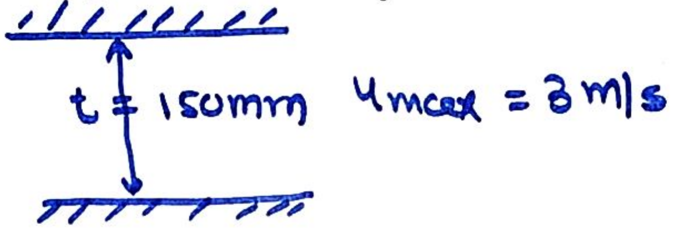
Q.1 Calculate (i) the pressure gradient (ii) the shear stress at two horizontal parallel plates and (iii) the discharge per meter width for the laminar flow of oil with a maximum velocity of 3 m/s between two horizontal parallel fixed plates which are 150 mm apart. take dynamic viscosity = 2.5 N.s/m^2

given Data →



$u_{max} = 3$ m/s

$t = 150$ mm

$= 0.15$ m

$\mu = 2.5$ N.s/m^2

$\frac{\partial p}{\partial x} = ?$

$\tau_0 = ?$

$q = ?$

1) Pressure gradient

$$u_{max} = -\frac{1}{8\mu}\frac{\partial p}{\partial x}\cdot t^2$$

$$\frac{\partial p}{\partial x} = -\frac{u_{max}\, 8\mu}{t^2}$$

$$= -\frac{3 \times 8 \times 2.5}{(0.15)^2}$$

$$\frac{\partial p}{\partial x} = -2666.66 \ \frac{N/m^2}{m}$$

2) τ_0

$$\tau_0 = -\frac{1}{2}\frac{\partial p}{\partial x}\cdot t$$

$$= -\frac{1}{2}(-2666.66) \times 0.15$$

$$\tau_0 = 200 \text{ N/mm}^2$$

3) $$q = \bar{u} \times \text{area}$$

$$= \bar{u} \times (t \times 1)$$

$$= \frac{2}{3} u_{max} \times t$$

$$= \frac{2}{3} \times 3 \times 0.15$$

$$q = 0.3 \text{ m}^3/\text{sec}/\text{m}$$

Q.2 Two parallel plates 80 mm apart have laminar flow of oil between them with maximum velocity of flow is 1.5 m/s. Calculate : (I) Discharge per meter width (II) Shear stress at the plate (III) The difference in the pressure between two points 20 meter apart. (IV) Velocity gradient at the plates. (V) Velocity at 20 mm from the plate. Assume viscosity of oil 24.5 poise.

Given Data

$t = 80\,mm$

$u_{max} = 1.5\,m/s$

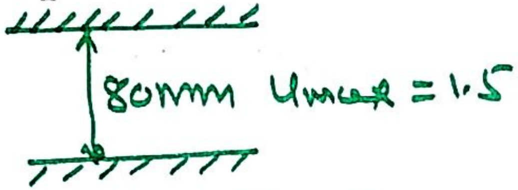
$\mu = 24.5$ Poise

$= 2.45\ N.s/m^2$

width $= 1$ unit

$L = 20\,m$

$y = 20\,mm$



$\bar{u} = \frac{2}{3} u_{max}$

$\bar{u} = \frac{2}{3} \times 1.5$

$\bar{u} = 1\,m/s$

(1) $Q = \bar{u} \times area$

$= \bar{u} \times (t \times 1)$

$= 1 \times \frac{80}{1000} \times 1$

$Q = 0.08\ m^3/sec$

(2) τ_0

$\tau_0 = -\frac{1}{2} \frac{\partial p}{\partial x} . t$

$\tau_0 = -\frac{1}{2} \frac{\partial p}{\partial x} . 0.08$

$\bar{u} = -\frac{1}{12\mu} \frac{\partial p}{\partial x} . t^2$

$-\frac{\partial p}{\partial x} = \frac{12 \mu \bar{u}}{t^2}$

$= \frac{12 \times 2.45 \times 1}{(0.08)^2}$

$\frac{\partial p}{\partial x} = -4593.75\ N/m^2/m$

$\tau_0 = -\frac{1}{2} \times -4593.75 \times 0.08$

$\tau_0 = 183.75\ N/m^2$

(3) $\Delta P = \frac{12 \mu \bar{u} L}{t^2}$

$= \frac{12 \times 2.45 \times 1 \times 20}{(0.08)^2}$

$\Delta P = 91.875\ kPa$

(4) $\frac{\partial u}{\partial y}$ $\quad \tau = \mu \frac{\partial u}{\partial y}$

$\frac{\partial u}{\partial y} = \frac{\tau}{\mu} = \frac{183.75}{2.45}$

$\frac{\partial u}{\partial y} = 75\ (1/s)$

(5) $u \rightarrow y = 20\,mm$

$u_y = -\frac{1}{2\mu} \frac{\partial p}{\partial x} . (ty - y^2)$

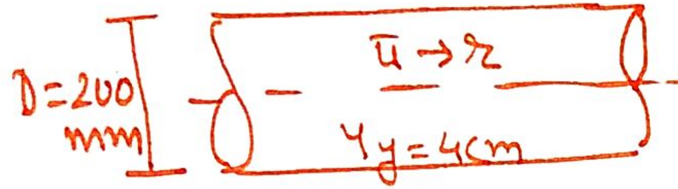
$$u_y = -\frac{1}{2\mu}\frac{\partial p}{\partial x}(ty - y^2)$$

$$y = 20mm$$
$$= 0.02m$$

$$u_{y=20mm} = -\frac{1}{2 \times 2.45} \times -4593.75 \times (0.08 \times 0.02 - (0.02)^2)$$

$$\boxed{u_{y=20mm} = 1.125 \text{ m/sec}}$$

Q.3 A laminar flow is taking place in a pipe of diameter of 200 mm. The maximum velocity is 1.5 m/sec. Find the mean velocity and the radius at which this occurs. Also calculate the velocity at 4 cm from the wall of the pipe.



$u_{max} = 1.5\ m/sec$

$$u = \frac{1}{4\mu}\left(-\frac{\partial p}{\partial x}\right)\cdot(R^2 - r^2)$$

given Data

$d = 200mm$
$= 0.2\ m$

$u_{max} = 1.5\ m/s$

$y = 4\ cm$
$= 0.04\ m$

u

$$\bar{u} = \frac{u_{max}}{2}$$

$$= \frac{1.5}{2} = 0.75\ m/s$$

→ mean Velocity occur at radius

$r = 0.707R$

$r = 0.707 \times D/2$

$= 0.707 \times 0.2/2$

$\boxed{r = 0.0707\ m}$

$r = R - y$

$= 0.1 - 0.04$

$r = 0.06\ m$

$$\bar{u} = \frac{1}{4\mu}\,\frac{-\partial p}{\partial x}\cdot R^2$$

$$\frac{1}{4\mu}\cdot\frac{-\partial p}{\partial x} = \frac{\bar{u}}{R^2} = \frac{0.75}{(0.1)^2} = 75$$

$u = 75 \times ((0.1)^2 - (0.06)^2)$

$u = 0.48\ m/s$

$y = 0.04\ m \rightarrow \boxed{u = 0.48\ m/s}$