Fluid & Its Properties

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

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

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

ρ_{Air} = 1.2 kg/m^3

ρ_{Water} = 1000 kg/m^3

ρ_{Hg} = 13600 kg/m^3

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

$w = \rho g$

w_{H_2O} = 9810 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) = γ P

Ratio of Specific heats

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

Viscosity (μ): When fluid is at motion the resistance offered by one layer of fluid to the adjacent layer of fluid in 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: N-S/m^2

Dimension: $[ML^{-1}T^{-1}]$

MKS unit: kg/m-s

CGS unit: gm/cm-s (Poise)

1 Poise = 10^{-1} kg/m-s

Variation of Viscosity with temp :

Fluid → Liquid T ↑ μ ↓

Fluid → Gas T ↑ μ ↑

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

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

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

CGS unit: cm^2/sec (Stoke)

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

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

e.g. Air, Water, Oil etc.

μ_{water} = 1 cP at 20^0 C

Ideal fluid: Fluid having zero viscosity (μ = 0).

Cohesion & Adhesion:

A ↔ A (Cohesion: force of Attraction between same molecules)

A ↔ B (Adhesion: force of Attraction between different molecules)

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

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

σ depends on both liquid & gas which are forming interface

$\sigma_{H_2O/Air}$ = 0.0736 N/m

Variation of surface tension with temp: T ↑ σ ↓

Gauge Pressure under various conditions :

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

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

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

Where D is the diameter