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Section:. A

Subject:. Advanced Fluid Mechanics

Question No. 1

Part (a):

Write down expression for velocity profile in laminar flow inside the pipe.

Answer:

VELOCITY PROFILE IN LAMINAR FLOW:

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

from viscosity ∵ $\tau = \mu \frac{du}{dy}$

where u is value of velocity at distance y from boundary.

∵ $y = r_0 - r$

$dy = dr_0 - dr$

$dr_0 = \text{Const} = 0$

∴ $dy = -dr$

∵ $\tau = -\mu \frac{du}{dr}$

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Now,

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

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

Integrating,

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

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

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

$\therefore C = u_{max}$

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

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

Now as we know $u = 0$ when $r = r_0$

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

It is also known as V_{cr}.

$$\therefore V_c = \frac{h_L \gamma}{4\mu L} \cdot r_0^2 = \frac{h_L \gamma}{16\mu L} \cdot D^2$$

The average velocity may be taken as.

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

Question No. 2

Given Data:

Oil having $S = 0.7$

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

Dia. of pipe $= 150\ mm = 0.15\ m$

Required Data:

Centerline Velocity = ?

Velocity at 10mm from edge = ?

Velocity at edge of pipe = ?

Max. Shear stress at wall = ?

Solution:

First we will check whether the flow is laminar or turbulent;

$$R = \frac{DV}{\nu} \quad \text{---(1)}$$

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

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

$$R = \frac{(0.15)(0.298)}{1.8 \times 10^{-5}}$$

$$= 233.37 < 2000 \text{ (laminar)}$$

$$V_{cr} = 2U = 2 \times 0.028$$

$$V_{cr} = 0.056 \text{ m/sec}$$

As,

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

at

$$r = r_0 = 0.025 \text{ m}, \quad u = 0$$

$$u_{max} = kr^2$$

$$k = u_{max}/r^2 = \frac{0.056}{(0.025)^2}$$

$$k = 9.96$$

We get an equation:

$$u = 0.056 - 9.96 (r^2) \quad \text{—} (x)$$

Velocity at 10mm from edge

$r = 0.065$ m

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

$$V = 0.014 \text{ m/sec}$$

Velocity at edge;

$r = 0.075$ m

$$V = 0.056 - 9.96 (0.075)$$

$$V = -0.00002 \text{ m/sec} \quad \text{Say } V = 0$$

Shear Stress at wall,

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

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

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

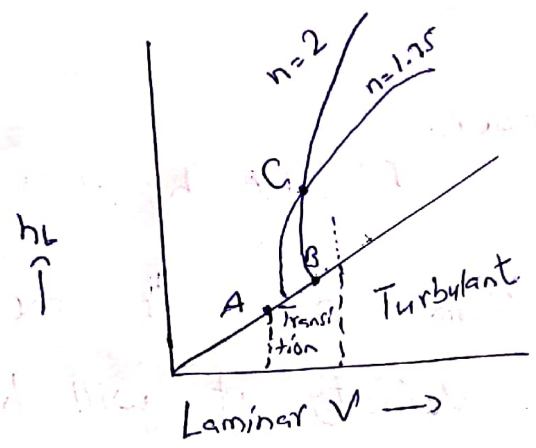
Question No. 1

part (b):

Answer:

Critical Reynold Number: If the headloss in given length of a 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 increase in velocity. change flow from laminar to turbulant cause change in headloss. Thus if values are plotted, lines obtained with slope ranging about 1.75 to 2.

Thus, for laminar, drop of energy varies as V ¼ for turbulant, friction varies as V^n where n is 1.75 to 2.



The upper critical reynold's number corresponding to point B is indeterminate and depends upon the care taken to prevent initial disturbance. Its value is 4000.

But normally, its impossible for flow to be in straight line after R is at 2000. Thus lower value is much more definite than higher one ¼ is dividing point. Thus lower value is true terminal Reynold Number.

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