Mid Term Paper

Subject :: Advance Fluid Mechanics

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Attempt All Questions:-

Q1(a) Write down expression for velocity profile in laminar Flow inside the Pipe.

Ans Velocity profile for laminar Flow:-

As we have

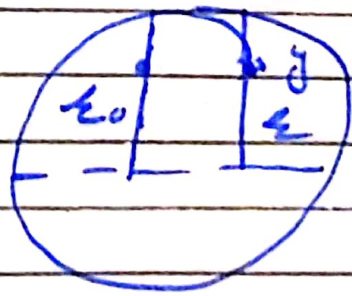
$$h_L = \frac{\tau . 2L}{r \gamma}$$

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

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

Thus,

$$y = r_0 - r$$



$$dy = d r_0 - dr$$

$$dy = -dr$$

$\because d r_0$ constant value

Putting value in (x)

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

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

Integrating on b/s

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

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

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

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

(velocity at any point)

Assume $k = \frac{h_L \cdot \gamma}{4 \mu L}$ $\therefore u = u_{max} - k r^2$

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

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

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

(It is also known as critical velocity.)

Now

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

↙ average velocity

Critical velocity is also written as

$$V_c = \frac{h_L \gamma \cdot D^2}{16 \mu L}$$

The average velocity may taken as

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

As $\gamma = g \rho$

$\mu / \rho = \nu$

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

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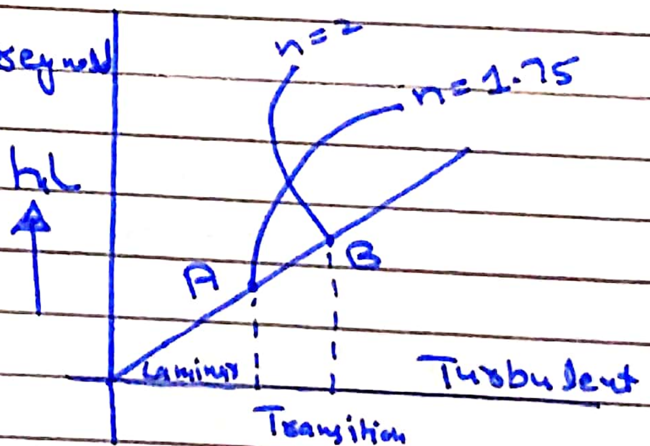
Q1(b) Define Critical Reynold number. Write down its equation:-

Ans If head loss in 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 head loss 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 indeterminate & depend 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 at 2000.

$$R = \frac{DV\rho}{\mu} = \frac{DV}{\nu} \text{ (Circular pipe)}$$

⇒ The lower value point A is much definite than higher one. Lower value is true critical Reynold number & is equal to 2000.

$h_L \propto V$

$h_L \propto V^n$

Formula for Reynold number is expressed as.

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

If

$Re < 2000$ Laminar

$Re > 4000$ Turbulent

$2000 < Re < 4000$ Transition

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Q2 Given Data:-

Specific Gravity (S) = 0.7
Kinematic viscosity (ν) = 1.8×10^{-5} m²/sec
Dia of pipe (d) = 150mm = 0.15m
Discharge (Q) = 0.5 L/sec

$$Q = \frac{0.5}{1000} = 5 \times 10^{-4} \text{ m}^3/\text{sec}$$

Sol:-

$$\text{Area} = \frac{\pi}{4}(0.15)^2 = 0.0176 \text{ m}^2$$

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

$$V = \frac{5 \times 10^{-4}}{0.0176}$$

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

$$\text{Reynold No } (R) = \frac{DV}{\nu}$$

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

$$R = 233 < 2000$$ (So flow is laminar)

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Now we have find Centerline velocity.

$V_{cr} = 2v_{cr}$

$v_{cr} = 2(0.028) = 0.056 \, m/sec$

$u = u_{max} - k r_0^2$

For $r = r_0 = 0.15/2 = 0.075m$

$u = 0$

Now we have

$u^0 = u_{max} - k r^2$

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

$k = 9.96$

We get equ from this

$u = 0.056 - 9.96(r^2)$ — (*)

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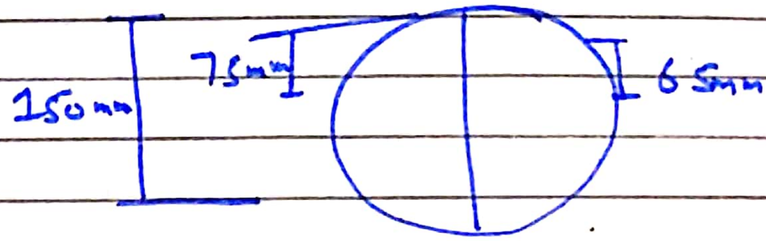

velocity at edge,

$r = 0.075m$

$v = 0.056 - 9.96(0.075)$

$v = -0.00002 \ m/sec$ $\quad v = 0$

velocity at 10mm from edge

$r = 0.065m$

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

$v = 0.014 \ m/sec$

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

$f = 0.27$

$\rho_{oil} = 0.7 \times 1000 = 700 \ kg/m^3$

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Max Shear stress at wall of Pipe

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

$$\overline{\tau_0} = \frac{0.27}{8} \times 700 \times (0.056)^2$$

$$\overline{\tau_0} = 0.074 N/m^2$$

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