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SECTION # B

Subject # Advance Fluid Mechanics

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Q1

part 1

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

Ans:

Velocity Profile:

=> As $h_L = \frac{\tau 2L}{w r}$ From viscosity $\tau = \mu \frac{du}{dy}$

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

= $y = r_0 - r$

$dy = dr_0 - dr$

= $dr_0 = \text{const} = 0$

= $dy = -dr$

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

=

Now:- $h_L = \frac{-\mu\, du\, 2L}{w\, r\, dr}$

=

or

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

=

Integrating

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

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

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

$u = U_{max}$

$\Rightarrow C = U_{max}$ ∵

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

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

Now As we know that $u = 0$ where $r = r_0$

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

its also known as Vcv

$$= V_{cv} = \frac{h_L \gamma}{4\mu L} r_0^2 = \frac{h_L \gamma}{16\mu L} D^2$$

The average velocity may be taken as.

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

$$= \frac{h_{cr} D^2}{32 \mu L}$$ As = $\gamma - g\rho$, $\mu/\rho = u$

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

$$u = \frac{-1}{2}.$$

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Q No 1

Part b

Define critical Rynold Number? Write down its equation.

Ans:-

Critical Rynold Number :-

it is defined that the number which decide whether flow is laminar or turbulent. If head loss in given length of uniform pipe is measured at different pipe value of velocity. it will found that as long as velocity is low enough 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 turbulent cause change in head loss. thus If value are plotted, lines are obtained with slope ranging about 1.75 to 2.

Thus for laminar drop of energy various as V and for turbulent, friction various as V where

n is 1.75 to 2.

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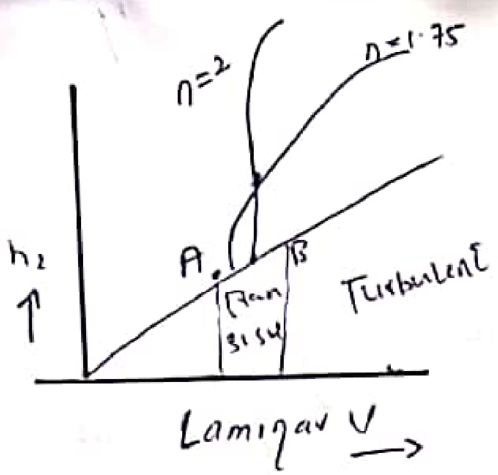

The upper critical reynolds number corresponding to point b is interminate and depend upon case taken to prevent initial disturbance. its value is 4000, But normally, its impossible for flow to be in straight line after R is at 2000. Thus lower value is much more definite than higher one and is dividing point. Thus lower value is true critical Reynold number.

Equation:-

$$R = \frac{DV\rho}{\mu} = \frac{DV}{\nu}$$

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equation for determine critical Reynold number

$$N_{REC} = 3470 - 1370\,n$$

Q2

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Numerical

Given Data :

oil of S = 0.7

Kinematic velocity = 1.8×10^{-5} m²/s.

dia = 150mm at 0.5 m³/s. = Q

Velocity = 10mm

Dia = 0.15m.

Find :-

(1) Centerline velocity U_{max} = ?

(2) Velocity at 10mm from edges = ?

(3) Velocity at edges of pipe = ?

(4) max shear stress at wall of pipe = ?

Solution :-

First check the flow of pipe.

$$= V = \frac{Q}{A} \Rightarrow \frac{0.5}{\frac{\pi}{4}(0.5)^2}$$

$$\Rightarrow \boxed{V = 28.29 \text{ m/s}}$$

$\Rightarrow R = \dfrac{DV}{\nu}$

$\Rightarrow \dfrac{(0.15)(28.29)}{1.8 \times 10^{-5}}$

$\Rightarrow R = 235750 > 2000$

So Flow is turbulent.

Now:

$f = \dfrac{0.316}{(R)^{0.25}} \Rightarrow f = \dfrac{0.316}{(235750)^{0.25}}$

$f = 0.0143$

$\Rightarrow$ Centerline Velocity :-

$= U_{max} = V(1 + 1.33\sqrt{f})$

$= 28.29(1 + 1.33\sqrt{0.0143})$

$= U_{max} = 32.74$ m/s.

Now:

Velocity at 10 mm from edges.

$$u = U_{max} - 2.5\sqrt{\frac{\tau_0}{\rho}} \ln \frac{y_0}{y_0 - y}$$

First calculate shear.

$$\tau_0 = f\frac{\rho V^2}{8}$$

$$\Rightarrow \frac{(0.0143)(0.7 \times 1000)(28.29)^2}{8}$$

$$\Rightarrow \boxed{\tau_0 = 1001.40 \ N/m^2}$$

shear stress at wall.

$$\Rightarrow u_{10mm} = U_{max} - 2.5\sqrt{\frac{1001.40}{0.7 \times 1000}} \ln \frac{0.075}{0.075 - 0.01}$$

$$\Rightarrow \boxed{u_{10mm} = 32.31 \ m/s}$$

Velocity at edges:-

$\Rightarrow U_{max} = V(1 + 1.33\sqrt{f})$

$\Rightarrow V = \dfrac{U_{max}}{1 + 1.33\sqrt{f}}$

$\Rightarrow V = \dfrac{32.74}{1 + 1.33\sqrt{0.0143}}$

$\Rightarrow \boxed{V = 28.24 \text{ m/s.}}$

END