SHROFF S. R. ROTARY INSTITUTE OF CHEMICAL TECHNOLOGY
ANKLESHWAR

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FLUID PROPERTIES

Properties of Fluid

- To study the behavior of fluids it is essential that some important properties need to be studied.

1. Density

Density of fluid is defined as the ratio of mass of fluid to its volume

$$Density\ (\rho) = \frac{Mass\ of\ fluid: M}{Volume\ of\ fluid: V}$$

$$\rho = \frac{M}{V}$$

SI unit of density (ρ) is kg/m^3 The density (ρ) is also referred as mass density

Density (ρ) of water is 1000 kg/m^3 at 4°C
Density (ρ) of mercury is 13600 kg/m^3 at 0°C
Density (ρ) of air is 1.29 kg/m^3 at 0°C

2. Specific Weight

It is defined as weight per unit volume of fluid. It is denoted by $'w'$

$$Specific\,Weight\ (w) = \frac{Weight\ of\ fluid{:}\,W}{Volume\ of\ fluid{:}\,V}$$

$$(w) = \frac{W}{V} = \frac{Mg}{V} = \rho g$$

SI unit of specific weight is

$$w = \rho g = \frac{kg}{m^3} \times \frac{m}{s^2} = \frac{N}{m^3}$$

Specific weight is also known as weight density

3. Specific Gravity

It is defined as ratio of specific weight of given fluid to specific weight of standard fluid. It is denoted by S

Fluids can be classified into two groups

(i) Liquids (ii) Gases

Specific gravity for liquids is defined as ratio of specific weight of liquid to specific weight of water

$$S_l = \frac{w}{w_{water}} = \frac{\rho g}{\rho_{water} g} = \frac{\rho}{\rho_{water}}$$

Specific gravity of liquids is also defined as ratio of density of given liquid to density of water.

Specific gravity for gases is defined as ratio of specific weight of given gas to specific weight of air at NTP.

$$Specific\ gravity\ for\ Gases\ (w) = \frac{Specific\ weight\ of\ gas}{Specific\ weight\ of\ air\ at\ NTP} = \frac{w}{w_{air}} = \frac{\rho g}{\rho_{air} g} = \frac{\rho}{\rho_{air}}$$

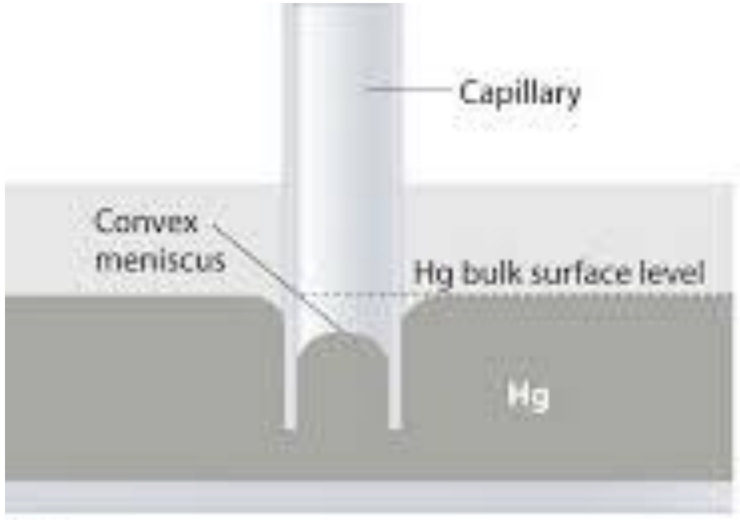
Specific gravity of gases is also defined as ratio of density of given gas to density of air at NTP.

4. Adhesion

- The property of liquid which enables its molecules to stick to the molecules of solid boundary is called as adhesion. Liquid wets the surface of container in which it is kept.
- Example: glass rod dipped in water or milk gets wetted with the same.

