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SUBJECT # Advance fluid Mechanic's

SIR # Eng. ABDUL WAHEED

Ques 1a:-

write down expressions for velocity profile in laminar flow inside the pipe?

Answer

Velocity profile for laminar flow:-

As we have

$$hL = \frac{\tau . 2L}{\varepsilon r}$$

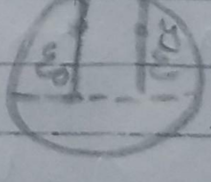
From viscosity $\Rightarrow$ $\tau = \mu \frac{du}{dy}$ —— (x)

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

Thus

$$y = \varepsilon_0 - \varepsilon$$

$$dy = d\varepsilon_0 - d\varepsilon$$



$\therefore d\varepsilon_0$ constant value

putting value in (x)

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

Now $hL = \frac{\tau . 2 . L}{\varepsilon r} . \varepsilon dr$

Integrating on b/s

$$\int du = \int -\frac{hLr}{2\mu L} \cdot r \cdot dr$$

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

Now for $r = 0$, $u = u_{max}$

Putting value

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

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

$C = u_{max}$

Thus $u = u_{max} - \frac{hLr}{2\mu C} \cdot \frac{r^2}{2}$

(velocity at any point)

Assume $K = \frac{hLr}{4\mu L}$ $\therefore u = u_{max} - K r^2$

As for $r = r_0$, $u = 0$

$$0 = u_{max} - K r_0^2$$

$$u_{max} = K r_0^2 = \frac{hLr}{4\mu L} \cdot r_0^2$$

(It is also known as critical velocity)

Now

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

where av = avelge velocity

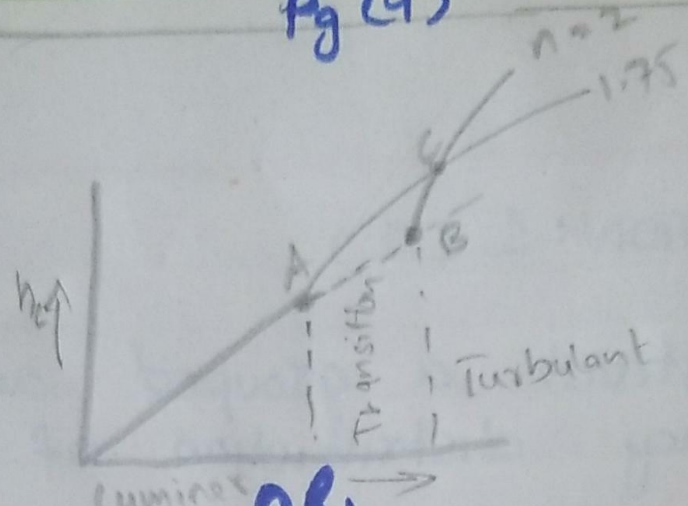
Que 1 b:-

Define crytical rynold number. Write down it's equation

Answer:

Crytical rynold number:-
If head loss in given length of uniform pipe is measured at different values of velocity It will found 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 chang flow from laminar to turbulant cause change in head loss. Thus if value are plotted, line obtained with slope ranging about 1.75 to 2
Thus for laminer 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 intermediate and depends upon care taken to prevent initial disturbance. It's value is 4000 but normally its impossible for flow to be in stright line after R is at 2000.



OR

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

For example:

In external flow over a flat plate critical reynolds number $5*10^5$ and renolds number below it flow would be laminar and above the critical reynold's number flow will be turbulant.

In case of internal flow it reynolds number is below 2000 (critical reynolds number) flow would be laminar & if it is above 4000 flow would be treated as turbulant, region from reynolds num 2000-4000 is transition.

* **Equation:** Ratio of intertial force to viscous force is called Reynold's number

$$R = \frac{FI}{FV} \Rightarrow FI = ma = \rho l^3 \cdot \frac{L}{T^2}$$

$$\Rightarrow \rho L^4 T^{-2} = \rho \left(\frac{L}{T}\right)\left(\frac{L}{T}\right) \Rightarrow \rho v^2 L^2$$

$$FV = \mu (du/dy) A = \mu (V/L) L^2 = \mu V L$$

$$R = \frac{L^2 v^2 \rho}{L V \mu} = \frac{L V \rho}{\mu} = \frac{L V}{\nu} \Rightarrow \nu = \text{Kinematic velocity}$$

For circular pipe :-

$$\boxed{R = \frac{D V \rho}{\mu} = \frac{D V}{\nu}}$$

Que 2:-

An oil of (s = 0.7) and kinetic velocity viscosity of 1.8×10^{-5} m/s . . .
. . . . wall of pipe.

Ans :-

Given data:-

-> Oil having S = 0.7
-> Kinematic viscosity = 1.8×10^{-5} m²/sec
-> Dia of pipe = 150 mm = 0.15m
-> Flow = 0.5 L/sec = 0.0005 m³/sec

Req:-

* Centerline velocity = ? , * Velocity at 15mm from edge = ? * Velocity at edge of pipe = ?
* Max shear stress at wall = ?

Solution:-

First we check flow is laminar or Turbulent.

$$R = \frac{Dv}{\nu} \quad \text{—} \quad (1)$$

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

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

$R = \frac{(0.15)(0.028)}{1.8\times10^{-5}} \Rightarrow \boxed{233.37} < 2000$ (laminar)

~~R = 233.37~~ $V_{cr} = 2v \Rightarrow 2\times 0.028 \Rightarrow \boxed{0.056\ m/sec}$

As

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

at

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

Thus

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

$U_{max} = Kr^2$

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

$\boxed{K = 9.96}$

We get a equation

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

at

Velocity at 10mm from edge

$r = 0.065\,m$

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

$V = 0.014\ m/sec$

Velocity at edge;

$r = 0.075\,m$

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

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

Similarly

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

$$f = 0.27$$

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