SNS COLLEGE OF TECHNOLOGY

Department of

MECHANICAL ENGINEERING

Fluid mechanics and machinery

PROPERTIES OF FLUID

Fluid mechanics

It is the branch of science which deals with the behaviour of fluids at rest as well as in motion.

Fluid static

The study of fluid at rest.

Fluid Kinematics

The study of fluid in motion where pressure forces are not considered.

Fluid Dynamics

The study of fluids in motion where pressure forces are considered.

Density

Density or mass density of a fluid is defined as the ratio of mass of fluid to its volume.

$$\rho = \frac{\text{Mass of fluid (kg)}}{\text{Volume of fluid } (m^3)}$$

Specific Weight or Weight Density

Specific weight of a fluid is the ratio between the weight of a fluid to its volume.

$$w = \frac{\text{Weight of the fluid}}{\text{Volume of the fluid}}$$

$$w = \frac{(\text{Mass of the fluid} \times \text{Acceleration due to gravity})}{\text{volume of the fluid}}$$

$$w = \rho \times g$$

Specific volume

Specific volume of the fluid is defined as the volume occupied by a unit mass of the fluid.

$$\text{Specific volume} = \frac{\text{Volume of the fluid } (m^3)}{\text{Mass of the fluid (Kg)}}$$

$$= 1/\rho$$

Specific Gravity

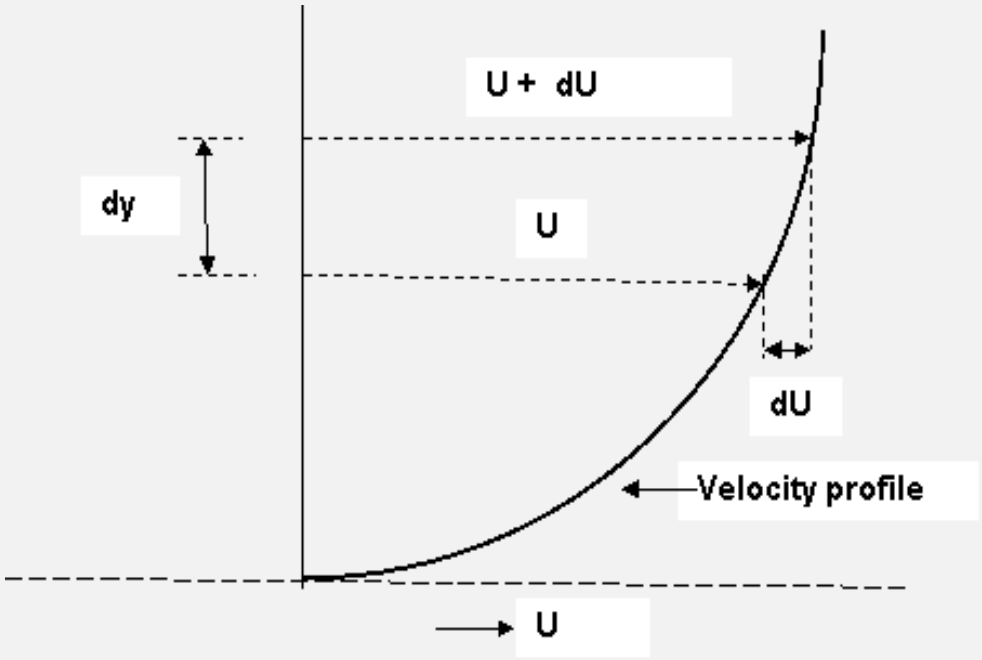
Specific gravity is defined as the ratio of density of a fluid to the density of the standard fluid.

$$S = \frac{\text{Density of Liquid}}{\text{Density of water}}$$

The standard fluid for liquid is water and for gas it is air.

Viscosity

Viscosity is defined as the property of a fluid which offers resistance to then movement of one layer of fluid over another adjacent layer of fluid.