5. Cohesion

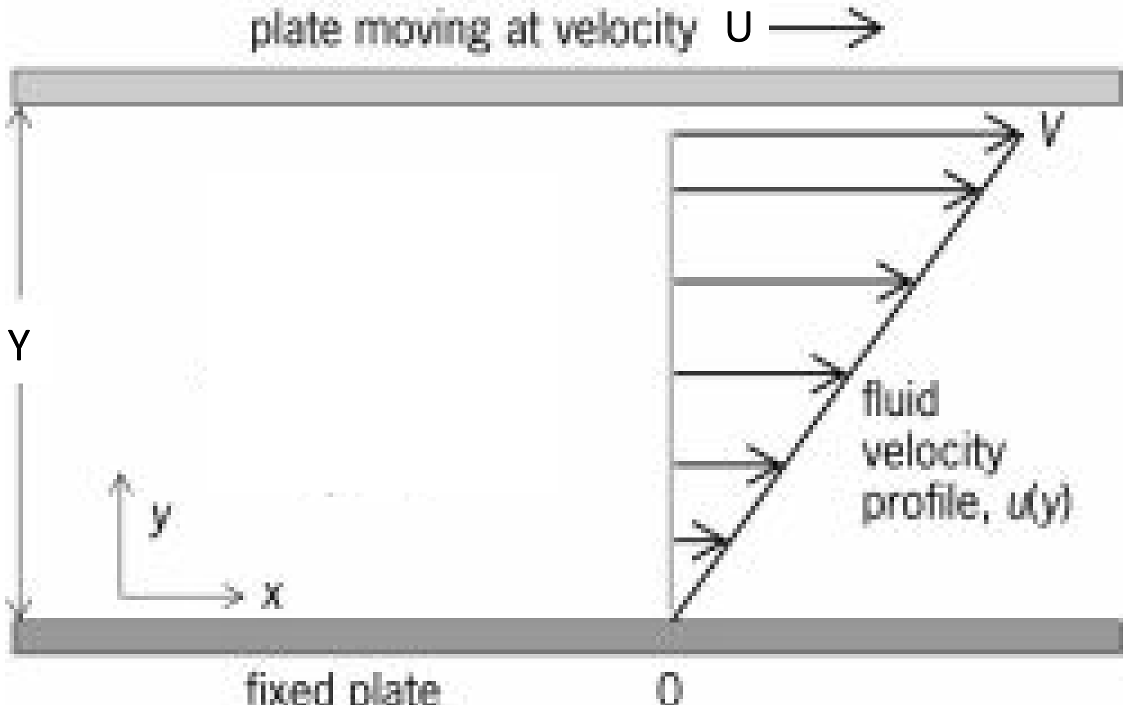
- The property of liquid by which molecules of same liquid attract each other or intermolecular force of attraction between molecules of same liquid is called cohesion.
- Example: Mercury have a high



6. Viscosity

- Viscosity is defined as the property of fluid which offers resistance to flow of fluid under influence of shear force
- With shear force existing fluid undergoes deformation
- The property of viscosity controls the flow of fluid over a horizontal surface.

$$\text{Shear Stress} = \frac{Shearing\ force}{Area}$$



Shear Stress ∝ Velocity gradient

$$\tau \propto \frac{du}{dy}$$

$$\tau = \mu \frac{du}{dy} \qquad \mu = Viscosity$$

$$\mu = \frac{\tau}{du/dy} \qquad \mu = Dynamic\ viscosity$$

SI unit of dynamic viscosity is kg/m.sec

Viscosity of water is 1cp at 20 °C

Viscosity of air is 0.0181cp at 20 °C

$$Kinematic\ Viscosity(\vartheta) = \frac{Dynamic\ Viscosity\ (\mu)}{Density\ of\ fluid\ (\rho)}$$

