Chapter 2 : **Fluid Flow Phenomena**

Important terms ⇒

- ★ **Potential Flow :** **The flow of ideal fluid (incompressible and zero viscosity) is called potential flow.**
  - ■ **Neither circulation nor eddies form (irrotational)**
  - ■ **Friction can't develop (no dissipation of mechanical energy to heat)**

- ★ **Laminar flow :** **At low velocities fluids tend to flow without lateral mixing and adjacent layers slide past one another like playing cards.**

- ★ **Bingham plastic :** **Above a particular threshold, the flow is linear.**

- ★ **Pseudo-plastic :** **Graph between shear stress and shear rate is concave downwards at low shear and becomes nearly linear at high shears (shear rate thinning)**

- ★ **Dilatent :** **Graph between shear stress and shear rate is concave upwards at low shear and becomes nearly linear at high shears (shear rate thickening)**

- ★ **Thixotropic :** **Liquid breaks down under continuous shear and on mixing give lower shear stress for a given shear rate(i.e.; viscosity decreases with time)**

★ **Rheopectic :** Liquid breaks down under continuous shear and on mixing give higher shear stress for a given shear rate.

★ **Viscosity :** In newtonian fluid, the proportionality constant between shear stress and shear rate is called viscosity.

★ **Turbulence types :** 1) Wall turbulence
2) Free turbulence

★ **Boundary layer :** It is defined as that part of a moving fluid in which the fluid motion is influenced by the presence of a solid boundary. Velocity at boundary layer is 99% of the bulk fluid velocity.

★ **Fully Developed flow :** Flow with an unchanging velocity distribution.

★ **Transition Length :** Length of entrance region of tube necessary for boundary layer to reach centre of the tube and for fully developed flow to be established.

Important Formulas ⇒

1) **Newton's Viscosity Law :**

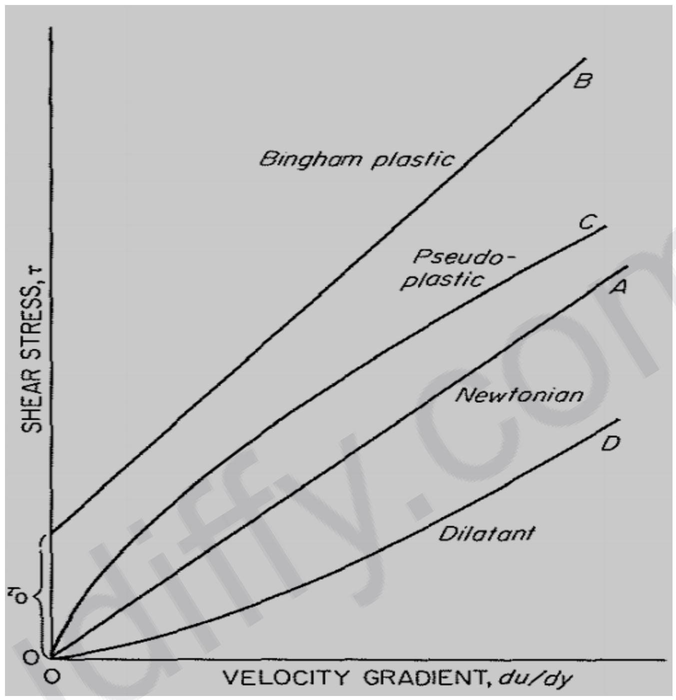
$$\tau_v = \mu \frac{du}{dy}$$

2) **Viscosity of gas vs temperature :**

$$\frac{\mu}{\mu_0} = \left(\frac{T}{273}\right)^n$$

μ = viscosity at absolute temperature T, K
μ_0 = viscosity at 0°C (273 K)
n = constant

3) Newtonian and Non-newtonian fluids :



4) Ostwald-de Waele equation (power law) :

$$\tau_v g_c = K' \left(\frac{du}{dy}\right)^{n'}$$

where, *K'* and *n'* are constants called the *flow consistency index* and the *flow behavior index,* respectively.

5) **Reynolds number :**

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

6) **Eddy viscosity :**

$$\tau_t g_c = E_v \frac{du}{dy}$$

7) **Total shear stress in turbulent flow :**

$$\tau g_c = (\mu + E_v)\frac{du}{dy}$$

8) **Transition from laminar to turbulent flow :**

$$N_{Re,x} = \frac{x u_\infty \rho}{\mu}$$

where x = distance from leading edge of plate
u_∞ = bulk fluid velocity
ρ = density of fluid
μ = viscosity of fluid

9) **Transition length for laminar flow :**

$$\frac{x_t}{D} = 0.05 N_{Re}$$