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Subject :→ Fluid Mechanics-II

Department:→ civil-engineering

Exam :→ mid term (summer)

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Q1:→
a):→ Write down expressions for velocity profile in laminar flow inside the pipe?

Ans a):→ Velocity Profile for laminar flow:→

As we have

$$h_L = \frac{\tau_o 2L}{\xi r}$$

From viscosity => $\tau = \mu \frac{du}{dy}$ → (X)

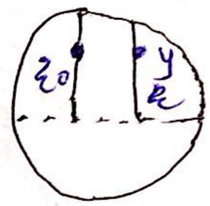
→ where "u" is velocity at distance "y" from the boundary

Thus,

$$y = \xi_o - \xi$$

$dy = d\xi_0 - d\xi$

$dy = -d\xi$



$\therefore d\xi_0$ constant value

Putting value in equation (x)

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

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

integrating on both side,

$$\int du = \int -\frac{hLr}{2\mu L} \cdot \xi \cdot d\xi$$

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

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

putting value

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

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

$C = u_{max}$

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

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

As for $\xi = \xi_0$, $u = 0$

$0 = u_{max} - K\xi_0^2$ or

$u_{max} = K\xi_0^2 = \frac{h_L \gamma}{4\mu L} \cdot \xi_0^2$

→ (It is also known as critical velocity).

Now $V_{av} = \frac{V_c \xi + 0}{2} = 0.5 V_c \xi$

↓

average velocity.

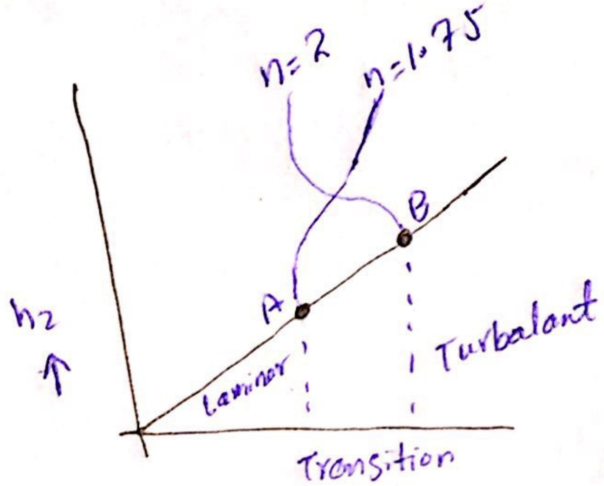
Q1):→

b):→ Define critical Rynold number. write down its equation?

b) Ans:→ Critical Reynold number:→ If headloss 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 headloss due to friction will be directly propotional to velocity but the flow changes from laminar to turbulant, the headloss varies as V where n is 1.75 to 2.

$h_L \propto V$

$h_L \propto V^n$



→ The upper critical reynold number corresponding to point B is indeterminate and depends on care taken to prevent initial distarbance. its value is 4000 but normally it is not possible flow to be in striaght line after R is 2000. The lower value point A is meet definite than higher one lower value is ture critical Reynold number and is equal to 2000.

Q3 :→

Ans :→

Given Data

Specific Gravity (S) = 0.7

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

Dia of pipe (d) = 150mm = 0.15m

Discharge (Q) = 0.5 L/sec

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

Sol :→ Area $= \frac{\pi}{4}(d^2)$

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

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

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

$V = 0.028\ m/sec$

Reynold number (R) = DV/ν

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

$= 233 < 2000$

↳ so laminar flow

Now centerline velocity,

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

$= 2(0.028)$

$= 0.056\ m/sec$

$u = U_{max} - K \xi_o^2$

for $\xi = \xi_o = \frac{0.15}{2} = 0.075m,\ u = 0$

Thus,

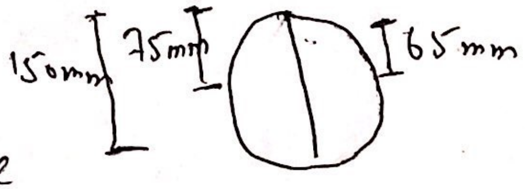
$U_{max} = K r^2$

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

$K = 9.96$

we get a equation

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



velocity at 10mm from edge

$r = 0.065m$

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

$V = 0.014\ m/sec$

Velocity at edge;

$r = 0.075m$

$V = 0.056 - 9.96(0.075)$

$V = 0.0002\ m/sec$ say $V = 0$

Similarly

$f = \frac{64}{R} = \frac{64}{233}$

$f = 0.27$

Shear stress at wall;

$\tau_0 = \frac{f}{4} \cdot \rho \frac{V^2}{2}$

$\tau_0 = \frac{0.27}{4} \times (0.7 \times 1000) \times \frac{(0.056)^2}{2}$

$\tau_0 = 0.074\ N/m^2$