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Sec :- C

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Subject :- Adv. Fluid Mechanics

Question :- 01 P(A)

Velocity Profile in laminar flow inside the pipe :-

→ For a circular Pipe :-

The laminar flow is defined to have the flow Reynolds number < 2000

Reynolds Number :-

$$Re = \frac{\rho V D}{\mu} = \frac{VD}{\nu} < 2000$$

for Laminar flow

→ Laminar Pipe flow :-

The Shear stress laminar flow is linearly related the fluid viscosity.

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

Added by the above relation.

$$\mu \frac{du}{dr} = -\frac{r}{2} \frac{dp}{dx}$$

To Intergrate the above Yields.

$$u = \frac{1}{\mu} \frac{dp}{dx} \frac{r^2}{2} + C$$

The Integration constant C can be determined by $u =$ at $r = D/2$

(on solid boundry)

$$0 = \frac{1}{\mu} \frac{dp}{dx} \frac{r^2}{2} + C$$

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

putting values

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

$\therefore u_{max} = 0 + C$

$C = u_{max}$

Thus

$$u = u_{max} - \frac{hLr}{2\mu L} \cdot \frac{\varepsilon^2}{2}$$

$\therefore$ velocity at any Point

$\Rightarrow$ Assume $K = \frac{hL \cdot r}{4 \cdot \mu L}$ $(u = u_{max} - Kr^2)$

As for $\varepsilon = \varepsilon_o$, $u = 0$

Date:

$$0 = \mu_{max} - K\varepsilon_0^2$$

$$\text{or } \mu_{max} = Kq_0^2 = \frac{hLv}{4\mu L} = \varepsilon^2$$

It is also know critical velocity.

Now,

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

(average velocity)

$\Longleftrightarrow$

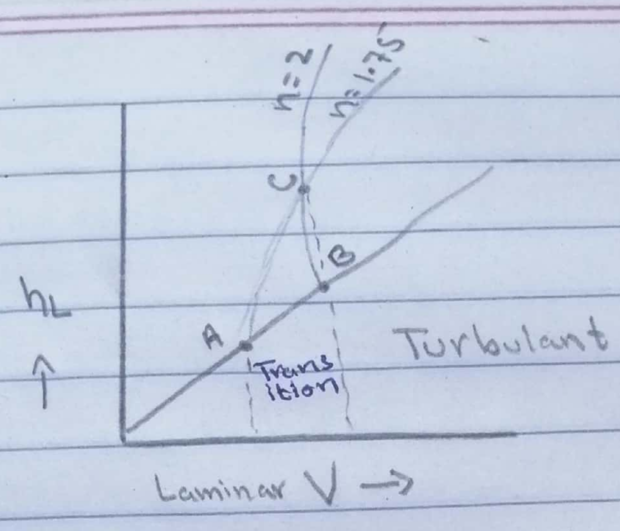
Question :- 01 P(B)

Critical Reynolds :-

Critical reynolds number which decides whether flow is laminar or turbulent.

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, changes flow from laminar to turbulant change in head loss. Thus if value are plotted, lines ~~dot~~ obtained with Slope raunging about 1.75 to 2.

Thus for laminar, drop of energy varies 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 depends upon care taken to prevent initial disturbance. It value is 4000. But normally, its impossible for flow to be In straight the after R ~~flow~~ is at 2000. Thus lower value is much more definite than higher one and is dividing point. Thus lower value is true crictical Reynold's number.

$$R = \frac{DV\rho}{\mu} = \frac{DV}{\nu}$$

Q2 Given Data.

Oil having $S = 0.7$
Kinematic 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 10mm from edge = ?

velocity at edge of pipe = ?

Max shear stream at well = ?

Solution:

First we check the flow is Liminar or turbulent;

$$R = \frac{DV}{\nu} \rightarrow 1$$

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

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

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

$R = 233.33 < 2000$ (LAMINAR FLOW)

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

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

As:

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

at

$r = r_0 = 0.075\,m, \quad u = 0.$

Thus

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

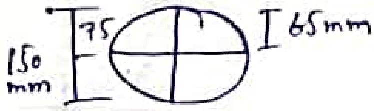
$$U_{max} = Kr^2$$

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

$\boxed{K = 9.96}$

we get a equation;

$$u = 0.056 - 9.96(r^2) \longrightarrow *$$



→ velocity at 10 mm from edge

$$r = 0.065 m$$

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

$$\boxed{V = 0.014 \ m/sec}$$

velocity at edge;

$$r = 0.075 m$$

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

$$V = -0.00002 \ m/sec$$ Say $V = 0$

Similarly:

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

$$\boxed{f = 0.27}$$

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Shear stress at wall ;

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

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

$$\boxed{\tau = 0.074 \ N/m^2}$$

Ans

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