Introduction to Fluid Mechanics
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Lecture – 55
Pipe Flow - Part – I

In many engineering applications, we also have internal flows; that means, flow is there occurring in a confinement. As an example we can refer to the flow through a pipe. So, pipe is a confinement within which the fluid is flowing, and it is unlike the case of a solid surface like a flat plate or a circular cylinder over which the flow is flowing. So, those cases are called as external flows and the pipe flow is an example of an internal flow.

Now, when you have a flow through a pipe or an internal flow as an example, we have to first understand that what is the basic difference in terms of like analyzing an internal flow and an external flow.

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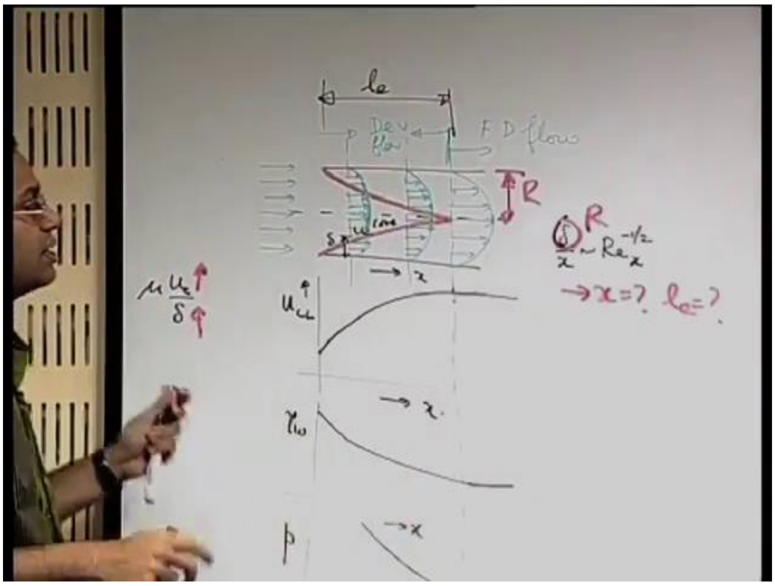

So, if we consider a velocity profile within the boundary layer, there are velocity gradients then the velocity profile is virtually uniform and then again within the boundary layer it starts having its gradients.

Wall shear stress is dependent on the velocity gradient at the wall. Velocity gradient is $\mu \dfrac{u_c}{\delta}$.

The wall shear stress should decrease as you are moving along the axis of the pipe.

$$\frac{\delta}{x} \sim \mathrm{Re}_x^{\frac{1}{2}}$$

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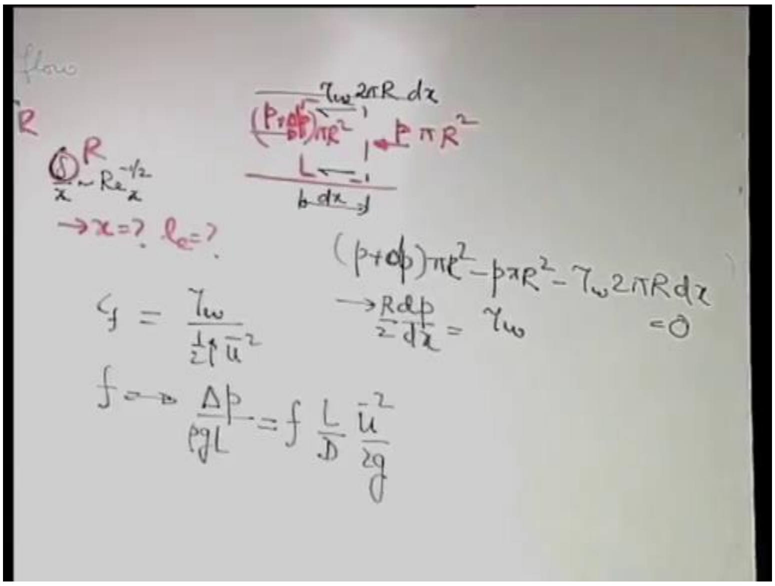

$$C_f = \frac{\tau_w}{\frac{1}{2}\rho \bar{u}^2}$$

$$f \rightarrow \frac{\Delta p}{\rho g} = f\,\frac{L}{D}\frac{\bar{u}^2}{2g}$$

$$\left(p + \Delta p\right)\pi R^2 - p\pi R^2 - \tau_w 2\pi R d\tau = 0$$

$$\frac{Rdp}{2dx} = \tau_w$$

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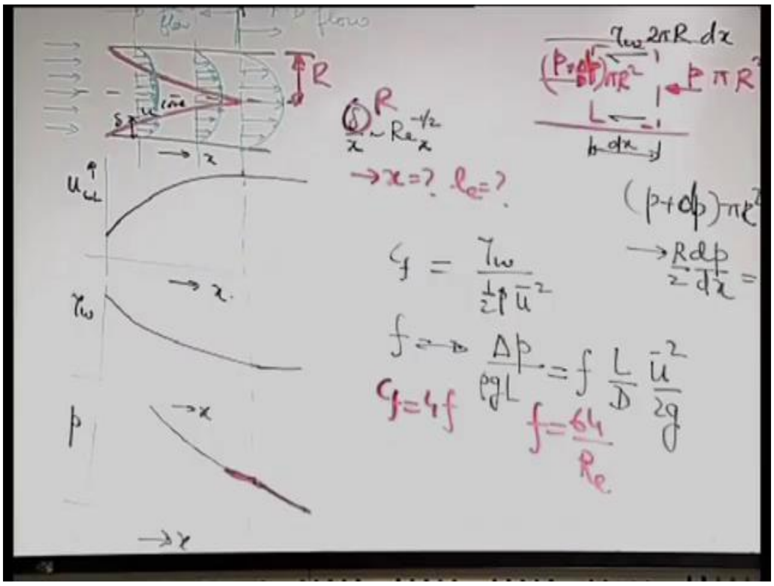