Consider two layers of fluid at a distance “dy” apart with velocity of “U” and “U + dU”.

- Viscosity together with relative viscosity causes shear stress acting between fluid layers.

- Shear stress is proportional to the rate of change of velocity with respect to “y”.

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

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

- μ = Coefficient of dynamic viscosity or viscosity.
- $\mu = \tau / (du/dy)$
- Viscosity is also defined as the shear stress required to produce unit rate of shear strain.

Units : SI system : Ns/m^2

CGS system : $dyne\text{-}sec/cm^2$ (Poise)

Newton's Law of Viscosity

It states that the shear stress (τ) of a fluid element layer is directly proportional to the rate of shear strain.

Kinematic Viscosity

Kinematic viscosity is defined as the ratio between the dynamic viscosity and density of fluid.

Units :

SI system : m^2/s

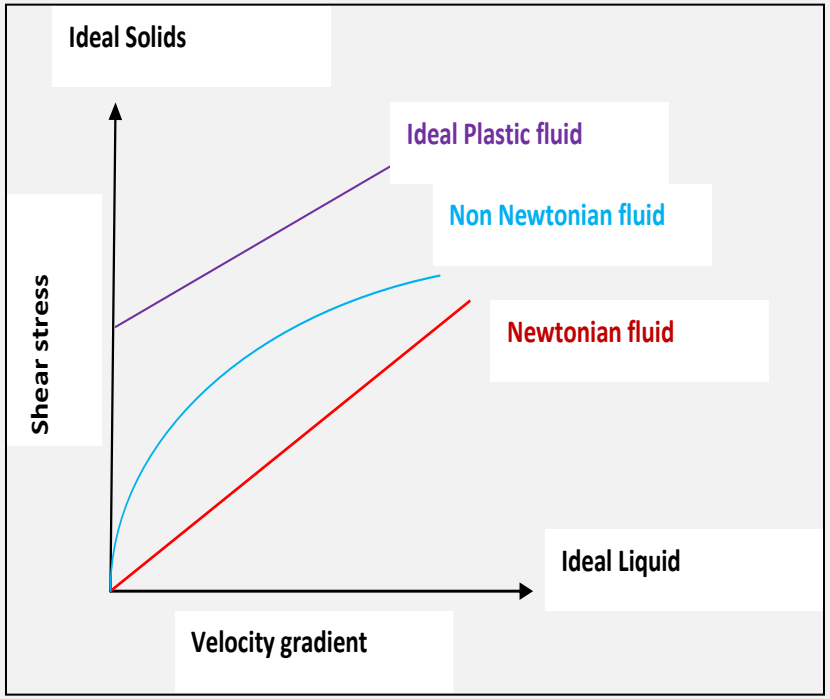
CGS system : cm^2/s (Stokes)

$$\gamma = \frac{\text{Viscosity}}{\text{Density}}$$

$$\gamma = \frac{\mu}{\rho}$$

Types of Fluids

- Ideal Fluid
- Real Fluid
- Newtonian Fluid
- Non Newtonian Fluid



Effect of Temperature on Viscosity

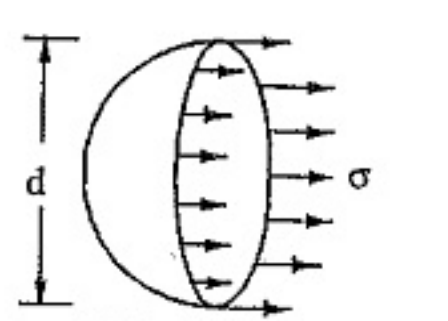
- Viscosity **decreases** with **increase in temperature** of liquid.
- Viscous Forces
- **Cohesive Forces**
- **Molecular momentum transfer**
- In liquid the cohesive forces dominates due to closely packed molecules and with the increase in temperature, the cohesive forces decreases hence decreasing the viscosity.

