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17/ENG05/009
MECHATRONICS ENGINEERING
MCT 322

QUESTION 1

a(i) 3 conditions for Coutte flow
- Plates must be parallel
- One plate is at rest while the other is in motion
- Flow is steady and uniform and fluid is viscous

(ii) Conditions used to determine nature of flow
- Density
- Viscosity
- Compressibility
- Velocity.

(iii) Differences between Aerofoil and Hydrofoil

Aerofoil	Hydrofoil
- Designed to produce lift in air	Designed to produce lift in water
- Works in compressible ~~fluid~~ fluid ie (air)	Works in incompressible fluid (water)
- Are present in aircraft and car aerodynamics surfaces	Are present in boat, ship and submarine bodies

b. $U = \frac{Uy}{b} + \frac{1}{2M}\left(\frac{-dP}{dx}\right)(by - y^2)$

$U = 1$

$b = 10 \div 1000 = 0.01$

$M = (0.9 - 100) \div 10 = 0.0009$ ~~~~ Ns/m^2

$-\frac{\delta P}{\delta x} = \frac{60 \times 10^3}{60} = 10^3$

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

Scanned with CamScanner

$P_1 = 250 kN/m^2 \quad P_2 = 80 kN/m^2$

$$h_1 - h_2 = \left(\frac{250 \times 10^3}{1260 \times 9.81} + 1\right) - \left(\frac{80 \times 10^3}{1260 \times 9.81}\right) + 0$$

$$\text{"} = 21.225 - 6.47$$

$$\delta h = 14.755$$

$$\frac{\delta h}{\delta x} = -\frac{14.755}{\sqrt{2}} = -10.433$$

$$\frac{\delta P}{\delta x} = w \frac{\delta h}{\delta x} = 1260 \times 9.81 \times -10.43$$

$$\frac{\delta P}{\delta x} = -128{,}958$$

$V = 1.5$

$b = 0.01$

$\mu = 0.9$

$$u = -\frac{1.5}{0.01} y - \frac{1}{2(0.9)} (-128{,}958)(0.01y - y^2)$$

$$u = -150y + 716.433y - 71643.33y^2$$

$$u = 566.43y - 7.164333 \times 10^4 y^2$$

) Shear stress distribution

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

$$= 0.9 \times \left(\frac{-1.5}{0.01}\right) - \frac{1}{2} (-128958)(0.01 - 2y)$$

$$\tau = -135 + 644.79 - 128958y$$

$$= 509.79 - 128958y$$

u_{max}

For u_{max} $\frac{du}{dy} = 0$

$$\frac{d}{dy}(566.43y - 71643.33y^2) = 0$$

$u = 100y + 5555.55556y - 555555.556y^2$

$u = 5655.55556y - 555555.556y^2$

$u = y(5655.55556y - 555555.556y)$

Discharge per unit width

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

$q = \int_0^{0.01} \left[5655.55556y - 555555.556y^2\right] dy$

$q = \left[5655.55556\frac{y^2}{2} - 555555.556\frac{y^3}{3}\right]_0^{0.01}$

$q = \left[5655.55556\frac{(0.01)^2}{2} - 555555.556y\frac{(0.01)^3}{3}\right] - [0]$

$q = 0.09759\, m^3/s$

Shear stress on upper plate

$\tau = \mu . \frac{du}{dy}$

$= 0.0009 \frac{d}{dy}\left(5655.55556y - 555555.556y^2\right)$

$= 0.0009\,(5655.55556 - 1111111.112y$

For top plate $y = 0.01$

$\tau_0 = 0.009(5655.55556 - 1111111.112(0.01))$

$\tau_0 = -49.100004\ N/m^2$

QUESTION 2

(a) Velocity distribution

$u = -\frac{U}{b}y - \frac{1}{2\mu}\left(\frac{dP}{dx}\right)(by - y^2)$

$\frac{\partial P}{\partial x} = w\frac{\partial h}{\partial x}$

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

$566.43 - 143286.66 = 0$

$y = \frac{566.43}{143286.66}$

$y = 0.00395$

$y = 3.95 \times 10^{-3} m$

$u_{max} = 566.43(3.95 \times 10^{-3}) - 71643.33(3.95 \times 10^{-3})^2$

$u_{max} = 1.12 m/s$

(c) shear stress at upper plate

$\tau(0.01) = 509.79 - 128958(0.01)$

$= -779.79 N/m^2$