HYDRAULICS AND HYDRAULIC MACHINES

Fluid:

A fluid is a substance which is capable of flowing or moving under the action of shear force (however small the force may be). In case of fluid as long as the shear force is there the deformation continue and hence in fluid rate of deformation is important than deformation. After the removal of force the fluid will never come back to its original position, whereas in case of solid, if the force is within elastic limit, after the removal of force it try to come back to the original position.

Example: Liquid, Gases and Vapours

Note: ***For a static fluid that is no shear force.***

Mechanical properties of fluids:

There are following mechanical properties of fluids

1. Density or Mass density
2. Specific weight or Weight density
3. Specific gravity
4. Specific volume
5. Compressibility
6. Viscosity
7. Surface tension
8. Capillarity

1. Density or Mass density: It is the ratio of mass of the fluid per unit volume. It is denoted by **ρ.**

Density= Mass of fluid / Volume of fluid

Its unit is Kg/m^3.

The density of water for all calculation purpose are taken as 1000 Kg/m^3.

Density depends on temperature and pressure. If temperature increases then density decreases and when pressure increases then density also increases.

2. Specific weight or Weight density: It is the ratio of weight of the fluid to its volume. It is denoted by **w**.

Specific weight = Weight of fluid / Volume of fluid

Its unit is N/m^3.

3. Specific gravity: It is the ratio of density of fluid to the density of standard fluid. It is denoted by **s**.

Specific gravity = Density of fluid / Density of standard fluid

In case of liquids, standard fluid is water and in case of gases, the standard fluid is either hydrogen or air at a given temperature and pressure.

It has no unit.

Specific gravity of water is 1 and that of mercury is 13.6.

4. Specific volume: It is the ratio of volume of the fluid to weight of fluid. It is reciprocal of specific weight. It is denoted by ***v***.

Specific weight = Volume of fluid / Weight of fluid

Its unit is m^3/N (in case of liquid) and m^3/Kg (in case of gas).

5. Compressibility: It is the reciprocal of Bulk modulus. It is denoted by **β**.

When $\beta = 0$, means fluid is incompressible.

That is $d\rho = 0$, means density constant.

A fluid is said to be incompressible if the density remains constant with respect to pressure. If Mach number is less than 0.3 then the fluid flow can be treated as incompressible.

6. Viscosity: The internal resistance offered by one layer of fluid to the other adjacent layer is known as viscosity.

Newton's law of viscosity: According to Newton law of viscosity shear stress is directly proportional to rate of shear strain.

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

Where τ = shear stress

$\frac{du}{dy}$ = velocity gradient

μ = co-efficient of viscosity or absolute viscosity or dynamic viscosity.

Variation of viscosity with temperature:

In case of liquid the intermolecular distance is small and hence cohesive forces are large. When we increase the temperature cohesive forces decreases, hence the resistance to the flow also decreases and therefore ***viscosity of a liquid decreases with increase in temperature***.

In case of gases the intermolecular distance is large and hence cohesive forces are negligible. With rise in temperature the molecular agitation (disturbance) increases and hence the resistance to the flow also increases. Therefore ***viscosity of a gas increases with increase in temperature***.

7. Surface Tension: Surface tension is a line force and it is expresses as force per unit length drawn on the surface and it acts normal to the line in the plane of surface.

Surface tension is basically due to unbalances cohesive force, with rise in temperature cohesive force decreases and hence surface tension also decreases.

Its unit is N/m.

Note: ***At critical point, surface tension is zero, because at critical point liquid-vapour interface vanishes.***

8. Capillarity: The rise or fall of a liquid when a small diameter tube is immersed in it, is known as capillarity.

Capillary rise is due to adhesion (example- water) and capillary fall is due to cohesion (example- mercury).

Therefore, capillarity is due to both adhesion and cohesion.

Note:

1. *The angle of contact for water and glass is about 29^0.*
2. *The angle of contact for mercury and glass is about 132^0.*
3. *The angle of contact for pure water in contact with clean glass tube is 0^0.*

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