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17 ENG01/001
Mechanical Engineering

1.) One of the parallel plates is at rest, while the other moves

ii] Characteristics of fluid

> The speed of flow
> Shape of the solid surface

iii]

Hydrofoil	Aerofoil
> A wing attached to the hull of a ship that raises it out of the water travelling at speed and thus reduces drag	Structure with curved surface designed to give the most favourable ratio of lift to drag in flight
> A lifting surface that operates in water	A wing of an aircraft

Question 1

(b) $\mu = 0.9$ centipoise

$b = 10\,mm = 0.01\,m$

$y = ?$

$V = 1\,ms^{-1}$

$dx =$ 6mm

$dp = 60\,KN/m^2 = 60 \times 10^3\,N/m^2$

(i) Velocity distribution

$$u = \frac{Vy}{b} - \left[\frac{1}{2\mu}\left(\frac{dp}{dx}\right)(by - y^2)\right]$$

$$u = \frac{1 \times y}{0.01} - \left[\frac{1}{2 \times (0.9 \times 10^{-3})} \cdot \left(-\frac{60 \times 10^3\,Nm^{-2}}{60}\right) \cdot (0.01y - y^2)\right]$$

$$= 100y - [0.556 \times 10^3 \times -10^3 \times (0.01y - y^2)]$$

$$= 100y - [-5560y + (5.56 \times 10^5 y^2)]$$

$$= 5660y + (5.56y^2 \times 10^5)$$

(ii) Flow rate $q = \frac{vb}{2} - \frac{b^3}{12\mu}\left(\frac{dp}{dx}\right)$

$$= \frac{1 \times 0.01}{2} - \left[\frac{(0.01)^3}{12(0.9 \times 10^{-3})} \cdot \left(\frac{60 \times 10^3}{60}\right)\right]$$

$$= 0.005 - [9.259 \times 10^{-5} \times -10^3]$$

$$= 0.005 + 9.259 \times 10^{-2}$$

$$= 0.005 + 0.0926$$

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

(iii) Shear stress distribution

$$= \frac{\mu u}{b} - \left[\frac{1}{2}\left(\frac{dp}{dx}\right) \cdot (b - 2y)\right]$$

$$= \frac{0.9(10^{-3})}{0.01} - \left[\frac{1}{2}[-10^3] \cdot (0.01 - 2y)\right]$$

$$= 0.09 - [0.5 \times -10^3 \times (0.01 - 2y)]$$

$$= 0.09 - [-5 + 10^3 y]$$

$$= 5.09 - 1000y$$

Question 2

$\mu = 0.9 Ns/m^2$ $\theta = 45^0$

$\rho = 1260 kg/m^3$

$V = -1.5 ms^{-1}$

$b = 0.01 m$

$P_1 = 250 KNm^{-2}$

$P_2 = 80 KNm^{-2}$

Solution

$P_i = P_1 + \rho gh$

$= 250 \times 10^2 + (1260 \times 9.81 \times 1)$

$= 262.6 \times 10^3 Nm^{-2}$

$P_2' = P_2 + \rho gh$

$= 80 \times 10^3 + (1260 \times 9.81 \times 0)$

$= 80 \times 10^3$

$S_p = 262.6 \times 10^3 - 80 \times 10^3$

$= 182.6 \times 10^3 Nm^{-2}$

Flow in downslope while upper plate moves upslope

$-\frac{S_p}{S_x} = \left(\frac{182.6 \times 10^3}{\sqrt{2}}\right)$

$\frac{S_p}{S_x} = -128.95 \times 10^3 Nm^{-3}$

1) Velocity distribution

$u = \frac{V_y}{b} - \left[\frac{1}{2\mu} \cdot \left(\frac{S_p}{S_x}\right) \cdot (by - y^2)\right]$

$= \frac{-1.5y}{0.01} - \left[\frac{1}{2(0.9)} \cdot (-128.95 \times 10^3)(0.01y - y^2)\right]$

$= -150y - [0.556 \cdot (-128.95 \times 10^3)(0.01y - y^2)]$

$= -150y - [-716.96y - 7.17 \times 10^{-1} y^2]$

$= -150y + 716.96y + 7.17 \times 10^4 y^2$

$= +566.96y + (7.17 \times 10^4) y^2$

) Stress (Shear) distribution

Where $u = 566y + 7.17 \times 10^4 y^2$

$\frac{du}{dy} = 566 + 1.43 \times 10^5 y$

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

$\tau = 0.9\,(566 + 1.43 \times 10^5 y)$

$\tau = 509.4 + 1.287 \times 10^5 y$

(iii) Max velocity

u_{max} occurs at $du/dy = 0$

Substituting back into the previous equation

$0 = 566.4 + 1.43 \times 10^5 (y)$

$y = \dfrac{-566.4}{1.43 \times 10^5}$

$y = -3.958 \times 10^{-3}\ m$

Therefore

$u_{max} = 566.96 (y) + (7.17 \times 10^4)(y^2)$

$= -2.24 + 1.12$

$= -1.12\ ms^{-1}$

In the opposite direction of flow

(iv) $\tau = 509.4 + 1.287 \times 10^5 (-3.958 \times 10^{-3})$

$= 509.4 + (-509.39)$

$= 0.01\ Nm^{-2}$