cm = 0.1m$

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

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

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

Vaccum Pressure = 30cm of mecury (Hg)
= -0.3m mecury (Hg)

$P_2 = -0.3 \times 13.6$

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

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

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

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

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

$Q_{actual} = \frac{5.03417 \times 10^{-3}}{0.03042}$

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

3) $d_0 = 15cm = 0.15m$

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

$d_1 = 30cm = 0.3m$

$A_1 = \frac{\pi d_1^2}{4} = \frac{\pi (0.3)^2}{4} = 0.0707m^2$

$Cd = 0.64$

differential reading (y) = 50cm = 0.5m

(S_{Hg}) specific gravity or mercury = 13.6

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

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

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

$= 0.5(14.11)$

$= 7.055m$

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

$$Q = \frac{0.64 \times 0.0197 \times 0.0707}{\sqrt{0.0707^2 - 0.0197^2}} \times \sqrt{2 \times 9.81 \times 7.035}$$

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

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

4) depth = 15m
Manometer reading = 170mm = 0.17m
Specific gravity mercury S_{Hg} = 13.6
specific gravity seawater S_{swater} = 1.026

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

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

$$h = 0.17 \times 12.255$$

$$h = 2.08335m$$

Velocity $v = \sqrt{2gh}$

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

$$v = 6.3934 m/s$$

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

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

Ideal flow rate = nominal displacement × speed

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

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

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

$$= 2.94 \times 100\%$$

$\therefore \simeq 294\%$

Fluid power = Actual rate × Pressure

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

$= 1249.5$ watts

Shaft power = Torque × angular speed

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

$= 2 \times \pi \times 28.33$

$= 178.0026$ rad/s

Shaft power $= 15 \times 178.0026$

$= 2670.039$ watts

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

$$= \frac{1249.5}{2670.039} \times 100\%$$

$= 0.468 \times 100\%$

$= 46.8\%$