Fluidics MCT 322

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1a For Couette flow, the following must adhere to these formulae;

I The velocity is defined by:

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

II Flowrate is defined by:

$$q = \frac{Ub}{2} - \frac{1}{2\mu}\frac{\delta P}{\delta x}\left[\frac{b^3}{6}\right] \text{ or } q = \frac{Ub}{2} - \frac{b^3}{12\mu}\frac{\delta P}{\delta x}$$

III Shear stress is defined by:

$$\tau = \frac{\mu U}{b} - \frac{\mu}{2\mu}\left(\frac{\delta P}{\delta x}\right) \cdot (b - 2y)$$

Conditions used to determine the nature of flow;

I Flow velocity (v)

ii Pipe diameter (D)

III Density of the fluid (ρ)
IV Viscosity (μ)

Aerofoil	Hydrofoil
i This is used when the fluid is gas	Used when the fluid is liquid.
ii The foils are bigger than that of the hydro-foil.	Here the foils are smaller than those of aerofoil.
iii Here the lift force is generated due to the pressure on the angle of attack	Here the lift force is generated due to the pressure on the bottom of the foil.

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$\mu = 0.9 \times 10^{-3}\ Nsm^{-5}$
$b = 10 \times 10^{-3}\ m$
$u = 1ms^{-1}$
at 60m $\Delta p = 60\ kNm^{-2}$

i $u = \frac{U_y}{b} + \frac{1}{2u} \frac{\delta p}{\delta x} (y^2 - by)$

$y = b$

$u = U + \frac{1}{2u} \frac{\delta p}{\delta x} (b^2 - b^2)$

$\therefore\ u = 1ms^{-1}$

ii $q \Rightarrow$ discharge per unit with
$= \frac{Ub}{2} - \frac{b^3}{12u} \frac{\delta p}{\delta x}$
$= \frac{1 \times 10 \times 10^{-3}}{2} = \frac{(10 \times 10^{-3})^3}{12 \times 0.9 \times 10^{-5}} \times \frac{60000}{60}$
$= 0.005 - 925925.9$
$= -925925.9m$

iii $\tau_0 = \frac{Uu}{b} + \frac{1}{2} \delta P / \delta x\ (2y - b)$

at $y=0$

$$= \frac{1\times 0.9\times 10^{-3}}{10\times 10^{-3}} + \frac{1}{2}\times 1000(2-(10\times 10^{-3}))$$

$$= 0.09 + 995 = 995.09\ Nm^{-3}$$ //

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

$\rho = 1260$

Specific gravity $= 1260/1000 = 1.26$

$b = 16mm = 0.016m$

$V = 1.5m/s$

$P_1 = 250\ kN/m^2$

$P_2 = 80\ kN/m^2$

Velocity and shear stress distribution between the plates

$$h_1 - h_2 = \left(\frac{P_1}{\gamma_1} + Z_1\right) - \left(\frac{P_2}{\gamma_2} + Z_2\right)$$

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

$$= 21.225 - 6.47$$

$$= 14.755m$$

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

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

$$= -12.8983 \, N/m^2$$

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

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

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

$$= 566.57y - 7.16577 \times 10^4 y^2$$

Shear distribution:

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

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

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

$$= 509.92 - 128933y$$

Max Volume V_{max} $\frac{du}{dy} = 0$

$$\frac{d}{dy}\left(566.57y - 71657y^2\right)$$

$$566.57 - 143314y = 0$$

$$y = \frac{566.57}{143314}$$

$$V_{max} = 566.57(3.95 \times 10^{-5}) - 71657(3.95 \times 10^{-5})^2$$

$$= 2.238 - 1.118$$

$$= 1.12$$

Shear Stress:

$$\tau = 509.92 - 128983 \times 0.01$$

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

$$= -0.78 \ N/m^2$$

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