

CONCEPTS OF
MECHANICAL
ENGINEERING – I
(25ME111)

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WEEK 04

- Properties of Engineering Materials
- **Mechanical Properties** - Elasticity, Plasticity, Malleability, Ductility, Brittleness, Strength, Toughness, Hardness, Stiffness, Resilience, Creep, Endurance, Fatigue & Machinability.
- **Thermal Properties** - Thermal conductivity, Specific Heat, Thermal Expansion.
- **Electrical Properties** - Resistivity, Conductivity, Dielectric Strength, Temperature Coefficient.
- **Chemical Properties** - Reaction with Oxygen and Water.
- **Magnetic Properties**- Magnetic permeability, Magnetic Flux Density.

MECHANICAL PROPERTIES

These properties include the nature and behaviour of metals under the action of external forces. These are:

1. Elasticity:

It is that property of the metal by virtue of which the metals are able to regain their original shape and size after removal of the load.

2. Plasticity:

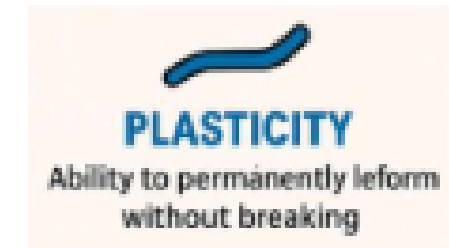
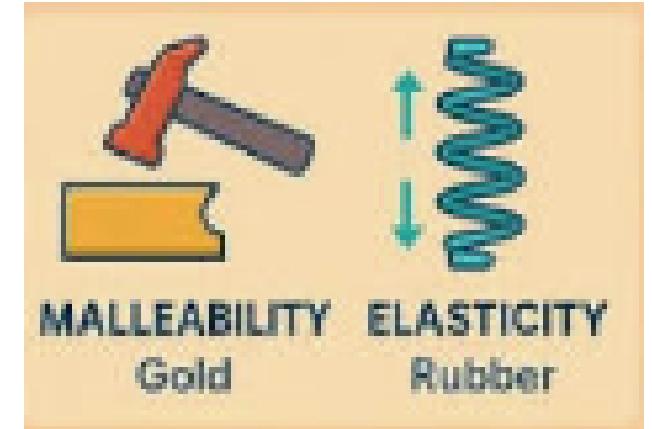
It is that property of the metal by virtue of which a metal takes place permanent deformation without fracture whenever it is subjected to the action of external forces. Ex: Rolling of structural steel or forging of metals, etc.

3. Malleability:

It is the ability of metal to be hammered into thin sheets. Gold and silver are highly malleable.

4. Ductility:

It is that property of the metal by virtue of which a metal can be drawn into wires or elongated before rupture takes place



5. Brittleness:

It is that property of the metal by virtue of which a metal will fracture suddenly without any appreciable deformation.

6. Strength:

Strength may be defined as the property of a metal by virtue of which it can withstand or support an external force or load without rupture.

7. Toughness:

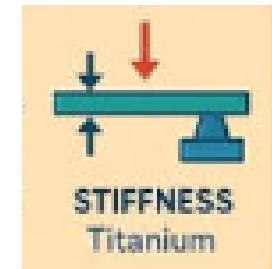
It is defined as that property by virtue of which a metal can absorb maximum energy before fracture takes place.

8. Hardness:

It is that property of the metal by virtue of which a metal resists abrasion, indentation and scratching by relatively harder materials.

9. Stiffness:

It is defined as that property by virtue of which a metal will not deform or deflect when load is applied.



10. Resilience:

It is defined as that property by virtue of which a metal stores energy and resists shock or impact loads.

11. Creep:

It is defined as that property by virtue of which a metal deforms continuously and slowly under a steady load.

12. Endurance:

It is defined as that property of a metal by virtue of which it can withstand varying stresses (same or opposite nature).

13. Fatigue:

Fatigue is the gradual weakening of a material due to repeated Loading.

This can lead to the development of cracks and the subsequent failure of material.

14. Machinability:

It is a measure of how easily a metal can be cut, shaped or finished using machining processes.

It is also known as the ability of a material to be machined with a satisfactory finish at a low cost.



THERMAL PROPERTIES

1. Thermal conductivity: Thermal conductivity of a metal can be defined as the number of Kilo Joules of heat that would flow per second through a specimen of one sq. metre in cross-section and 1 metre in length when the temperature gradient is 1°C .

2. Specific heat: Specific heat of a metal can be defined as an amount of energy required to raise the temperature of one gram of the substance through one degree Celsius. It can be measured in Joules or Calories.

3. Thermal expansion: Thermal expansion of a metal can be defined as a tendency to expand when they are heated to a considerable temperature.

