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DEPARTMENT: MECHANICAL ENGINEERING

1a Conditions for couette flow
1) Two surfaces must be involved.
2) Presence of viscous fluid in the space between the two surfaces.
3) One of the surfaces should be moving tangentially relative to the other.

ii Conditions that can be used to determine the nature of flow
1) Velocity of the flow
2) Density of the fluid
3) Viscosity of the fluid
4) The pipe diameter if it is in ~~a~~ closed conduit

iii

Aerofoil	Hydrofoil
Used to produce lift while moving in water.	Used to produce lift while moving in water.
Can be found in helicopters	Can be found in boats

b) $\mu = 0.9$ centipoise $\rightarrow 0.9 \times 10^{-2}$ poise

10 poise $= 1 Ns/m^2$

0.9×10^{-2} poise $= \frac{0.9 \times 10^{-2}}{10}$

$\therefore \mu = 0.9 \times 10^{-3} Ns/m^2$

$b = 10mm \rightarrow 10 \times 10^{-3} m$

$\partial x = 60m$

Pressure difference $\partial p = 60kN/m^2 \rightarrow 60 \times 10^3 N/m^2$

Pressure gradient; $-\frac{\partial p}{\partial x} = \frac{60 \times 10^3}{60}$

$\frac{\partial p}{\partial x} = -1 \times 10^3 N/m^2/m$

$U = 1\, m/s$

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

$u = \frac{(1)y}{10\times10^{-3}} - \frac{1}{2\times0.9\times10^{-3}} (-1\times10^{3}) \cdot (10\times10^{-3} y - y^2)$

$u = 100y - 555.556(-10y + 1\times10^{3} y^2)$

$u = 100y + 5555.56y - 555556y^2$

$u = 5655.56y - 555556y^2\ m/s$

ii Discharge per unit width; $q = \frac{Ub}{2} - \frac{b^3}{12\mu} \frac{\partial p}{\partial x}$

$U = 1\, m/s$

$b = 10\times10^{-3} m$

$\mu = 0.9\times10^{-3}\ Ns/m^2$

$\frac{\partial p}{\partial x} = -1\times10^{3}\ N/m^2/m$

$q = \frac{(1)(10\times10^{-3})}{2} - \frac{(10\times10^{-3})^3}{12\times(0.9\times10^{-3})} (-1\times10^3)$

$q = 5\times10^{-3} - \frac{1}{10800} (-1\times10^3)$

$q = 0.0976\ m^3/s/m$

iii Shear stress at the upper plate

$\tau = \frac{\mu U}{b} - \frac{1}{2}\left(\frac{\partial p}{\partial x}\right)(b - 2y)$

at upper plate $y = b$

$\mu = 0.9\times10^{-3}\ Ns/m^2$

$b = 10\times10^{-3} m$

Since $y = b$ $\therefore$ $y = 10\times10^{-3} m$

$\frac{\partial p}{\partial x} = -1\times10^{3}\ N/m^2/m$

$U = 1\, m/s$

$$\tau = \frac{09 \times 10^{-3} \times 1}{10 \times 10^{-3}} - \frac{1}{2}(-1 \times 10^{3})(10 \times 10^{-3} - 2(10 \times 10^{-3}))$$

$\tau = 0.09 - 5$

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

2a $\mu = 0.9 \ Ns/m^2$

$\rho = 1260 \ kg/m^3$

$\theta = 45^\circ$ to horizontal

$U = 1.5 \ m/s$

$b = 10mm \rightarrow 10 \times 10^{-3} m$

$p_1 = 250 \ kN/m^2$

$p_2 = 80 \ kN/m^2$

$P_1 = p_1 + \rho g z_1$

$= 250000 + 1260 \times 9.81 \times 1$

$= 262360.6 \ N/m^2$

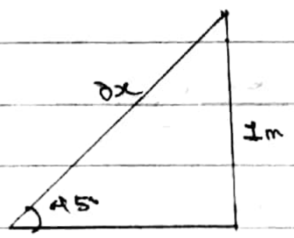
$P_2 = p_2 + \rho g z_2$

$= 80000 + 1260 \times 9.81 \times 0$

$= 80000 \ N/m^2$

To find ∂x

Since the pressure gauges are mounted 1m vertically apart and the parallel plates are inclined at 45°



$$\tan 45^\circ = \frac{1}{\partial x}$$

$$\partial x = \frac{1}{\tan 45}$$

$\partial x = \sqrt{2} \ m$

Pressure gradient ; $-\frac{\partial p}{\partial x} = \frac{p_1 - p_2}{\partial x}$

$$\frac{\partial p}{\partial x} = \frac{262360.6 - 80000}{\sqrt{2}}$$

$$\frac{\partial p}{\partial x} = -128948.42 \ N/m^2$$

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

Since V is acting opposite to the fluid flow

$$= -\frac{1.5y}{10\times10^{-3}} - \frac{1}{2\times0.9}(-128948.42)(10\times10^{-3}y - y^2)$$

$$= -150y - 0.5556(-1289.4842y - 128948.42y^2)$$

$$= -150y + 716.44y - 71643.74y^2$$

$$u = 566.44y - 71643.74y^2$$

a) $\tau = \frac{\mu V}{b} - \frac{1}{2}\left(\frac{\partial p}{\partial x}\right)(b - 2y)$

$\mu = 0.9 \ Ns/m^2$

$V = 1.5 m/s$

$b = 10\times10^{-3} m$

$\frac{\partial p}{\partial x} = -128948.42 \ N/m^2/m$

$$\tau = \frac{0.9\times(-1.5)}{10\times10^{-3}} - \frac{1\times(-128948.42)(10\times10^{-3} - 2y)}{2}$$

$$\tau = -135 - \frac{1}{2}(-1289.4842 + 257896.84y)$$

$$\tau = -135 + 644.7421 - 128948.42y$$

$$\tau = 509.7421 - 128948.42y \ N/m^2$$

b) at maximum velocity $\frac{\partial u}{\partial y} = 0$

$\therefore$ $566.44 - 143287.48y = 0$

$$y = \frac{566.44}{143287.48}$$

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

$U_{max} = 566.44\,(3.95 \times 10^{-3}) - 71643.74\,(3.95 \times 10^{-3})^2$

$U_{max} = 1.112\ m/s$

c at upper plate $y = b$

Since $b = 10 \times 10^{-3}\ m$

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

$\tau = 509.7491 - 128948.42\,(10 \times 10^{-3})$

$\tau = -779.74\ N/m^2$

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