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ELECT / ELECT

19/ENG04/062

Sol. to Assignment

1.) length, $L = 2.0m$

velocity flow at smaller end $= V_1 = 5m/s$

" " " lower end $= V_2 = 2m/s$

Pressure head at smaller end $= P_s = 2.5m$ of liquid

Let the loss of head $= H_L = \frac{0.35(V_1 - V_2)^2}{2g}$

$= \frac{0.35(5-2)^2}{2 \times 9.81} = 0.161m$

Let pressure head at the lower end $= P_2 = ?$

Applying Bernoulli's Equation

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

where $P_s = \frac{P_1}{\rho g}$ and $P_2 = \frac{P_2}{\rho g}$

$Z_1 = 2.0$ and $Z_2 = 0$ (datum line passes through section 2)

Imputting values

$$-25 + \frac{5^2}{2\times9.81} + 20 = P_2 + \frac{2^2}{2\times9.81} + 0 + 0.161$$

$$25 + \frac{25}{19.62} + 2 - \left(\frac{4}{19.62} + 0.161\right) = P_2$$

$$5.774 - 0.365 = P_2$$

$\therefore P_2 = 5.409$ m of fluid.

2.) $D_1 = 20$cm, $D_2 = 10$cm

$$A_1 = \frac{\pi D_1^2}{4} = \frac{\pi(20)^2}{4} = 314.16\text{cm}^2$$

$$A_2 = \frac{\pi D_2^2}{4} = \frac{\pi(10)^2}{4} = 78.54\text{cm}^2$$

Density of water, $\rho = 1000$kg/m^3

Pressure at inlet = 17.658 N/cm^2 = 17.658×10^4 N/m^2

$$\therefore \frac{P_1}{\rho g} = \frac{17.658\times10^4}{1000\times9.81} = 18\text{m}$$

$\frac{P_2}{\rho g}$ = -30cm of mercury, $S_{Hg} = 13.6$

$$\frac{P_2}{\rho g} = -30\times10^{-2}\text{m of mercury} \times 13.6$$

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Let differential head = $\frac{P_1}{\rho g} - \frac{P_2}{\rho g}$

$= 18 - (-4.08)$

$= 18 + 4.08 = 22.08m \times 100 = 2208cm$

Using $Q = \frac{C_d \sqrt{2gh} \cdot A_1 A_2}{\sqrt{A_1^2 - A_2^2}}$

$= \frac{0.98 \times \sqrt{2 \times 981 \times 2208} \times 314.16 \times 78.54}{\sqrt{(314.16)^2 - (78.54)^2}}$

$= \frac{0.98 \times 2081.37 \times 24674.1264}{304.18412}$

$= 165455.3 cm^3/s$

$= \frac{165455.3}{1000} = 165.455$ lit/sec.

3.) $d_1 = 30cm$

$A_1 = \frac{\pi d_1^2}{4} = \frac{\pi (30)^2}{4} = 706.8 cm^2$

$d_2 = 15cm$

$A_2 = \frac{\pi d_2^2}{4} = \frac{\pi (15)^2}{4} = 176.72cm^2$

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Differential head, $h = x\left(\frac{S_g}{S_o} - 1\right)$

$h = 50\left(\frac{13.6}{0.9} - 1\right)$

$h = 705.56$ cm of oil

∴ The rate of flow of oil is

$Q = \frac{C_d \sqrt{2gh} \cdot A_1 \cdot A_2}{\sqrt{A_1^2 - A_2^2}}$

$Q = \frac{0.64 \times \sqrt{2 \times 981 \times 705.56} \times 706.86 \times 176.72}{\sqrt{(706.86)^2 - (176.72)^2}}$

$Q = 137443.29\ cm^3/s$

$Q = \frac{137443.29}{1000} = 137.44$ lit/s

4) $V = ?$

$V = \sqrt{2gh}$, $h = ?$

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

∴ $V = \sqrt{2 \times 9.81 \times 2.0834} = 6.393$ m/s

In km/hr, $V = \frac{6.393 \times 60^2}{1000} = 23.01$ km/hr

5.) Q = 0.05 m^3/min = 50 dm^3/min

P_2 = 15 bar = 15 × 100000 = 15 × 10^5 N/m^2

Speed = 1700 rev/min

T = 15 Nm, ND = 10 cm^3/rev

(i) Volumetric efficiency = $\frac{\text{Actual flow rate}}{\text{Ideal flow rate}}$

Ideal flow rate = Nominal flow rate × speed

= 10 cm^3/rev × 1700 rev/min

= 17000 cm^3/min

Ideal flow rate = $\frac{17000}{1000000}$ = 0.017 m^3/min

Actual flow rate = 0.05 m^3/min

∴ Volumetric efficiency = $\frac{0.05}{0.017}$ = 2.94% = 294%

(ii.) Fluid power = P × Q

P = 15 × 10^5 rev/m^2

Q = 0.05 m^3/min = $\frac{0.05}{60}$ = 8.33 × 10^{-4} m/s

Fluid power = 15 × 10^5 × 8.33 × 10^{-4}

= 15 × 10^5 × 83.3 × 10^{-5}

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Fluid power = 1249.5 watts

iii) Shaft power $= \frac{2\pi NT}{60} = \frac{2\pi \times 1700 \times 15}{60}$

Shaft power = 2670.35 watts

iv) Overall efficiency $= \frac{\text{Fluid power}}{\text{Shaft power}}$

$= \frac{1249.5}{2670.35} = 0.468$

$= 0.468 = 46.8\%$