ARSALAN KHAN

I.D NO 7614

PAPER FLUID 2

SUBMITTED TO ENGR. WAHEED

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QUESTION # 01:

Write down expressions for velocity profile in Laminar flow inside the pipe ?

Ans: As we know that

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

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

where "u" is velocity at distance "y" from the boundry.

Thus,

$$y = r_o - r$$

$$dy = \cancel{dr_o}^{\,0} - dr$$

$\because dr_o$ constant value

$$dy = -dr$$

putting values in equation (x)

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

Now ;

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

or

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

Integrating on both sides;

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

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

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

putting values

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

$\therefore U_{max} = 0 + C \rightarrow C = U_{maxi}$

Thus $U = U_{max} - \frac{h_L \gamma}{2\mu L} \cdot \frac{r^2}{2}$ ↗ velocity at any point

Assume

$$K = \frac{h_L \cdot \gamma}{4\mu L} \quad \because U = U_{max} - K r^2$$

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

$0 = U_{max} - k r_o^2$ or;

$U_{max} = k r_o^2 = \frac{h_L \gamma}{4 \mu L} \cdot r_o^2$

It is also known as critical velocity.

Hence;

$$\boxed{V_{av} = \frac{V_{c\ell} + 0}{2} = 0.5\, V_{c\ell}}$$

Average velocity.

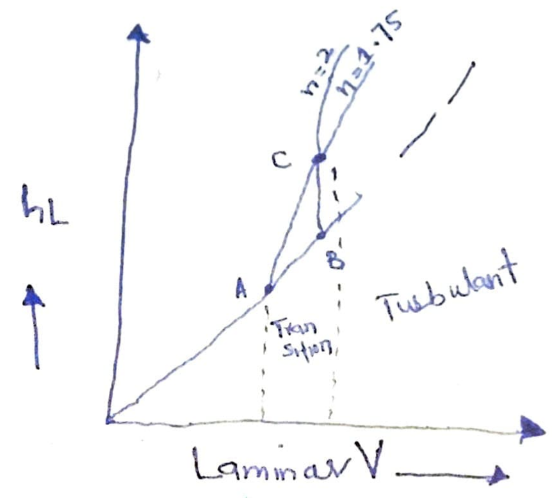
PART NO (b)

Answer : Define Critical Reynold number. Write down its equation.

CRITICAL RYNOLD NUMBER:

If head loss is given Length of uniform pipe is measured at different values of velocity. It will found that as long as velocity is low enough to secure laminar flow, the headloss due to friction will be directly proportional to velocity, but increase in velocity changes flow from laminar to turbulant cause change in head loss. Thus If values are plotted, lines obtained with slope ranging about 1.75 to 2.

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



The upper critical reynolds number corresponding to point B is indeterminate and depend upon care taken to prevent initial disturbance. It values is 4000. But normally, it is 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 OF REYNOLDS NUMBER:

Ratio of intertial force to viscous force is called Reynold number.

$$R = \frac{F_I}{F_v} \Rightarrow F_I = ma = \rho L^3 \cdot \frac{L}{T^2}$$

$$= \rho L^4 T^{-2} = \rho\left(\frac{L}{T}\right)\left(\frac{L}{T}\right)$$

$$= \rho V^2 L^2$$

$$F_v = \mu\left(\frac{du}{dy}\right)A = \mu\left(\frac{V}{L}\right)L^2 = \mu V L$$

$$\therefore \quad R = \frac{L^2 V^2 \rho}{L V \mu} = \frac{L V \rho}{\mu} = \frac{L V}{\nu}$$

ν = kinematic viscosity

For circular pipe;

$$R = \frac{D V \rho}{\mu} = \frac{D V}{\nu}$$

The Lower value (2000) is known as critical Reynolds number.

QUESTION # 02:

An oil of $(s = 0.7)$ and kinematic viscosity of 1.8×10^{-5} m^2/s flow in 150 mm pipe at $0.5\ m^3/s$. Find the centre line velocity. Velocity at 10 mm from edges and velocity at edge of the pipe. Also find maximum shear stress at wall of the pipe?

Answer:

Given Data:

oil of $S = 0.7$

Kinametic viscosity $= \nu = 1.8 \times 10^{-5}\ m/s$

Dia of pipe $= 150\text{ mm} = 0.15m$

$Q = 0.5\ m^3/sec$

Required:

Centre line velocity, $U_{max} = ?$

velocity at 10mm from edges = ?

velocity at edge of pipe = ?

Max shear stress at wall of pipe = ?

Solution:

As

check the flow of oil

$$V = \frac{Q}{A} = \frac{0.5}{\pi/4 \times (0.15)^2}$$

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

$$\rightarrow R = \frac{DV}{\nu}$$

putting the values

$$R = \frac{(0.15)(28.29)}{1.8 \times 10^{-5}}$$

$$R = 235750 > 2000$$

Flow is turbulant.

Now;

$$f = \frac{0.316}{R^{0.25}}$$

putting the values

$$f = \frac{0.316}{(235750)^{0.25}}$$

$$f = 0.0143$$

→ Centre line velocity

$$U_{maxi} = V\left(1 + 1.33\sqrt{f}\right)$$

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

$$U_{maxi} = 32.74 \text{ m/s}.$$

→ velocity at 10mm from edges

$$U = U_{max} - 2.5\sqrt{\frac{\tau_0}{\rho}} \ln \frac{r_0}{r_0 - r}$$

First calculate shear

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

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

$\tau_o = 1001.40 \ N/m^2$ Shearstress at wall

$$U_{10mm} = U_{max} - 2.5 \sqrt{\frac{\tau_o}{\rho}} \ln \frac{r_o}{r_o - r}$$

$$= 32.74 - 2.5 \sqrt{\frac{1001.40}{0.7 \times 1000}} \ln \frac{0.075}{0.075 - 0.01}$$

$U_{10mm} = 32.31 \ m/s$

→ velocity at edge;

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

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

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

$V = 28.24 \ m/s$