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Subject: Fluid Mechanics II

Mid-Term Examination 2020

Q: write down expression for velocity profile in laminar
(a) flow inside the pipe.

Velocity Profile:

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

from viscosity : $\tau = \mu \, du/dy$

where u is value of velocity at distance y from boundary

$\therefore y = r_0 - r$

$dy = dr_0 - dr$

$dr_0 = \text{Const} = 0$

$\therefore dy = -dr$

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

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

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

Integrating.

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

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

$u = U_{max}$

$\therefore C = U_{max}$

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

$u = U_{max} - kr^2.$

Now, As we know that $u = 0$ 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}

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

The average velocity may be taken as.

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

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

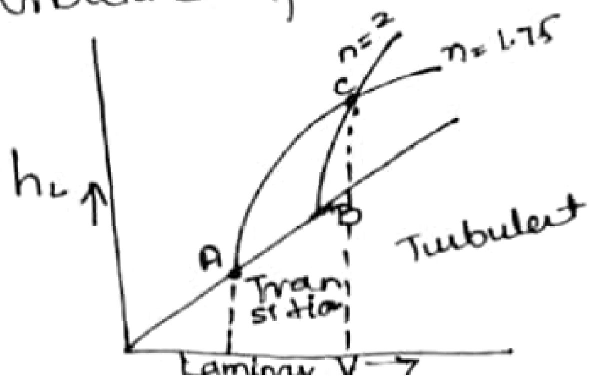
$$\frac{32 \mu L V}{D^2} \Rightarrow \frac{32 \mu L V}{\rho g \cdot D^2} = 32 \nu \frac{L}{g D^2} V$$

$$h_L = 32 V \mu L$$

(b) Define critical Rynold number. write down its equation.

Critical Rynold number: 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 friction will be directly proportional to velocity, but increase in velocity, to change 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) here n value is 1.75 to 2.



(2)

The upper critical reynolds number corresponding to point B is indeterminate and depends upon care taken to prevent critical disturbance. It's value is 4000. But normally, its impossible for flow to be in straight line after R_i 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.

$$\boxed{R_{cr} = \frac{DV\rho}{\mu} = \frac{DV}{\nu}}$$

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An oil of (S=0.7) and Kinematic .... at wall of pipe?

Q2: Given Data:

Oil of $S = 0.7$

Kinematic viscocity $= \nu = 1.8 \times 10^{-5} \, m^2/s$.

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

$Q = 0.5 \, m^3/s$.

Required data:

Centerline Velocity $U_{max} = ?$

Velocity at 10mm from edges $= ?$

Velocity at edge of pipe $= ?$

max shear stress at wall of pipe $= ?$

Solution: Check the flow of oil.

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

$$V = 28.29 \, m/s.$$

$\rightarrow R = \frac{DV}{\nu} = \frac{(0.15)(28.29)}{1.8\times10^{-5}}$

$R = 235750 > 2000$ (Flow is turbuland)

$f = \frac{0.316}{R^{0.25}} = \frac{0.316}{(235750)^{0.25}}$ $\quad \underline{f = 0.0143}$

$\Rightarrow$ Centerline velocity

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

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

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

$\Rightarrow$ velocity at 10mm from edges:

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

first calculate shear

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

$= (0.0143)(0.7\times1000)(28.29)^2$

Shear stress at wall $\rightarrow$ $\boxed{\tau_0 = 1001.40\ N/m^2}$

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

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

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

Velocity at edge.

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

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

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