Surface Tension

Surface tension is defined as the tensile force acting on the surface of the liquid in contact with gas or on the surface between two immiscible liquid.

Surface tension on liquid droplet

$$P = \frac{4\sigma}{d}$$

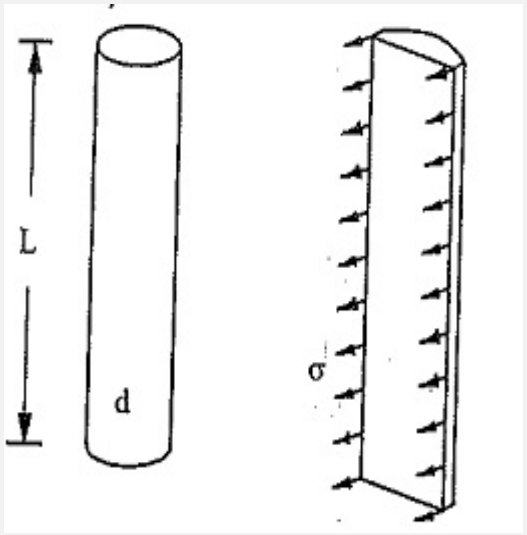


Surface tension on a hollow bubble

$$P = \frac{8\sigma}{d}$$

Surface tension on a liquid jet

$$P = \frac{\sigma * 2L}{L * d}$$



Where P = Pressure in N/ m^2

σ = Surface tension in N/m

d = diameter of the liquid droplet

L = length of water jet

Capillarity

Capillarity is defined as the phenomenon of rise or fall of a **liquid surface in a small tube** relative to adjacent general level of liquid when the tube is held vertically in the liquid.

- Rise of liquid in the tube - **Capillary rise**
- Fall of liquid in the tube - **Capillary depression**

Factors affecting rise or fall

1.Denisty of liquid

2. Diameter of the tube

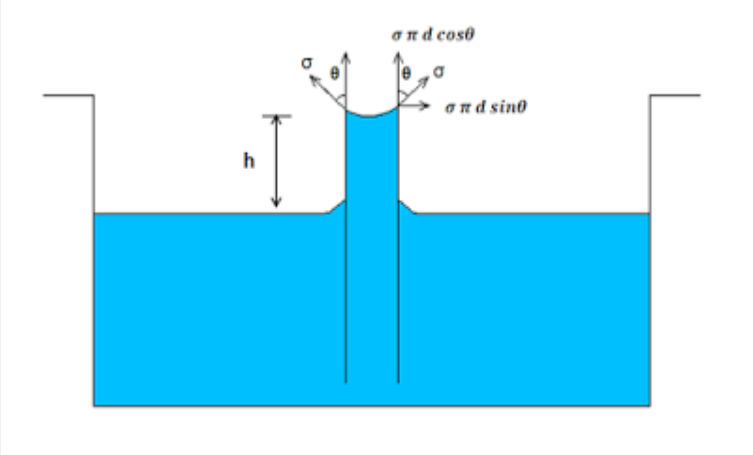
3.Surface tension of the liquid

Expression for Capillary rise

Under state of equilibrium weight of the liquid of height is balanced by the force at the surface of the liquid in the tube

Weight of liquid = **ρ x g x Area of tube x h**

$$= \rho \times g \times \pi \frac{d^2}{4} \times h$$



- Vertical component of the tensile force **$= \sigma \times \pi d \cos\theta$**
- Equating two equations,
- The capillary rise is given as $h = \frac{4\sigma \cos\theta}{\rho \times g \times d}$

- **$\theta = 0$ for clean water and glass tube**

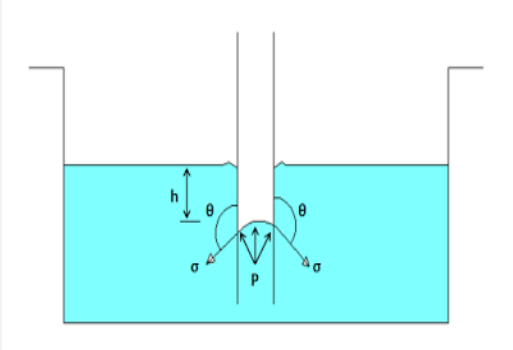
$$h = \frac{4\sigma}{\rho \times g \times d}$$

Where ρ= density;

σ= surface tension;

d = diameter of the tube

Expression for Capillary depression



If the glass tube is dipped in mercury the level of mercury in the tube is lower that the general level of the outside liquid.

