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Section :- "B"

Subject :- Advanced Fluid Mechanics

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"Summer"

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Question No 01

a) Write down expressions for velocity Profile in laminar flow inside the Pipe.

sol:

Velocity Profile in laminar flow

As

$$h_L = \frac{\tau \cdot 2L}{r \gamma}$$

from the velocity $\Rightarrow \tau = \mu \frac{du}{dy}$

where u is velocity at distance "y" from boundry.

Thus

$$y = r_0 - r$$

$$dy = dr_0 - dr$$

$$dr_0 = \text{const} = 0$$

$$dy = -dr$$

Thus

$$\therefore \quad \tau = -\mu \frac{du}{dr}$$

Now

$$h_L = \frac{-\mu \, du \, 2L}{r \, \gamma \, dr}$$

$$du = -\frac{h_L \gamma}{2 \mu L} r \, dr$$

Integrating b/ sides

$$\int du = \int -\frac{h_L \gamma}{2 \mu L} \cdot r \, dr$$

$$u = -\frac{h_L \gamma}{2 \mu L} \cdot \frac{r^2}{2} + C$$

Now Applying boundary conditions

when $r = 0$, $u = max$

Thus $U_{max} = 0 + C$

$$\therefore \quad C = U_{max}$$

Putting values in general equation.

$$U = -\frac{h_L \gamma}{2\mu L}\cdot\frac{r^2}{2} + c$$

$$\Rightarrow \quad u = U_{max} - \frac{h_L \gamma}{2\mu L}\cdot\frac{r^2}{2}$$

or

$$U = U_{max} - K r^2 \qquad \because K = \frac{h_L \gamma}{4\mu L}$$

Now As we know $u = 0$ when $r = r_0$

$$\therefore \quad U_{max} = K r_0^2 = \frac{h_L \gamma}{4\mu L}\cdot r_0^2$$

This is also know critical velocity "V_{cr}"

$$\therefore \quad V_c = \frac{h_L \gamma}{4\mu L}\cdot r_0^2 = \frac{h_L \gamma}{16\mu L}\cdot D^2$$

The average velocity will be

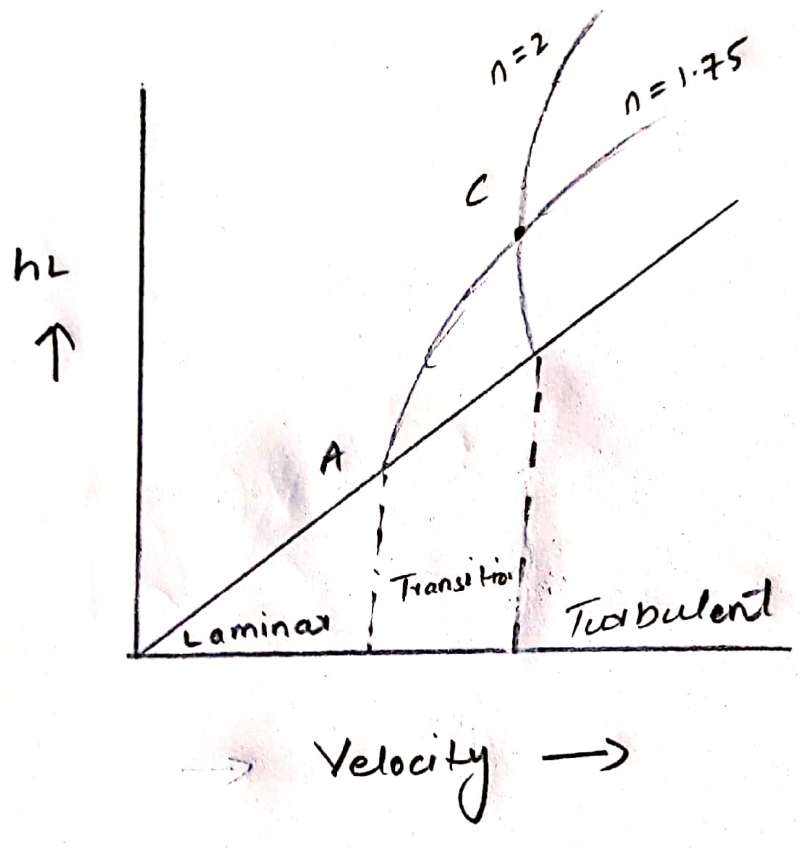
$$V_{av} = \frac{V_{cr} + 0}{2} = 0.5\,V_{cr}$$

b) Define critical Rynold number. write downs its equation.

