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Advance Fluid

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Q No1

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

As

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

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

where $u$ is velocity at distance "y" from boundary

Thus

$$y = r_0 - r$$

$$dy = \cancel{dr_0} - dr$$

$$dy = -dr$$

Thus

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

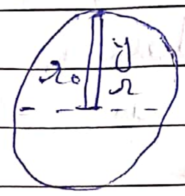
or

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

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

General Equation

Now applying boundry Condition




$U_{max} = 0 + C$

$\therefore C = U_{max}$

Putting value in general Eq

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

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

$$K = \frac{h_L \gamma}{4 \mu L}$$

for $r = r_0$, $u = 0$

Thus

$$0 = U_{max} - K r_0^2$$

$$U_{max} = K r_0^2$$

Q.1 (2)

Define Critical Reynold Number

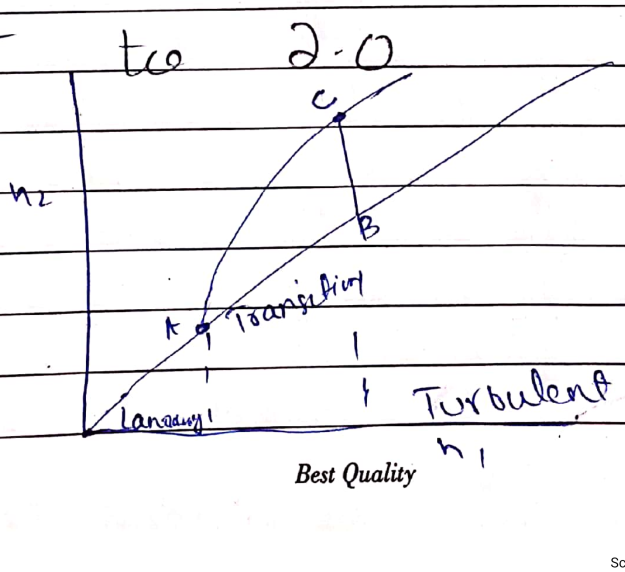
Critical Reynold Number:

If the head Loss in given Length of 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 proportional to

velocity but increase in velocity will change flow from laminar to turbulent causing change in head proportional to "V"

where n varies from

1.75 to 2.0



The upper critical number corresponds to point B. and depends on care taken to prevent initial disturbance.

It value is 4000 but it is impossible to achieve. The lower point A is more defined than higher one and it is known as true reynold number

It value is 2000

$$R = \frac{DV_{cr}}{V}$$

Q NO 2

GIVEN:

$S = 0.7$

$V = 1.8 \times 10^{-5}\ m^2/s$

$d = 150mm = 0.15\ m$

$Q = 0.5 L/s$

Required:

$f = ?$ , $T = ?$

velocity = ?

0.0005

0.017

SOLUTION:

Check flow

$R = \frac{DV}{U}$ $V = \frac{Q}{A} = \frac{0.001 \times 0.5}{\pi/4\,(0.15)^2}$

$V = 0.029$

$R = \frac{0.15 \times 0.029}{1.8 \times 10^{-5}}$

$= 241 < 2000$ laminar

As

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

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

$V_{cr} = 0.029 \times 2$

$= 0.058$

$U = U_{max} - K r_0^2$

$R = 0.15$

When $r = r_0 = 0.075 \Rightarrow U = 0$

Thus

$U_{max} = K r_0^2$

$K = \frac{U_{max}}{r_0^2}$

$= \frac{0.058}{(0.075)^2} = \frac{0.058}{0.0056}$

$= 10.35$

for Laminar $f = \frac{64}{R}$

$= \frac{64}{241}$

$= 0.265$

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

$$= \frac{0.26}{4} \times 0.7 \times 1000 \times \frac{(0.029)^2}{2}$$

$$= 0.065 \times 700 \times 0.00084$$

$$= 0.0382 \, N/m^2$$

Velocity at 10mm from edges

$$U = U_{max} - Kr_o^2$$

$$= 0.058 - 10.35(0.01)^2$$

$$= 0.058 - 0.00135$$

$$= 0.056$$

At boundry or edges of Pipe

$$U_{max} = 0 + C$$

when $r = 0$, $U = U_{max}$

$$U_{max} = 0.058$$

P-T-O

Max Shear stress at wall of pipe:

Maximum shear stress at wall of pipe is

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

$$= \frac{0.26}{8} \times 0.7 \times 1000 \times (0.029)^2$$

$$\tau_0 = 0.032 \times 700 \times 0.000841$$

$$= 0.018\ N/m^2$$