Mid Term Paper Summer - 20

Name — Rizwan ullah khan

ID — 7807

Subject — Adv. fluid mechanics

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Submitted to — Engr. Abdul waheed.

Name : Rizwan ullah khan   ID : 7807

Q:1 | Part (A)

Velocity profile in Laminar flow :-

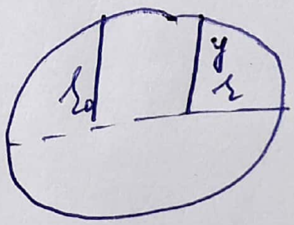
As $h_L = \frac{\tau \cdot 2 \cdot L}{r \gamma}$ ——— (x)

From viscosity → $\tau = \mu \frac{du}{dy}$

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

Thus

$y = r_0 - r$



$dy = d r_0^{\nearrow 0} - dr$

$dy = -dr$

Putting values in (x)

$\tau = -\mu \frac{du}{dr}$ ($\because dr \rightarrow$ constant value)

Now, $h_L = \frac{\tau \cdot 2 \cdot L}{r \cdot \gamma}$ • $r\,d\gamma$

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Integrating Both Side

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

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

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

put value

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

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

$C = U_{max}$.

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

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

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Now as we know that $u = 0$ when $r = r_o$

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

also known as V_{cr}

$$V_{cr} = \frac{h_L \gamma}{4 \mu L} \cdot r_o^2 = \frac{h_L \gamma}{16 \mu L} \cdot D^2$$

The average velocity may be taken as

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

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

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

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

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Q 1 Part B :-

Critical Reynold number:-

If head loss is given length 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 turbulent, the head loss varies as V^n where n is 1.75 to 2.

⇒ The upper Critical reynold number corresponding to point B is inderminate and depends on Care taken to

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prevent initial disturbance.

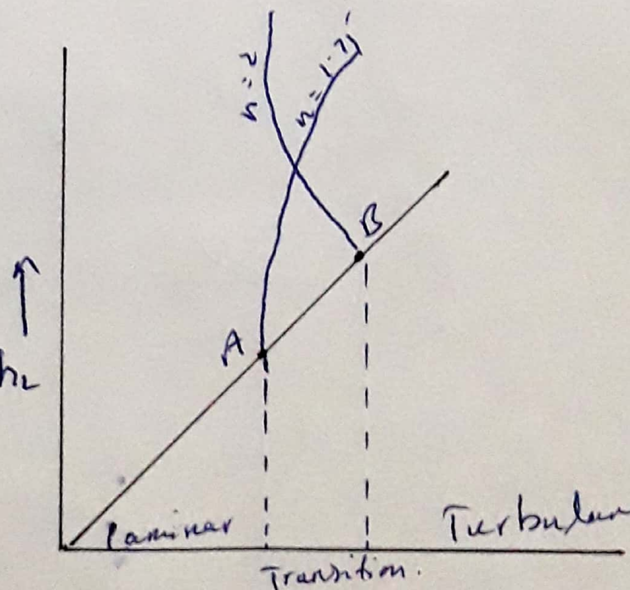
⇒ Its value is 4000 but normally it is not possible for flow to be in straight line after R is at 2000.

⇒ The lower value point A is much difinite than higher one. Lower value is true Critical Reynold number and is equal to 2000.

$$R = \frac{D V_{cr.}}{\nu}$$

$h_L \propto V$

$h_L \propto V^n$



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Question 2 /

Given data :-

Kinematic viscosity = $\nu = 1.8 \times 10^{-5}\ m^2/sec$

Diameter of pipe $(d) = 150mm = 0.15m$

Specific Gravity of oil $(S) = 0.7$

Discharge / flowrate $= Q = 0.5\ Lit/sec$

$= \frac{0.5}{1000} = 0.0005\ m^3/sec$

Solution:-

First Find Reynold Number.

$R = \frac{DV}{\nu}$ → V is unknown

$Q = AV \Rightarrow V = Q/A$

$A = \frac{\pi}{4} d^2 = \frac{\pi}{4}(0.15)^2 = 0.0176 m^2$

$V = \frac{0.0005}{0.176}$ $\boxed{V = 0.028 m/sec}$

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So Reynold number will be

$$R = \frac{DV}{\nu} = \frac{0.15 \times 0.028}{1.8 \times 10^{-5}} = 233$$

$\boxed{R = 233} < 2000$

↓

So flow is Laminar.

Now Critical velocity:-

$V_{cr} = 2 V_{av}$

$V_{cr} = 2(0.028) = 0.056 \text{ m/sec}$

By formula

$u = U_{max} - K r_o^2$

Find value of K.

For $r = r_o$, $u = 0$

$\Rightarrow 0.15/2 = 0.075 m$

So

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$0 = U_{max} - k r_o^2$

$k = \frac{U_{max}}{r_o^2} = \frac{(0.056)}{(0.075)^2} = 9.95$

Velocity at 10 mm from Edge of Pipe:-

By formula

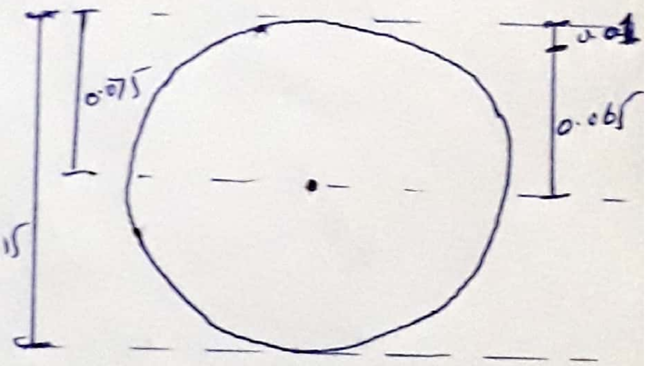
$u = U_{max} - k r_o^2$

$= 0.056 - (9.95)(0.075)^2$

$u = 0.0000312$ m/sec

↓

negligable so we can consider zero (0).



Max Shear Stress at wall of pipe:-

$\overline{\tau_o} = \frac{f}{8} \cdot \rho \cdot V^2$

$= \frac{0.27}{8} \times 700 \times (0.056)^2$

$\boxed{\overline{\tau_o} = 0.074 \text{ N/m}^2}$

For Laminar

$f = 64/R$

$= 64/233$

$\boxed{f = 0.27}$

$S = \frac{\rho_{fluid}}{\rho_{water}} = \frac{\rho_{oil}}{1000}$

$0.7 = \frac{\rho_{oil}}{1000} \Rightarrow \boxed{\rho_{oil} = 700 \text{ kg/m}^3}$