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Section	A
Subject	Advance Fluid Mechanics
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Q No 1 Part (a)

Expresion For Velocity Profile in laminar Flow

As $= h_L = \frac{\tau 2L}{R\gamma}$

From viscocity $\therefore \mu \, du/dy$

Where μ is value of velocity at distance from boundry.

$\therefore y = r_0 - r$

$dy = dr_0 - dr$

$d r_0 = \text{constant} = 0$

$dy = dr$

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

Now

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

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

Integrating::

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

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

$r = 0 \quad u = u_{max}$

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

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

$$U = U_{max} - K r^2$$

Now as we know that $V = 0$ when $r = r_0$

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

It is also known as V_{cr}

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

The average velocity may be taken as.

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

$$= \frac{h_L \gamma D^2}{32 \mu L}$$

As $\gamma = g\rho$, $\mu / \rho = \nu$

$$\frac{32 \mu L V}{\gamma D^2} \Rightarrow \frac{32 \mu L V}{\rho g \cdot D^2} \Rightarrow 32 \frac{\nu L}{g D^2} V$$

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QNo # (01) (b)

Critical Rynold Number

Definition

The reynold number at the flow becomes turbulent is called the critical reynold number, Re_{cr}. The value of critical reynold number is different for different geometric and flow condation. For internal flow in circular pipe, The generally accepted value of critical reynold's number is

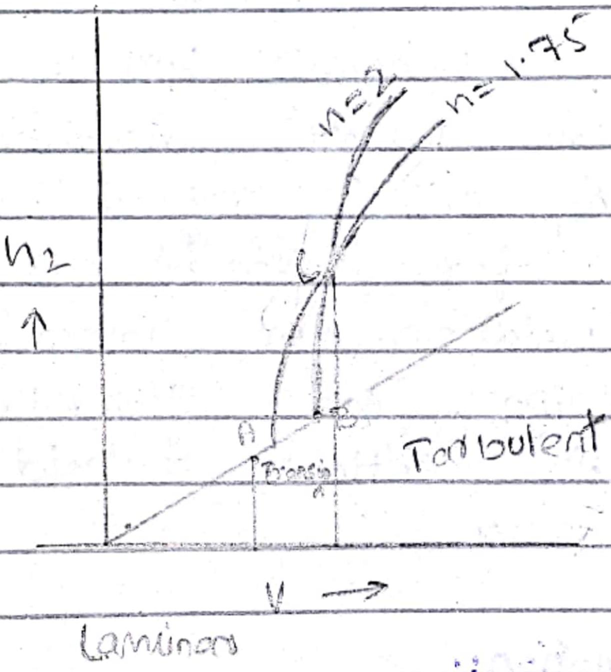
$Re_{cr} = 2300$

Explanation:.

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 frication will be directly proportional to velocity, but increase in velocity change flow from laminar to turbulent 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 varies as U and for turbulent frication varies as U^n where n is 1.75 to 2.

Graphical Explanation:



The upper critical reynolds number corresponding to point B is intermirate and depeds upon care taken to prevent intial disturbine. Its value is 4000, But normally its possible for flow to be in straight afte R at 2000. Thus lower value is mush more definite then higher one and is dividing point. Thus lower value is true critical Reynold number.

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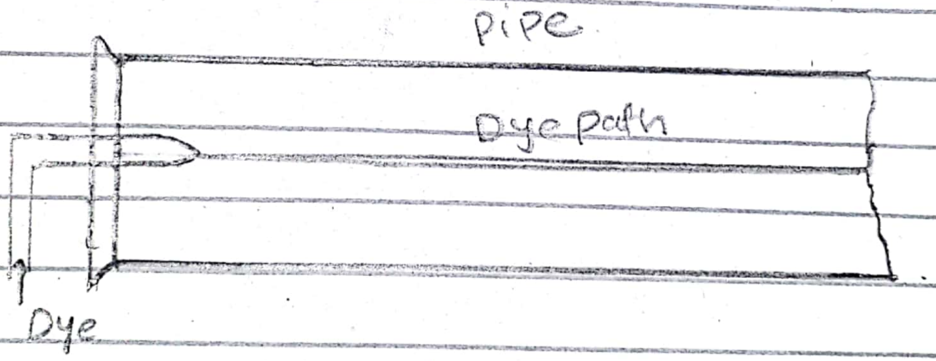
- ## Evuation of Critical reynold number

$$R = \frac{DVP}{\mu} = \frac{DV}{V}$$

For a circular pipe, we usally take the significent linear dimension L as the pipe diameter D.



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Q No # 2

Given Data

Oil having $S = 0.7$
Kinametic viscosity $= 1.8 \times 10^{-5}\ m^2/sec$
Dia of pipe $= 150\,mm = 0.15\,m$
Flow $= 0.5\ L/sec = 0.0005\ m^3/sec$

Required Data

Centerline velocity = ?
Velocity at 10 mm from edge
Velocity at edge of pipe
Max shear stress at wall

solution

As we know that

First we chick Flow is laminar oR turbulent.

$$R = \frac{DV}{\nu} \longrightarrow (A)$$

Now

$$V = \frac{Q}{A} = \frac{Q}{\frac{\pi}{4}d^2} \qquad \because A = \frac{\pi}{4}d^2$$

$$V = \frac{0.0005}{\frac{\pi}{4}(0.15)^2}$$

$$V = 0.028 \text{ m/sec}$$

Now put V in eq (A)

$$R = \frac{(0.15)(0.028)}{1.8 \times 10^{-5}}$$

$R = 233.37 < 2000$ so The flow is (laminar)

$V_{cr} = 2V = 2 \times 0.028$

$V_{cr} = 0.056 \text{ m/sec}$

As

$$u = u_{max} - Kr^2$$

at

$r = r_0 = 0.075 \text{ m}, \; u = 0$

Thus

$\cancel{u}^{0} = u_{max} - Kr^2$

$u_{max} = Kr^2$

$$K = u_{max}/r^2 = \frac{0.056}{(0.075)^2}$$

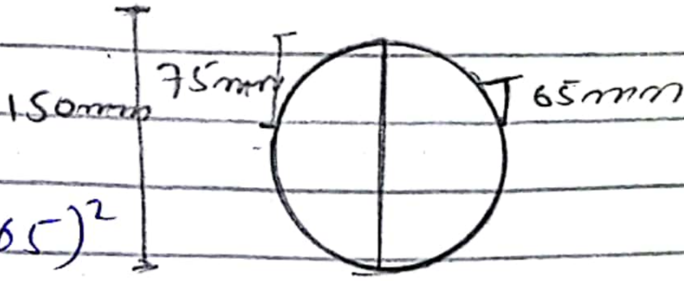
$K = 9.96$

We get a equation

$$u = 0.056 - 9.96(r^2) \rightarrow (B)$$

Velocity at 10mm form edge

$r = 0.065\,m$



$$V = 0.056 - 9.96(0.065)^2$$

$$V = 0.014\ m/sec$$

Velocity at edge

$$r = 0.075\,m$$

$$V = 0.056 - 9.96\,(0.075)$$

$$V = -0.00002\ m/sec \quad say\ v = 0$$

Similarly :-

$$f = \frac{64}{R} = \frac{64}{233.33}$$

$$f = 0.27$$

Shear stren at wall

$$\tau = \frac{f}{4} \rho \frac{V^2}{2} \quad \text{—— (c)}$$

putting values

$$\tau = \frac{0.27}{4} \times (0.7 \times 1000) \times \frac{(0.056)^2}{2}$$

$$\tau = 0.074 \ N/m^2$$