

Fluid & Its Properties

Fluid: Matter which can flow (Liquid & Gas).

Internal Resisting shear force (Shear stress) is zero at rest.

Density (ρ): Density (ρ) = $\frac{\text{Mass}(m)}{\text{Volume}(V)}$

$$\rho_{Air} = 1.2 \text{ kg/m}^3$$

$$\rho_{Water} = 1000 \text{ kg/m}^3$$

$$\rho_{Hg} = 13600 \text{ kg/m}^3$$

Specific weight (w): Specific weight (w) = $\frac{\text{Weight}(W)}{\text{Volume}(V)}$

$$w = \rho g$$

$$w_{H_2O} = 9810 \text{ N/m}^3$$

Specific Gravity (S): Specific Gravity (S) = $\frac{\text{Density of fluid}}{\text{Density of standard fluid}}$

Standard fluid is Water for liquid

Standard fluid is Air for Gas

Compressibility (β): variation of volume with change in pressure.

$$\beta = \frac{-dV/V}{dP}$$

Bulk modulus (K): $K = \frac{dP}{-dV/V} = \frac{dP}{d\rho/\rho} = \frac{1}{\beta}$

Isothermal Bulk Modulus of Ideal Gas (K_I) = P

Adiabatic Bulk Modulus of Ideal Gas (K_A) = γP

Ratio of Specific heats

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No Slip Condition: Relative velocity of fluid wrt a solid surface is zero at solid surface.

Viscosity (μ): When fluid is in motion the resistance offered by one layer of fluid to the adjacent layer of fluid is known as viscosity.

Newton's Law of Viscosity:

$$\tau = \mu \frac{d\theta}{dt}$$

Strain rate

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

(for linear velocity profile)

Velocity gradient

Units of Viscosity: S I unit: $\text{N}\cdot\text{s}/\text{m}^2$
Dimension: $[\text{M}\text{L}^{-1}\text{T}^{-1}]$
MKS unit: $\text{kg}/\text{m}\cdot\text{s}$
CGS unit: $\text{gm}/\text{cm}\cdot\text{s}$ (Poise)

$$1 \text{ Poise} = 10^{-1} \text{ kg}/\text{m}\cdot\text{s}$$

Variation of Viscosity with temp :

Fluid $\begin{cases} \rightarrow \text{Liquid } T \uparrow \mu \downarrow \\ \rightarrow \text{Gas } T \uparrow \mu \uparrow \end{cases}$

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Kinematic Viscosity (ν): Kinematic Viscosity (ν) = $\frac{\text{Dynamic Viscosity } (\mu)}{\text{Density } (\rho)}$

Units of Kinematic Viscosity: MKS unit: m^2/sec

Dimension: $[\text{M}^0\text{L}^2\text{T}^{-1}]$

CGS unit: cm^2/sec (Stoke)

$$1 \text{ Stoke} = 10^{-4} \text{ m}^2/\text{sec}$$

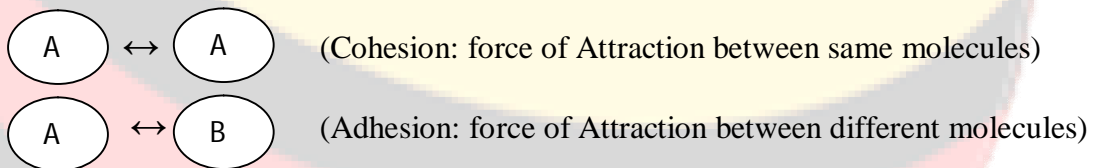
Newtonian Fluid: Fluids which follows the Newton's law of Viscosity.

e.g. Air, Water, Oil etc.

$$\mu_{\text{water}} = 1 \text{ cP at } 20^\circ \text{C}$$

Ideal fluid: Fluid having zero viscosity ($\mu = 0$).

