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17/ENG05/024

MECHATRONICS ENGR.

1a i) Three conditions for coutte flow;

- The shear stress
- The flow rate
- The velocity

ii) Four conditions to determine the value of flow:

- The mean flow velocity (v)
- The pipe diameter (D)
- The density (ρ)
- The fluid viscosity (μ)

iii) Difference between Aerofoil and hydrofoil;

Aerofoil	Hydrofoil
* It is used for gaseous fluid	* It is used for liquid fluid
* The foils (wings) are better than foils on a hydrofoil boat	The foils on a hydrofoil are smaller than the foil (wings) on an aeroplane
* Lift force is due to the angle of attack	Lift force is due to the pressure on the bottom of the foil.

1b) $$u = \frac{u}{D} + \frac{1}{2\mu}\left(\frac{-\delta P}{\delta x}\right)\left(by - y^2\right)$$

$$= \frac{1}{0.01} + \frac{1}{2 \times 0.0009}\left(10^3\right)\left(0.01 \times y - y^2\right)$$

$= y(100 + 5555.55 - 555555.55y)$

$\therefore u = y(5655.55 - 555555.55y)$

ii) discharge per unit width

$$q = \int_0^b u\,dy$$

$$= \int_0^{0.01} (5655.55y - 555555.55y^2)\,dy$$

$$= \left[\frac{5655.55y^2}{2} - \frac{555555.55y^3}{3}\right]$$

$$= \left[\frac{5655.55 \times (0.01)^2}{2} - \frac{555555.55 \times (0.01)^3}{3}\right]$$

$$= 0.2827775 - 0.185185$$

$$= 0.975\ m^3/s$$

iii) The shear stress at the upper plate.

$$\text{Shear stress} = \mu \times \left(\frac{du}{dy}\right) = \mu \frac{\delta}{\delta y}(5655.55y - 555555.55y^2)$$

$$= 0.0009(5655.55 - 1111111.1y)$$

$\therefore$ for the top plate; $y = 0.01\,m$

$$T = 0.0009(5655.55 - 1111111.1 \times 0.01)$$

$$= 4.91\ N/m^2$$

2) $\mu = 0.9\ Ns/m^3$, $\rho = 1260$; Specific gravity $= \frac{1260}{1000} = 1.26$

$b = 10mm = 0.01m$; $U = 1.5ms^{-1}$; $P_1 = 250\,KN/m^2$; $P_2 = 50\,KN/m^2$

a) velocity & shear stress distribution btw the plate:

$$h_1 - h_2 = \left(\frac{P_1}{w} + Z_1\right) - \left(\frac{P_2}{w} + Z_2\right)$$

$$= \left(\frac{250 \times 10^3}{1.26 \times 9810} + 1\right) + \left(\frac{80 \times 10^3}{1.26 \times 9810} + 0\right)$$

$= 21.225 - 6.47$

$= 14.755 m$ in $\sqrt{2}$ m or 1.414 m.

$$\frac{\delta h}{\delta x} = \frac{-14.755}{1.414} = -10.435$$

$$\frac{\delta P}{\delta x} = \frac{w \delta h}{\delta x} = (1.26 \times 9810 \times (-10.435))$$

$= -128983 N/m^2$ or $-128.983 KN/m^2$

$$\therefore u = \frac{u}{b} \cdot y = \frac{1}{2\mu} \cdot \left(\frac{\delta P}{\delta x}\right)(by - y^2)$$

$$= \frac{-1.5}{0.01} y - \frac{1}{2 \times 0.9} \times (-128.983 \times 10^3)(0.01y - y^2)$$

$$= -150y + 716.57y - 71657y^2$$

$$= 566.57y - (7.165 \times 10^{-4})y^2$$

The shear stress distribution is given as

$$\tau = \mu \cdot \frac{u}{b} - \frac{1}{2} \frac{\delta P}{\delta x} (b - 2y)$$

$$= 0.9 \times (-1.5/0.01) - \frac{1}{2} * (-128983) \cdot (0.01 - 2y)$$

$$= -135 + 644.92 - 128983y$$

$$= 509.92 - 128983y$$

$$= 509.92 - 1.289 \times 10^5 y$$

(5) maximum flow velocity, V_{max};

for max velocity $\frac{du}{dy} = 0$

$$\frac{\delta}{\delta y}(566.57y - 71657y^2) = 0$$

$$566.57 - 143314y = 0$$

$y = 566.57/143314$ $\therefore y = 3.95 \times 10^{-3}$ m

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$$u_{max} = 566.57(3.95\times10^{-3}) - 7165 + (3.95\times10^{-3})^2$$

$$= 2.238 - 1.118 \Rightarrow 1.12\,ms^{-1}$$

ⓒ The Shear stress on the upper plate

$$\tau_{0.01} = 509.92 - (128983 \times 0.01)$$

$$= -780\ N/m^2$$