CRITICAL REYNOLDS NUMBER :-

If head loss in given length of uniform pipe is measured at different values of velocity. It will found that as long as velocity is low enough to secure laminar flow. The head loss due to friction will be directly Proportional to velocity. but increase in velocity. change flow from Laminar to turbulant cause change in head loss Thus if values are Plotted lines obtained with slope ranging about 1.75 to 2.

Thus for laminar, drop of energy various as v and for turbulant friction varies as v^n where n is 1.75 to 2.



The upper critical reynolds number corresponding to Point B is indeterminate and depend upon ease to Prevent intial disturbance. Its value is 4000.

But normally, its impossible for flow to be in straight the after R is at 2000. Thus lower value is much more definite than higher one is dividing Point. Thus Lower value is true Critical Reynold number.

Equation :-

$$R = \frac{D V_{cr}}{\upsilon}$$

Question No (02)

An oil of ($S = 0.7$) and kinematic viscosity of 1.8×10^{-5} m^2/s flows in 150mm Pipe at 0.5 m^3/s. Find the centre line velocity. velocity at 10 mm from edges and velocity at adge of the Pipe. Also find max shear stress at wall of the Pipe ?

Given data:-

$S = 0.7$

$V = 1.8 \times 10^{-5}$ m^2/s

$d = 150mm, 0.15m$

$Q = 0.5 L/s$

Required data :

$f = ?$

$T = ?$

velocity = ?

1)

Solution :-

<u>check flow</u>

$R = \frac{DV}{\upsilon}$ $V = \frac{Q}{A} = \frac{0.001 \times 0.5}{\pi/4 \, (0.15)^2}$

$V = 0.029$

$R = \frac{0.15 \times 0.029}{1.8 \times 10^{-5}}$

$= 241 < 2000$ laminar

As $V_{av} = \frac{V_{cr}}{2}$

$V_{cr} = V_{av} \times 2$

$V_{cr} = 0.029 \times 2$

$= 0.058$

$U = U_{max} - k r_0^2$

When we have $r = r_0 = 0.075 \Rightarrow U = 0$

$\therefore U_{max} = k r_0^2$

$$K = \frac{U_{max}}{r_0^2}$$

$$= \frac{0.058}{(0.075)^2} = \frac{0.058}{0.0056}$$

$$= 10.35$$

For Laminar

$$f = \frac{64}{R}$$

$$= \frac{64}{241}$$

$$= 0.265$$

$$\tau = \frac{f}{4} \cdot \rho \cdot \frac{V^2}{2}$$

$$= \frac{0.26}{4} \times 0.7 \times 1000 \times \frac{(0.029)^2}{2}$$

$$= 0.065 \times 700 \times 0.00084$$

$$= 0.0382 \; N/m^2$$

velocity at 10 mm from edge

$$U = U_{max} - k r_0^2$$

$$= 0.058 - 10.35 \, (0.01)^2$$

$$= 0.058 - 0.00135$$

$$= 0.058 - 0.00135$$

$$= 0.056$$

At boundry or Edges of Pipe.

$$U_{max} = 0 + C$$

when $r = 0$, $U = U_{max}$

$$U_{max} = 0.058$$

Max shear stress at wall of Pipe.

Maximum shear stress at wall of Pipe is

$$\tau_0 = \frac{f}{8} \times \rho \times V^2$$

$$= \frac{0.26}{8} \times 0.7 \times 1000 \times (0.029)^2$$

$$= 0.032 \times 700 \times 0.00841$$

$$\tau_0 = 0.018 \ N/m^2$$