For example: The linear co-efficient of expansion of a metal can be defined as the increase in length per unit length for each degree rise in temperature.

THERMAL PROPERTIES

4. Thermal diffusivity: Thermal diffusivity is defined as the ratio of the thermal conductivity to the heat capacity of a material.

Thermal diffusivity of a material can be defined as thermal conductivity divided by the product of its density and specific heat capacity where the pressure is held the constant.

Thermal diffusivity of a material can also be defined as the measure of the rate at which particles or heat can spread.

5. Thermal fatigue: Thermal fatigue is defined as a type of mechanical failure that occurs where a material is repeatedly heated and cooled, causing it to expand and contract.

6. Thermal shock: When a material experiences a rapid change in a temperature, causing internal stresses that can lead to cracking or breaking is known as thermal shock.

7. Melting point: It can be defined as the temperature at which the material changes from a solid state to a liquid state.

ELECTRICAL PROPERTIES

1. Resistivity: It is the electric property of a material due to which, it resists the flow of electricity through it.

$$\text{Resistivity, } \rho = \frac{RA}{l}$$

Where,
R = Resistance of a material
A = Area of cross section
L = Length of a material

2. Conductivity: It is the electric property of a material due to which the electric current flows easily through the material.

$$\sigma = \frac{l}{RA}$$

It is the reciprocal of electrical resistivity.

ELECTRICAL PROPERTIES

3. **Dielectric strength:** It is the insulating capacity of a material against high voltage. A material having high dielectric strength can withstand sufficiently high voltage field across it before it will break down and conduct.

4. **Temperature co-efficient of resistance:** It is usually employed to specify the variation of resistivity, ρ with the temperature.

Temperature co – efficient of resistance

$$\alpha_T = \frac{\rho - \rho_0}{\rho_0} \times \frac{1}{T - T_0}$$

Where,

ρ = Resistivity at temperature T

ρ_0 = Resistivity at temperature T_0

T and T_0 , are degrees in Kelvin

CHEMICAL PROPERTIES

1. Reaction with oxygen: Many metals produce metal oxide by burning in the oxygen of the air.

2. Reaction with water: *Metals produce metal oxide and hydrogen gas while reacting with water, the metals like sodium and potassium react with water violently and an exothermic reaction takes place.*

3. Reaction with acid: Salt and hydrogen are produced when a metal reacts with an acid.

4. Reaction with Base: *When metal reacts with base, the outcome is the formation of salt and the release of hydrogen*

Magnetic Properties

1. Diamagnetic materials: These are the materials whose relative permeability is *slightly less than* unity and they repel the lines of force slightly.

2. Paramagnetic materials: These are the material's whose relative permeability is *slightly greater than* unity and are magnetised *slightly*. They attract the lines of forces weakly

3. Ferro-magnetic materials: These are the materials whose relative permeability is *much greater than* unity and *t dependent on the field strength*. They act the lines of force strongly.

Magnetic Properties

4. Magnetic permeability: It is an *ability of a material to allow the magnetic flux when the object is placed inside the magnetic field.*

The readiness of a material to accept magnetism is expressed by its permeability.

Permeability is the measure of magnetization produced in a material when it placed in the magnetic field.

5. Magnetic flux density: It is defined as *the flux or lines of force passing per unit area through any substance through a plane at right angles to the direction of magnetic flux.*

6. Magnetic field strength: It may be defined as *the field strength at any point within a magnetic field is the number of lines of force passing through a unit area round the point considered and held perpendicular to the lines.*

It may *also be defined as the field strength at any point within a magnetic field is the force exerted by a unit North pole at that point.*

Magnetic Properties

7. Magnetic moment: When a coil carrying a current I is located in a region of uniform magnetic flux density, will experience a torque whose magnitude is depends on the area of the coil, the current and the component of flux density in the plane of the coil,

then the magnetic moment or magnetic dipole moment can be defined as the product of current and the area of the coil i.e.

$$P_m = I \times A \quad \text{Ampere-m}^2 \text{ (A-m}^2\text{)}$$

It is a vector quantity, where, I =Current in Ampere, A = area of the coil.

Magnetic Properties

8. Magnetization (M): The magnetization can be defined as the magnitude of magnetic moment per unit volume when the materials are placed in presence of magnetic field. It is a vector quantity.

The magnetization M is given by

$$M = N \times P_m$$

Where, N = Number of magnetic dipoles per unit volume

P_m = Magnetic moment.

Magnetic Properties

9. Magnetic susceptibility: It can be defined as the ratio of the magnetization (M) to the magnetizing force (H).

$$\text{Magnetic susceptibility (Z)} = \frac{\text{Magnetization}}{\text{Magnetizing force}} = \frac{M}{H}$$

Magnetic susceptibility is a dimensionless quantity.

Any
Question

