LAWAL ADEOLA IBUOMENAAN

18/ENG05/029

MECHATRONICS

FLUID MECHNICS

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1) Relative density = 0.8

S.g = $\frac{\text{density of fluid}}{\text{density of water}} = \frac{0.8}{1000} = 8\times10^{-4}$

inlet diameter = 150mm ≈ 0.15m

Outlet diameter = 75mm ≈ 0.075m

Q = 40 liters/sec → m^3sec^{-1} ÷100

$\therefore Q = 0.4 m^3 sec^{-1}$

cd = 0.96.

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

$A_1 = \frac{\pi d^2}{4} = \frac{\pi (0.15)^2}{4} = 0.0177m^2$

$A_2 = \frac{\pi d^2}{4} = \frac{\pi (0.075)^2}{4} = 4.418\times10^{-3}m^2$

$\therefore 0.4 = 0.96 \times 0.0177 \times 4.418\times10^{-3}$

$0.4 = \frac{0.96\times0.0177\times4.418\times10^{-3}\sqrt{2\times9.81\times h}}{\sqrt{(0.0177)^2 - (4.418\times10^{-3})^2}}$

$0.4 = \frac{7.5071\times10^{-5}\sqrt{19.62h}}{0.0171}$

$= 91.11 = \sqrt{19.62h}$

$h = 423.09$

recall $h = \frac{P_1 - P_2}{w}$ where $w = Pg$

$P = S.g \times 1000 = 8\times10^{-4}\times1000 = 0.8$

$w = Pg = 0.8\times9.81 = 7.848$

$\therefore P_1 - P_2 = 423.09 \times 7.848 = 3320.41 Nm^{-2}$

2) $d_1 = 300mm \approx 0.3m$, $d_2 = 150mm \approx 0.15m$

S.g = 0.9, y = 250mm ≈ 0.25m

cd = 0.98, $h = \left[\frac{\text{S.g of mecury} - 1}{\text{S.g of oil}}\right]$

$\therefore h = 0.25\left(\frac{13.6}{0.9} - 1\right)$ $\therefore h = 3.53$

difference in elevation $(z_2 - z_1) = 300mm \approx 0.3m$

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

$A_2 = \frac{\pi d^2}{4} = \frac{\pi (0.15)^2}{4} = 0.0177 m^2$

(i) Discharge of oil (Q)

$\therefore Q = \frac{cd\ A_1 A_2\sqrt{2gh}}{\sqrt{A_1^2 - A_2^2}}$

$= \frac{0.98\times0.0707\times0.0177\sqrt{2\times9.81\times3.53}}{\sqrt{(0.0707)^2 - (0.0177)^2}}$

$= \frac{0.01021}{0.06845} = 0.1491 m^3 s^{-1}$

(ii) Pressure difference

$h = \left[\frac{P_1}{Pg} + z_1\right] - \left[\frac{P_2}{Pg} + z_2\right]$

$\therefore h = \left[\frac{P_1}{Pg} - \frac{P_2}{Pg}\right] + z_1 - z_2$

recall $h = 3.53$, $z_1 - z_2 = 0.3\ m$

$\therefore 3.53 = \left[\frac{P_1 - P_2}{Pg}\right] + 30.3$

But P = S.g of oil × 1000 = 0.9 × 1000 = 900

$P_1 - P_2 = (3.53 - 0.3)\times900\times9.81$

$= 28517.67 Nm^{-2}$.