$$f = 4C_f$$

$$f = \frac{64}{\mathrm{Re}_D}$$

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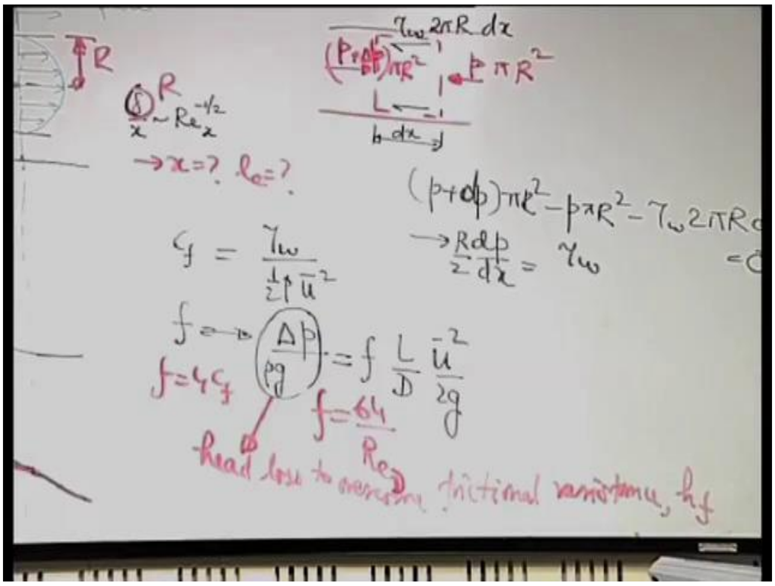

$$f \rightarrow \frac{\Delta p}{\rho g} \rightarrow$$ head loss to overcome frictional resistance, h_f

$$h_f = f\,\frac{L}{D}\,\frac{\bar{u}^2}{2g} \rightarrow \text{Darcy Weisbach equation}$$

$$h_f = \frac{128\mu QL}{\rho g\pi D^4} \rightarrow Hagen\ \text{Poiseuille Eqn}$$

$$Q = \mu\pi\frac{D^2}{4}$$

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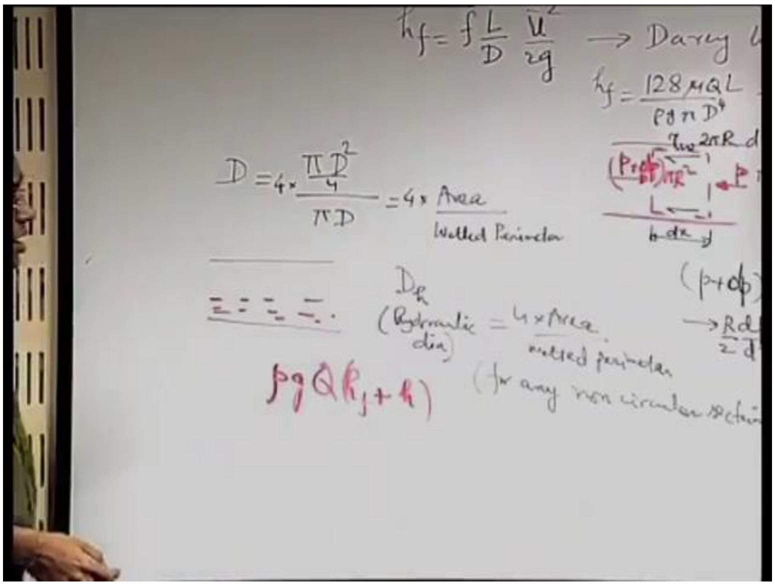

$$D = 4.\frac{\frac{\pi D^2}{4}}{\pi D} = 4\times\frac{Area}{Wetted\ \ Perimeter}$$

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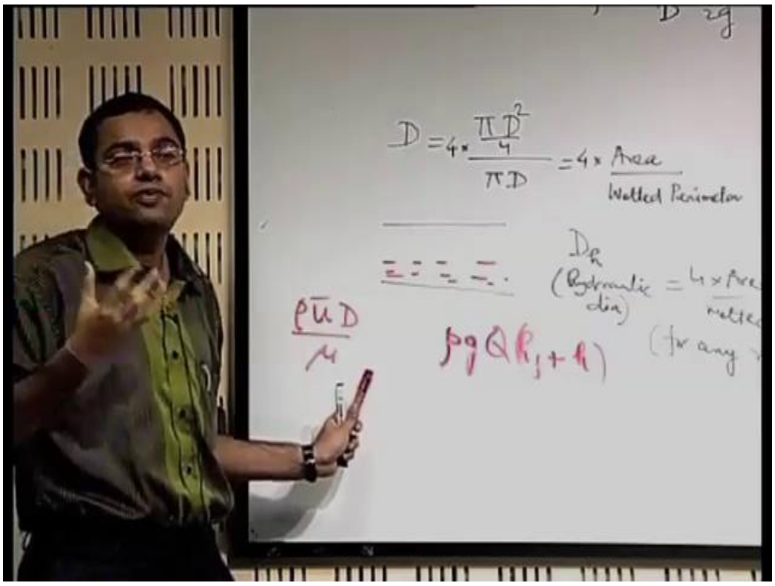

$$Re = \frac{\rho \bar{u} D}{\mu}$$