SI unit of kinematic viscosity is m^2/sec 1 stoke = 1 cm^2/sec

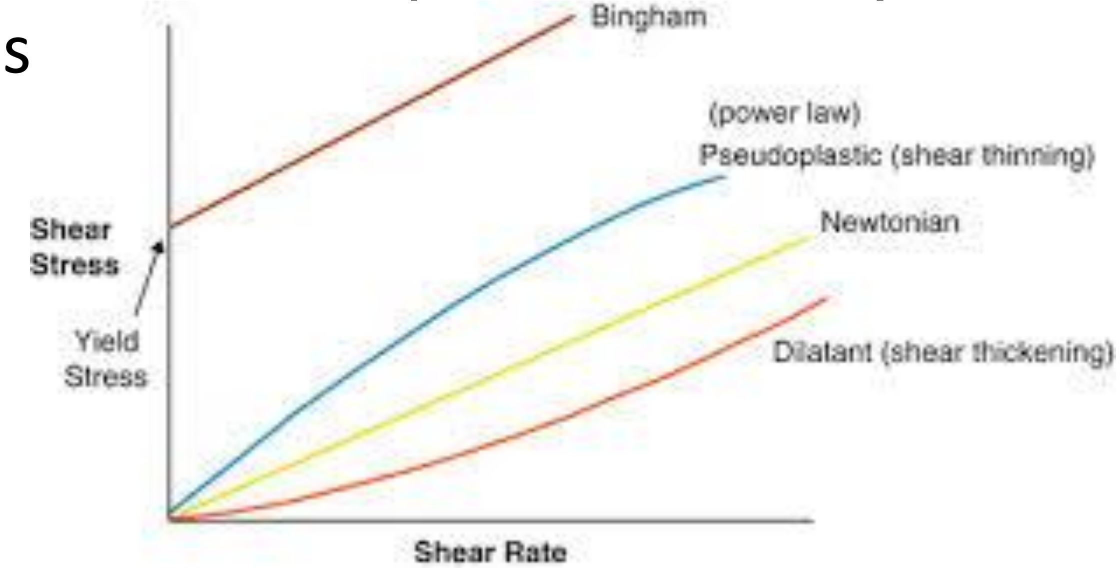
$$\boldsymbol{\tau \propto \frac{du}{dy} \quad \tau = \mu \frac{du}{dy}}$$

Fluids in which shear stress is directly proportional to velocity gradient or which follow Newton's law of viscosity is called as Newtonian fluids.

$$\tau \neq \mu \frac{du}{dy}$$

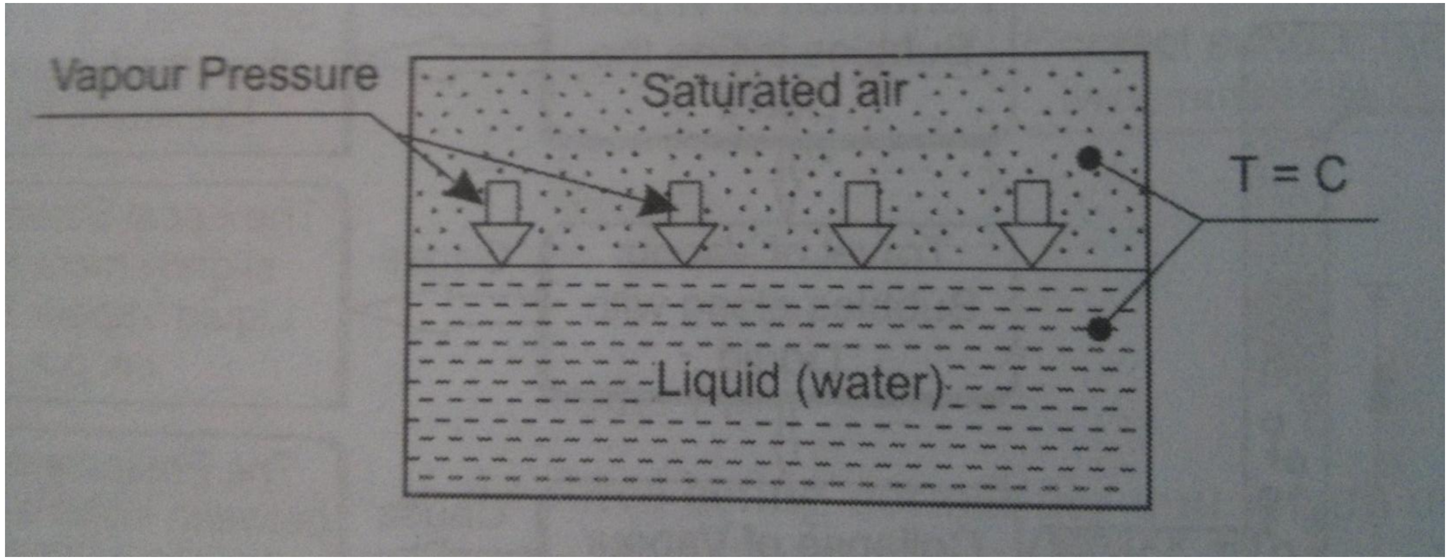
Fluids where shear stress velocity gradient relationship is not directly followed are called Non – Newtonian fluids