Cohesion & Adhesion:



Surface tension (σ): Tensile force normal to the line drawn on the surface & acts along the plane of surface

$$\text{Surface Tension } (\sigma) = \frac{\text{Tensile force (F)}}{\text{length (L)}}$$

σ depends on both liquid & gas which are forming interface

$$\sigma_{\text{H}_2\text{O}/\text{Air}} = 0.0736 \text{ N/m}$$

Variation of surface tension with temp: $T \uparrow \quad \sigma \downarrow$

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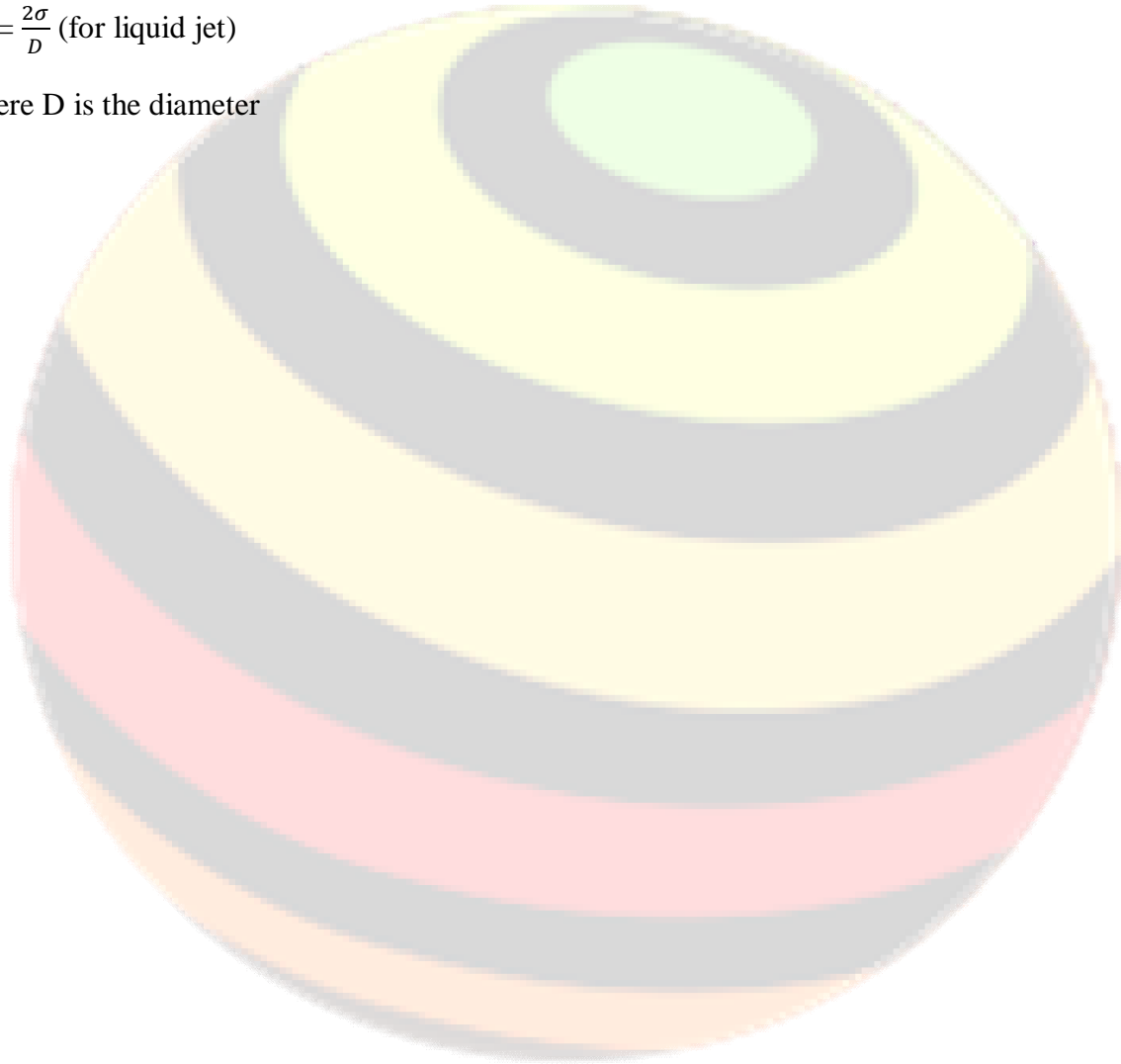
Gauge Pressure under various conditions :

$$\Delta P = \frac{4\sigma}{D} \text{ (for water Droplet \& Air Bubble in water)}$$

$$\Delta P = \frac{8\sigma}{D} \text{ (For soap bubble)}$$

$$\Delta P = \frac{2\sigma}{D} \text{ (for liquid jet)}$$

Where D is the diameter



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