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Paper : Advance Fluid Mechanics

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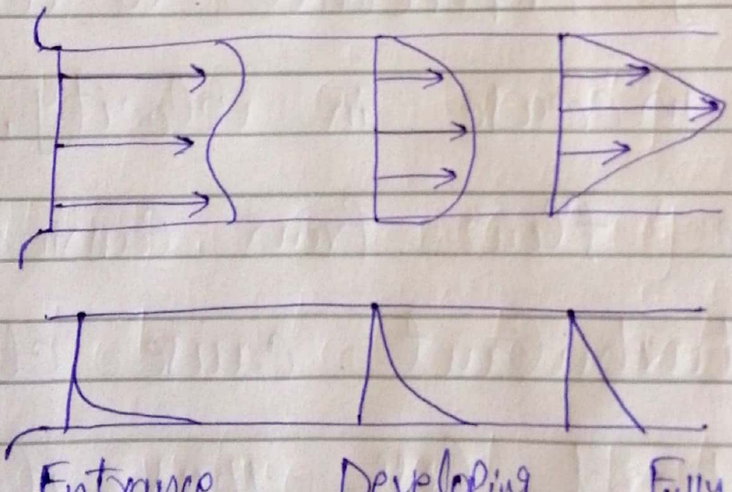
QNo. 1 (Part a)

Ans:- velocity Profile in laminar flow inside The Pipe:



Entrance Developing Fully Developed

velocity Profile:

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

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

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

$\because y = r_0 - r$

$dy = dr_0 - dr$

$dr_0 = \text{Constt} = 0$

$\because dy = -dr$

$$\tau = -\mu \frac{du \, 2l}{r \, r \, dr}$$

$$du = -\frac{hL\gamma}{2\mu l} \, r \, dr$$

Integrating

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

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

$\because C = u_{max}$

$$\Rightarrow \quad u = u_{max} - \frac{hL\gamma}{2\mu l} \cdot \frac{r^2}{2}$$

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

Now As we Know $u = 0$ when $r = r_0$

$$u_{max} = Kr_0^2 = \frac{hL\gamma}{4\mu l} \cdot r_0^2$$

it is also Known as V_{ce}

$$\because V_c = \frac{hL\gamma}{4\mu l} \cdot r_0^2 = \frac{hL\gamma}{16\mu l} \cdot D^2$$

The average velocity may be taken as.

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

$$= \frac{h_L \gamma D^2}{32 \mu L} \quad \text{As} \quad \gamma = g\rho,\ \mu/\rho = \nu$$

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

x ——— x ——— x ——— x ———

Part (b)

Critical Rynold number:

A critical Reynolds number is determined as a limit where The laminar flow changes to turbulent flow. If The calculated NRe is greater Then The critical Reynolds number NRec, The flow regime is turbulent; otherwise The flow regime is laminar.

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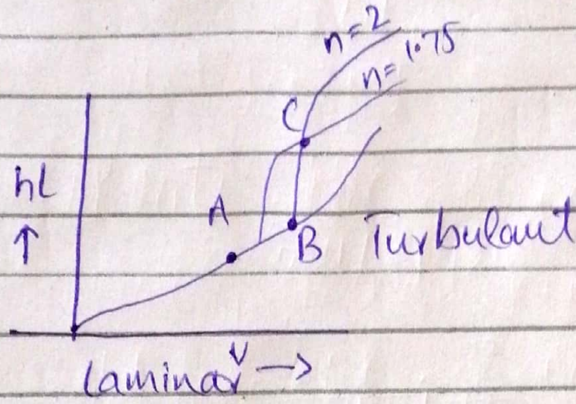
→ If head loss in given length of uniform Pipe is measured at different values of velocity, It will found That as long as velocity is low enough to secure laminar flow; The head loss due to ~~fa~~ friction will be directly Proportional to velocity, but increase in velocity, Change flow from laminar to turbulant cause change in head loss, Thus if values are plotted, lines obtained with slope 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.



⇒ Equation for Reynold number:

The Reynolds number (N_{Re}) is a dimensionless value That represents The ratio of Inertial forces to viscous forces in The fluid.

The general form of The Reynolds number is.

$$N_{Re} = \frac{D \times V \times \rho}{\mu}$$

where;

D = Diameter of The flow channel ft or m.

v = Average velocity of The fluid in The channel, ft/s or m/s.

ρ = Fluid density, lb_m/ft^3 or kg/m^3.

μ = viscosity of The fluid of Newtonian fluid or effective viscosity of non-Newtonian at The flow condition, lbm/ft.s or kg/m.s.

Reynolds number in fied units is expressed as.

$$N_{Re} = \frac{in\left(\frac{ft}{12\,in}\right) \times ft/s \times lbm/gal\left(\frac{7.48\,gal}{ft^3}\right)}{cP\left(\frac{6.72\times10^{-4}\,lbm/ft.s}{cP}\right)}$$

$$N_{Re} = \frac{928 \times D(in) \times v(ft/sec) \times \rho(lbm/gal)}{\mu(cP)}$$

Q No. 2:

Given Data:

Oil of $S = 0.7$

Kinamatic viscosity $= \nu = 1.8 \times 10^{-5} m^2/s$

Dia of Pipe $= 150mm = 0.15m$

$Q = 0.5 m^3/s$

Required Data:

Centerline velocity, $U_{max} = ?$

velocity at 10mm from edges = ?

velocity at edge of Pipe = ?

max shear stress at wall Pipe = ?

Sol:

check the flow of oil

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

$$= V = 28.29 \; m/s$$

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

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

$R = 235750 > 2000$

Flow is Turbulant

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

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

$$= 0.0143$$

→ Centerline velocity

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

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

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

→ 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.

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

$$= \frac{(0.0143)(0.7\times1000)(28.29)^2}{8}$$

$$\tau_0 = 1001.40 \ N/m^2$$

$$u_{10mm} = u_{max} - 2.5\sqrt{\frac{\tau_0}{\rho}} \ln \frac{r_0}{r_0 - r}$$

$$= 32.74 - 2.5\sqrt{\frac{1001.40}{0.7\times1000}} \ln \frac{0.075}{0.075 - 0.01}$$

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

→ velocity at edge:

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

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

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

$$\boxed{V = 28.24 \ m/s}$$