For Bingham plastics $\tau = \tau_0 + \mu \frac{du}{dy}$



7. Vapor Pressure

The partial pressure of water vapor in saturated air exerted on liquid surface is called as Vapor pressure



Vapor pressure increases with increase in temperature

8. Specific Volume

It is defined as volume per unit mass of fluid. It is denoted by ν

$$Specific\,Volume\ (\nu) = \frac{Volume\ of\ fluid{:}\,V}{Mass\ of\ fluid{:}\,M} = \frac{V}{M} = \frac{1}{M/V} = \frac{1}{\rho}$$

Specific volume is reciprocal of density

SI unit of specific volume m^3/kg

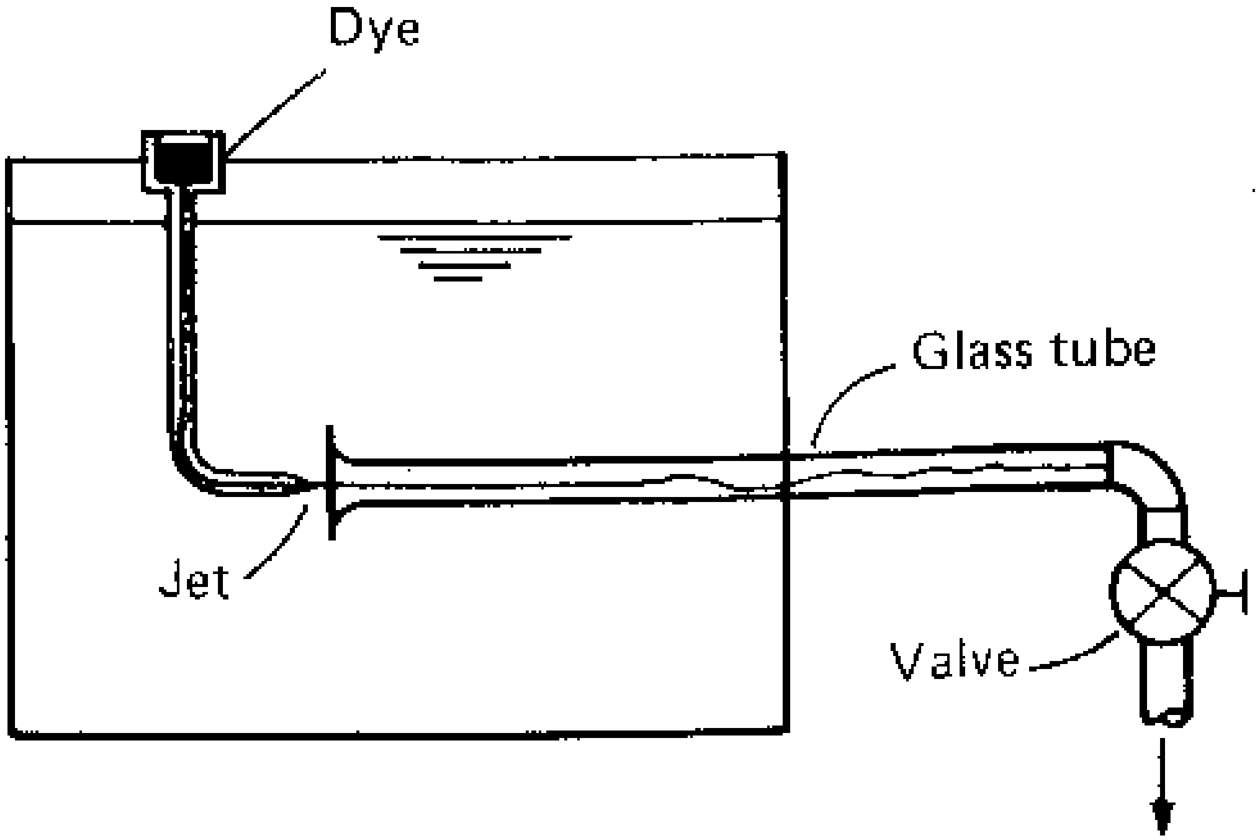
9. Capillarity

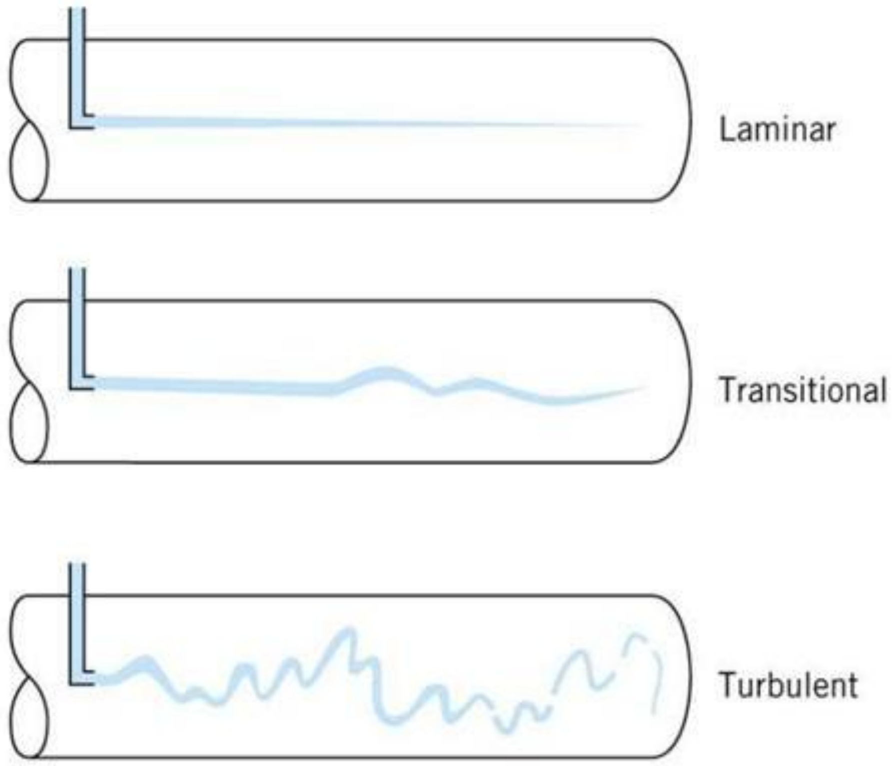
The phenomenon of rise or fall of liquid in a capillary tube is known as capillarity.

For water capillary rise will be observed due to predominant forces of adhesion.

For mercury, a drop in level will be observed when capillary tube is inserted in bath containing mercury. This is due to predominant forces of cohesion.

Reynold's Experiment





The condition in which flow pattern changes from laminar to turbulent depend on four quantities

1. Diameter of tube
2. Viscosity
3. Density
4. Average velocity of liquid

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

$$\boldsymbol{N_{Re} = Reynold's\ Number}$$