Name : Sarmad Mahmoud

ID : 7828

Sec : A

Subject : Advanced Fluid Mechanics

Submitted to : Engr Abdul Waheed.

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Q # 1 (a)

→ Velocity profile for laminar flow :-

As we have

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

From viscosity → $\tau = \mu \, du/dy$

where u is velocity at distance y from the boundary

Thus $y = r_0 - r$

$dy = dr_0 - dr$

$dy = -dr$

Putting value in τ $\because dr_0 = \text{constant}$

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

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

Integrating on both sides.

$$\int du = \int -\frac{hLr}{2\mu L} \frac{\xi^2}{2} + C$$

Now for $\xi = 0$, $u = max$ 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 $u = u_{max} - \frac{hLr}{2\mu L} \cdot \frac{\xi^2}{2}$

(Velocity at any point)

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

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

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

$u_{max} = k\xi_0^2 = \frac{h \cdot Lr}{4\mu L} \cdot \xi_0^2$

→ Also known as critical velocity

$V_{avg} = \frac{V_c\xi + 0}{2} = 0.5 V_c \xi$ - Ans.

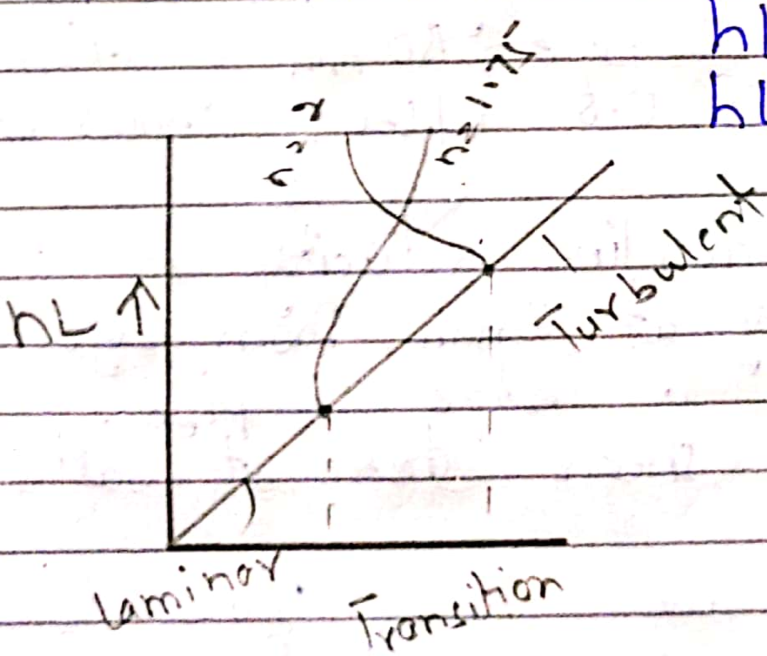
(b)

→ Critical Reynold Number :-

If headloss in given length of uniform pipe is measured at different values velocity it will be found as long as velocity is low enough to secure laminar flow, the headloss due to friction will be directly propotional to velocity but as the flow changes from laminar to turbulent the headloss varies as V^n 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 to prevent initial disturbance. Its value is 4000 but normally it is not possible for flow to be in straight line after R is 2000. The lower value point A is much definate than higher one. Lower value is true crytical Reynold number and is equal to 2000.

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

Q# 2

→ Problem

→ Given data :- Oil having $S = 0.7$
Kinematic viscosity $= 1.8 \times 10^{5}\ m^2/sec$
Dia of pipe $= 150\ mm = 0.15m$
Flow $= 0.5\ L/sec = 0.0005\ m^3/sec$

→ Required data :- Center line velocity
Velocity at 10mm from edge
" " edge of pipe.
Max shear stess at wall

→ Solution :- First we check flow is laminar or turbulent.

$$R = \frac{DV}{\nu} \quad — (i)$$

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

$V = 0.28\ m/sec$

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

$R = 233.37 < 2000$ (laminar)

$V_{cr} = 2V = 2 \times 0.028$
$= 0.056$ m/sec

As :-

$u = U_{max} - kr^2$

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

Thus

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

$U_{max} = kr^2$

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

$k = 9.96$

→ We get the equation

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

→ Velocity at 10 mm from edge.

$r = 0.065$

$V = 0.056 - 9.96(0.065)^2$
$= 0.014$ 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

$\tau = \frac{f}{4} \rho \frac{V^2}{2} = \frac{0.27}{4} \times (0.7 \times 1000) \frac{(0.056)^2}{2}$

$= 0.074$ N/m² — Ans.

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