18/ENG04/053 ENG 214 FLUID MECHANICS

NJOKU VICTORY ELECTRICAL ELECTRONICS

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

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

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

(hl) Head loss $= 0.1601m$

Apply Bernoulli's equation

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

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

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

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

$\frac{P_2}{w} = 5.7742 - 0.3640$; $\frac{P_2}{w} = 5.4102m$

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

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

$d_2 = 10cm = 0.1m$

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

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

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

Vaccum pressure = 30 cm of mecury (Hg)

$= -0.3\text{m}$ mecury (Hg)

$\frac{P_2}{w} = -0.3 \times 13.6$

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

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

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

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

$Q_{actual} = \frac{5.03477 \times 10^{-3}}{0.03042}$; $Q_{actual} = 0.1655\text{m}^3/\text{s}$

3) $d_0 = 15\text{cm} = 0.15\text{m}$

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

$d_1 = 30\text{cm} = 0.3\text{m}$

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

$C_d = 0.64$

Differential reading (y) = 50 cm = [redacted]

(S_{Hg}) Specific gravity of mecury = 13.6

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

Differential head (h) $= y\left[\frac{S_{Hg}}{S_{oil}} - 1\right] = 0.5\left[\frac{13.6}{0.9} - 1\right] = 0.5(14.11)$

$= 7.055\text{m}$

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

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

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

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

4) depth = 15m

manumeter reading = 170mm = 0.17m

Specific gravity mercury $S_{Hg} = 13.6$

Specific gravity seawater $S_{water} = 1.026$

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

$$h = 0.17(12.255) = 2.08335 \, m$$

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

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

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

5) Actual flow rate = $0.05 \, m^3/min = 8.33 \times 10^{-4} \, m^3/s$

Pressure = 15 bar = $15 \times 10^5 \, N/m^2$

Speed = 1700 rev/ = 28.33 rev/s

nominal displacement = $10 \, cm^3/rev = 1 \times 10^{-5} \, m^3/rev$

Torque input = 15 Nm

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

Ideal flow rate = nominal displacement × speed

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

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

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 rads

Shaft power = $15 \times 178.0026 = 2670.039$ watts

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

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

$= 0.468 \times 100 = 46.8\%$