The capillary depression is $h = -\frac{4\sigma \cos\theta}{\rho \times g \times d}$

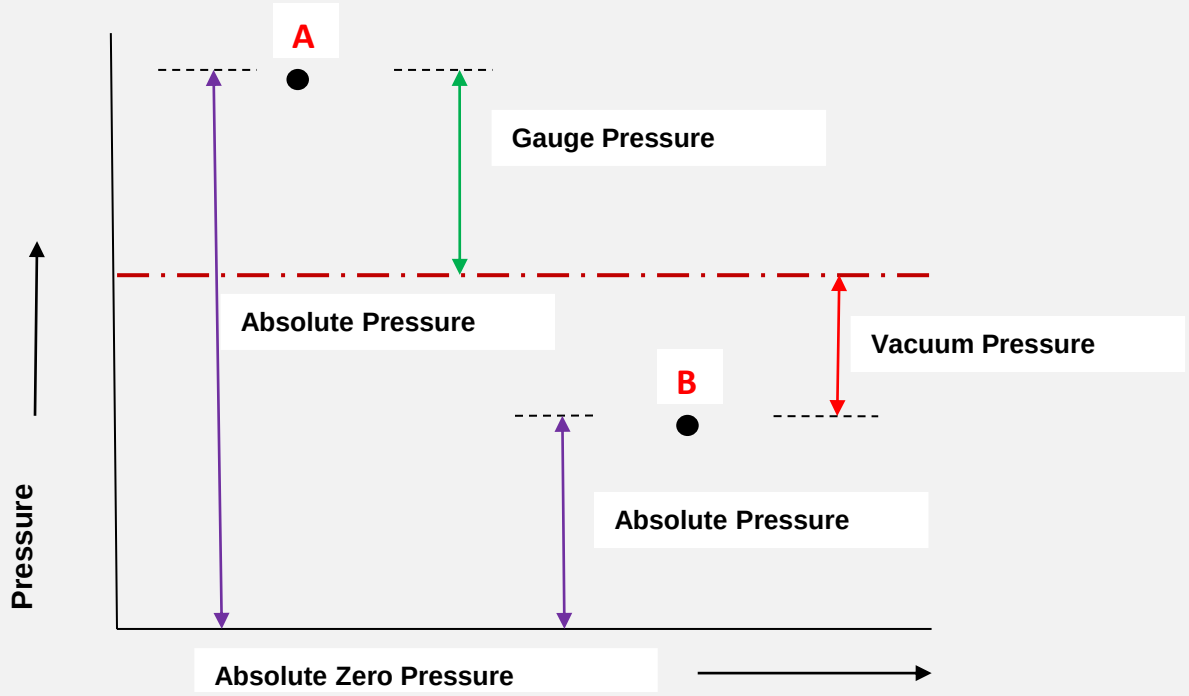
θ = 128 ° for mercury and glass tube

Where ρ= density; σ= surface tension ;d = diameter of the tube

The Pressure on a fluid is measured in two different systems

Absolute Pressure: The Absolute pressure is defines as the pressure which is measured with reference to absolute vacuum pressure.

Gauge Pressure: The Gauge pressure is defined as the pressure which is measured with the help of pressure measuring instrument, in which the atmospheric pressure is taken as datum.



Vacuum Pressure: It is defined as the pressure below the atmospheric pressure.