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Subject : Advance fluid mechanics

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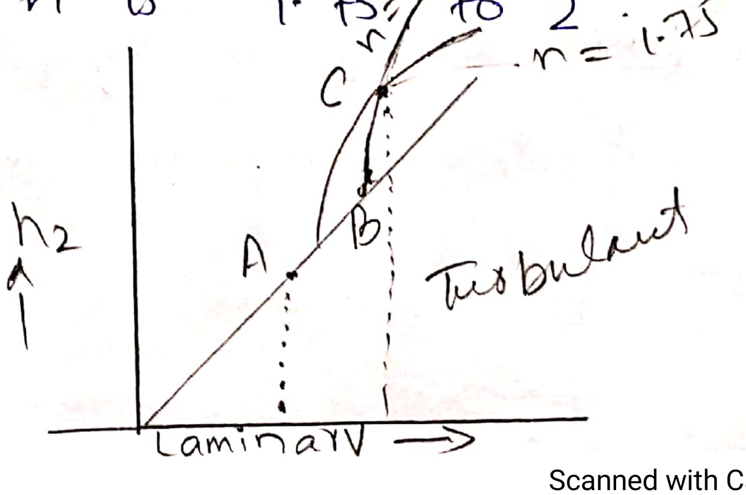
Q No 1 (b)

Ans

Reynold's number:: Critical

If head loss in given length of uniform pipe is measured at difficult values of 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 value are plotted, lines dotained with slope gauging about 1.75 to 2.

Thus for laminar drop of energy varies as V and for turbulant friction varies as V^4 when n is 1.75 to 2



The upper critical reynold's number corresponding to point B is intermediate and depend upon care taken to prevent initial disturbance. its value is 4000 but normally, it's impossible for flow to be in straight line after R is at 2000. thus lower value is much more definite than higher one and is dividing point. thus lower value is true critical Reynold number.

equation :-

$$R_{cr} = \frac{DV\rho}{\mu} = \frac{DV_{cr}}{\nu}$$

μ = fluid dynamic viscosity in kg/(m.s)

ρ = Fluid density in kg/m^3

V = fluid velocity in m/s

D = pipe diameter in m.

Velocity profile for liminar flow :-

As $h_L = \dfrac{\tau \cdot 2L}{\varepsilon r}$

From viscocity $\longrightarrow$ $\tau = \mu \dfrac{du}{dy}$

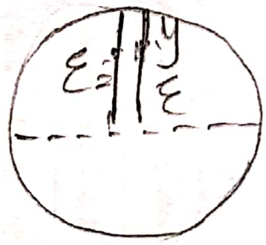
wher 'u' is velocity at distance 'y' From the boundry.

thus

$$y = \varepsilon_0 - \varepsilon$$

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

$$dy = -d\varepsilon$$



$d\varepsilon_0 \rightarrow$ constant value

putting value in (*)

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

Now, $h_L = \dfrac{\tau \cdot 2 \cdot L}{\varepsilon \cdot \gamma} = -\dfrac{\mu du \cdot 2L}{\varepsilon \cdot \gamma \cdot d\varepsilon}$

or $du = \dfrac{-h_L \gamma}{2\mu L} \cdot \varepsilon \, d\varepsilon$

Integrating b/s

$$\int du = \int -\frac{h_L \gamma}{2\mu L} \cdot \mathcal{E} \cdot d\mathcal{E}$$

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

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

putting value

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

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

→ Thus $u = u_{max} - \frac{h_L \gamma}{2 \cdot \mu L} \cdot \frac{\mathcal{E}^2}{2}$ $\quad$ $\cancel{u = u_{max}} - K\mathcal{E}^2$

→ Assume $K = \frac{h_L \gamma}{4 \cdot \mu L}$ ∴ $u = u_{max} - K l^2$

→ As for $\mathcal{E} = \mathcal{E}_0$, $u = 0$

$0 = u_{max} - K l^2$ or $u_{max} = K l^2 = \frac{h_{L0}}{4\mu L} \cdot \mathcal{E}^2$

It is also known as critical velocity

Now

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

Q No 3

Given data:

- Oil of $S = 0.7$
- Kinematic viscocity $= \nu = 1.8 \times 10^{-5}\ m^2/s$
- Dia of pipe $= 150\ mm = 0.15\ m$
- $Q = 0.5\ m^3/s$

Required data:

Centerline velocity, $U_{max} = ?$

velocity at 10mm from edge = ?

velocity at edge of pipe = ?

max shear stress at wall of pipe = ?

Solution:

Check the flow of oil

$$V = \frac{Q}{A} = \frac{0.5}{\frac{\pi}{4}(0.15)^2}$$

$$V = 28.29\ m/s$$

$$\rightarrow R = \frac{DV}{\nu} = \frac{0.15\,(28.29)}{1.8 \times 10^{-5}}$$

$$R = 235750 > 2000$$

- Flow is turbulent

$$F = \frac{0.316}{R^{0.25}}$$

$$F = \frac{0.316}{(235750)^{0.25}}$$

$$F = 0.0143$$

⇒ **Centerline velocity:**

$$U_{max} = v\left(1 + 1.33\sqrt{f}\right)$$

$$= 28.29\left(1 + 1.33\sqrt{0.0143}\right)$$

$$U_{max} = 32.74\ m/s$$

⇒ **Velocity at 10mm from edge:**

$$U = U_{max} - 2.5\sqrt{\frac{\tau_0}{\rho}}\ \ln \cancel{\frac{r_0}{r_0 - r}}\ \frac{r_0}{r_0 - r}\ \frac{r_0}{r_0 - r}$$

First calculate share

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

$$= \frac{(0.0143)(0.7 \times 1000)(28.29)^2}{8}$$

$$\boxed{\tau_0 = 1001.40\ N/m^2}$$ shear stress at wall.

$$U_{10\,mm} = U_{max} - 2.5\sqrt{\frac{\tau_0}{\rho}}\ \ln\frac{r_0}{r_0 - r}$$

$$= 32.74 - 2.5\sqrt{\frac{1001.40}{0.7 \times 1000}}\ \ln\frac{0.075}{0.075 - 0.01}$$

$$\boxed{U_{10\,mm} = 32.31\ m/s}$$

Velocity at edge :-

$$U_{max} = V\left(1 + 1.33\sqrt{f}\right)$$

$$V = \frac{U_{max}}{1 + 1.33\sqrt{f}}$$

$$V = \frac{32.74}{1 + 1.33\sqrt{0.0143}}$$

$$V = \boxed{28.24\ m/s}$$