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17/ENG06/014
MCT 322 (FLUIDICS & VIRTUAL LAB TECH)

Question 1

a i, Conditions for Coutte flow
- → Velocity
- → Stress
- → Flowrate

ii, Conditions that can be used to determine the nature of flow
- → Velocity
- → Viscosity
- → Diameter
- → Density

iii, Difference between aerofoil and hydrofoil

Aerofoil	Hydrofoil
→ A structure shaped to produce lift when moving in air	A wing attached to the hull of a ship that raises it out of the water when travelling at speed and thus reduces drag
→ A wing of an aircraft ~~A vessel equipped with such~~	A vessel equipped with such a device
→ It is the cross sectional shape of a wing, blade or sail	It is an attachment to the hull of a ship for lifting element;

b) Viscosity of the liquid μ = 0.9 Centipoise → 0.009 poise

10 poise → $1.0\ Nsm^{-2}$

0.009 poise → $\frac{0.009 \times 1.0}{10} = 0.0009\ Nsm^{-2}$

Viscosity $\mu = 0.0009\ Nsm^{-2}$

Distance btw the plates (b) = 10 mm → 0.01 m

Velocity of the upper plate (u) = $1\ ms^{-1}$

Pressure difference b/w the section 60 m apart = $60\ kNm^{-2}$

$$\therefore \left(-\frac{\partial p}{\partial x}\right) = \frac{60 \times 10^3}{60} = 10^3\ Nm^{-2}m^{-1}$$

i, Velocity distribution

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

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

$$= \frac{1}{0.01}y + 555555.5556\ (0.01y - y^2)$$

$$= \frac{y}{0.01} + 5555.55556y - 555555.5556y^2$$

$$= 100y + 5555.55556y - 555555.5556y^2$$

$= 5655.555556y - 555555.5556y^2$

$= y(5655.555556 - 555555.5556y)$

Hence the velocity distribution

$u = y(5655.555556 - 555555.5556y)$

ii, Discharge per unit width

$q = \int_0^{a} u\,dy$

$= \int_0^{0.01} (5655.555556y - 555555.5556y^2)$

$\left[5655.555556 \times \frac{y^2}{2} - 555555.5556 \times \frac{y^3}{3}\right]_0^{0.01}$

$= \left[5655.555556 \times \frac{0.01^2}{2} - 555555.5556 \times \frac{0.01^3}{3}\right]$

$= (0.282777778 - 0.1851851852)$

$= 0.0975925926\ m^3s^{-1}$

iii, Shear stress at upper plate

Shear stress, $\tau = \mu \left(\frac{du}{dy}\right)$

$= \mu \frac{\partial}{\partial y} (5655.555556y - 555555.5556y^2)$

$\tau = 0.0009 (5655.555556 - 1111111.11y)$

$y = b = 0.1m$ from top plate

$T_0 = 0.0009 (5655.555556 - 1111111.111 \times 0.01)$
$= -4.909999999 \simeq -5 Nm^{-3}$

2 Viscosity = $0.9 Nm^{-2}$
Density = $1260 kgm^{-3} = 1.26$
Distance between plates = $10mm = 0.01m$
Velocity of the upper plate = $1.5ms^{-1}$
$P_1 = 250 \; kNm^{-2}$
$P_2 = 80 \; kNm^{-2}$
Velocity & Shear Stress distibution btw the plate

$$h_1 - h_2 = \left(\frac{P_1}{w} + z_1\right) - \left(\frac{P_2}{w} + z_2\right)$$

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

$= 21.22555539 - 6.472177720 = 14.75337766$

$h_1 - h_2 \simeq 14.755$ in $\sqrt{2}m$ or $1.414m$

$$\frac{dL}{dx} = -\frac{14.755}{1.414} = -10.435$$

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

$= -128983 \; Nm^{-3}$

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

Scanned by CamScanner

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

$$u = \frac{-1.5}{0.01} \cdot y - \frac{1}{2 \times 0.9} \times (-128.983 \times 10^3)(0.0y - y^2)$$

$$= -150y + 716.5722222 - 71657.22222y^2$$

$$u = 566.57y - 71657y^2$$

Velocity distribution $u \rightarrow 566.57y - 71657 \times 10^4 y^2$

Shear distribution $T \rightarrow \mu \cdot \frac{u}{b} - \frac{1}{2}\frac{\partial P}{\partial x}(b - 2y)$

$$T = 0.9 \times \left(-\frac{1.5}{0.01}\right) - \frac{1}{2} \times (-128983)(0.01 - 2y)$$

$$= 133 + 644.92 - 128983y$$

$$T = 509.92 - 128983y$$

maximum flow velocity u_{max}

$$\frac{du}{dy} = 0$$

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

$$566.57 - 143314y = 0$$

$$y = 3.9533 \times 10^{-3} m$$

$V_{max} = 56657 (3.95 \times 10^{-3}) - 71657 (3.95 \times 10^{-3})^2$

$= 2.238 - 1.118 = 1.12 ms^{-2}$

Shear stress on the upper plate

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

$= -779.91$

$\simeq 780 N/m^2$