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Sec :- A

Subject :- Fluid Mechanics II

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Q no 1 (A)

Ans:-

Velocity profile for laminar flow:-

As we have

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

From viscosity $\Rightarrow \tau = \mu \dfrac{du}{dy}$ $\rightarrow$ (x)

Where "u" is velocity at distance "y" from the boundary.

Thus, $y = \varepsilon_0 - \varepsilon$

$$dy = \cancel{d\varepsilon_0}^{\,0} - d\varepsilon$$

$$dy = -d\varepsilon$$

$\because d\varepsilon_0$ constant value

Putting value in (x)

$$\tau = -\mu \frac{du}{d\varepsilon}$$

Now. $h_L = \dfrac{\tau \cdot 2 \cdot L}{\varepsilon\, r}$. $\varepsilon\, dr$

Integrating on b.s

$$\int du = \int -\frac{h_L r}{2\mu L} \cdot \varepsilon \cdot d\varepsilon$$

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

Now for $\mathcal{E}=0$, $u = u_{max}$

Putting value

$$u = -\frac{hL\gamma}{2\mu L} \cdot \frac{\mathcal{E}^2}{2} + C$$

$u = u_{max}$, $u_{max} = 0 + C$

$$C = u_{max}$$

Thus $u = u_{max} - \dfrac{hL\gamma}{2\mu L} \cdot \dfrac{\mathcal{E}^2}{2}$

(velocity at any point)

Assume $k = \dfrac{hL.\gamma}{4\mu L}$ $\therefore u = u_{max} - k\mathcal{E}^2$

As for $\mathcal{E} = \mathcal{E}_0$

$0 = u_{max} - k\mathcal{E}_0^2$ or $u_{max} = k\mathcal{E}_0^2 = \dfrac{hL\gamma}{4\mu L} \cdot \mathcal{E}_0^2$

It is also known as critical velocity

Nov,

$$V_{av} = \frac{V_{C\mathcal{E}} + 0}{2} = 0.5 V_{C\mathcal{E}}$$

Average velocity.

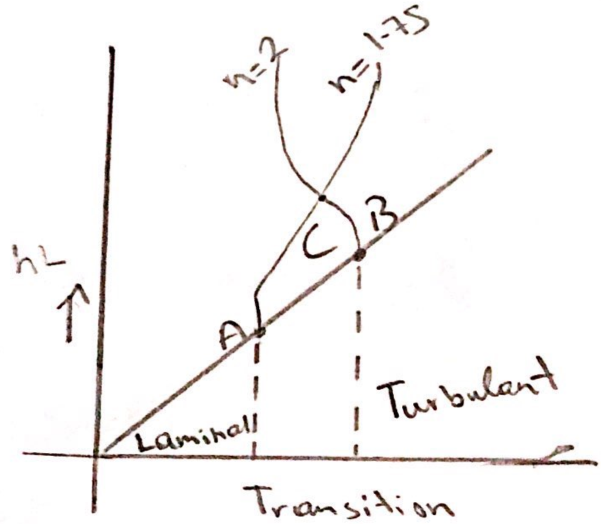
Q no (1) Part (B)

Critical Reynold number:-

If headloss is given lenght of uniform pipe is measured at different values of velocity, it will be found that as long as velocity is low enough to secure laminar flow the headloss due to friction will be directly proportional to velocity but as the flow changes from laminar to turbulant, the headloss varies as "v^n" where n is 1.75 to 2.

$h_L \propto v$

$h_L \propto v^n$



The upper critical reynold number corresponding to point B is indeterminate and depends on care taken to prevent initial disturbance its value is 4000 but normally it is not possible for flow to be in straight line after R is 2000. The lower value point A is much definite then higher one - lower values is true critical Reynold number and is equal to 2000.

$$R_e = \frac{\rho V L}{\mu}$$

Qno2)

Given Data:-

oil having $S = 0.7$

Kinematic viscosity $= 1.8 \times 10^{-5}$ m²/sec

Flow $= 0.5$ L/sec $= 0.0005$ m³/sec

Required Data:-

Centerline velocity =?

velocity at 10mm from edge =?

velocity at edge of pipe =?

Max shear stress at wall =?

Solution:-

First we will check flow is laminar or Turbulent

$$R = \frac{Dv}{\nu} \quad -①$$

$$v = \frac{Q}{A} = \frac{Q}{\frac{\pi}{4}d^2} = \frac{0.0005}{\frac{\pi}{4}(0.15)^2}$$

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

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

$$R = 233.37 < 2000 \text{ (laminar)}.$$

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

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

As:-

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

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

Thus

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

$u_{max} = kr^2$

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

$k = 9.96$, $K = 9.96$ Pas

we get a equation

$u = 0.056 - 9.96(r^2)$

velocity at 10mm from edge

$r = 0.065\text{m}$

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

$v = 0.014 \text{ m/sec}$

velocity at edge

$r = 0.075$

$v = 0.056 - 9.96(0.075)$

$v = -0.00002 \text{ m/sec}$ say $v = 0$

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Similarly :-

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

$$f = 0.27$$

Shear stress at wall :-

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

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

$$\tau_o = 0.074 \ N/m^2$$ Ans