CH-1 : Engineering Material And their Properties

Definition of Engg. material-

Engg. material is the branch of science which deals to selecting the correct materials for the application in which the engineered part is being used

Definition of Material-

A material is that act of which anything is or may be made. Material comprise a wide range of metals and Non-metals which must be operated upon to form the finshed product.

Material Classification-

a) Metal ← Ferrous
Non ferrous
b) Organics
c) Ceramics
d) Composites
e) Semi-conductors.

a) Metals-

Metals play a major role in the industrial and every day life of human beings. Ex- Iron, Al, Zn, Cu, Mg etc.

Characterstics of Metals-

i) Hardness
ii) plastic deformability
iii) Strength
iv) Ductility

v) Malleability
vi) Machinability
vii) stiffness
viii) High melting point
ix) Thermal conductivity
x) Good electrical conductivity
xi) Low specific heat.
xii) Weldability
xiii) Dimensional stability
xiv) Castability.

b) ceramics
i) It is usually consists of oxides, nitrides, silicades of various metals.
ii) Ceramics are used at high temperature.
iii) Ceramic materials contains compounds of metallic and non-metalic elements such MgO, SiO_2, SiC, etc.

Example- Sand, Brick, Glass, Cement, Concrete, Boron Nitride, Tungsten carbide etc.

Characteristics of ceramics-
i) Brittleness
ii) Hardness
iii) Insulation (To flow of electric current)
iv) Corrosion resistance.
v) High temperature Strength

c) Organic Material

There are Polymeric material composed of carbon compounds. Polymers are solids composed of long molecular chains.

Example - Rubber, plastics, fuels, Paper, woods, lubricants, Explosives, paints etc.

Characteristics of organic material -

i) Light weight
ii) Ductile in nature
iii) Soft
iv) Poor conductor of heat and electricity
v) Poor resistance to temperature.

Uses of Organic material -

i) As fuel
ii) As Lubricants
iii) As explosives
iv) For high tempt
v) For Protection against corrosion.
vi) As electric insulation
vii) As refrigerants.

d) Composites materials - It Consists of combinations of two dissimilar material into new material.

Example - Fibre reinforced composite and particle reinforced composites.

Characteristics of Composite material-

i) Stiffness
ii) Toughness
iii) High temp. strength

Uses
i) Industrial applications
ii) Household goods

e) Semi-Conductors -

Semi-conductors have electrical properties that are intermediate between the electrical Conductors and insulators. The electrical characteristics of these materials are extremely sensitive to the presence of minutes concentrations of impurity atoms, which concentrations may be controlled over very small region's

Properties of Engineering material

In the different material, properties are-

a) Mechanical Properties
b) Thermal properties
c) Magnetic properties
d) Electrical properties
e) Chemical properties
f) optical properties
g) Physical properties

Mechanical Properties-

1) a) Elasticity-

It is defined as the ability of material to deform and return back to its original shape when they load is removed

Plasticity-

It is defined as the ability of material to get Permanent deformation under the action of load.

Toughness-

It is the ability of material to absorb energy during Plastic deformation up to fracture

Resilence-

The Strain energy stored in a body within elastic limit; when loaded externally is called resilness.

Strain Energy- Potential energy stored in the body within elastic limit; is called strain energy.

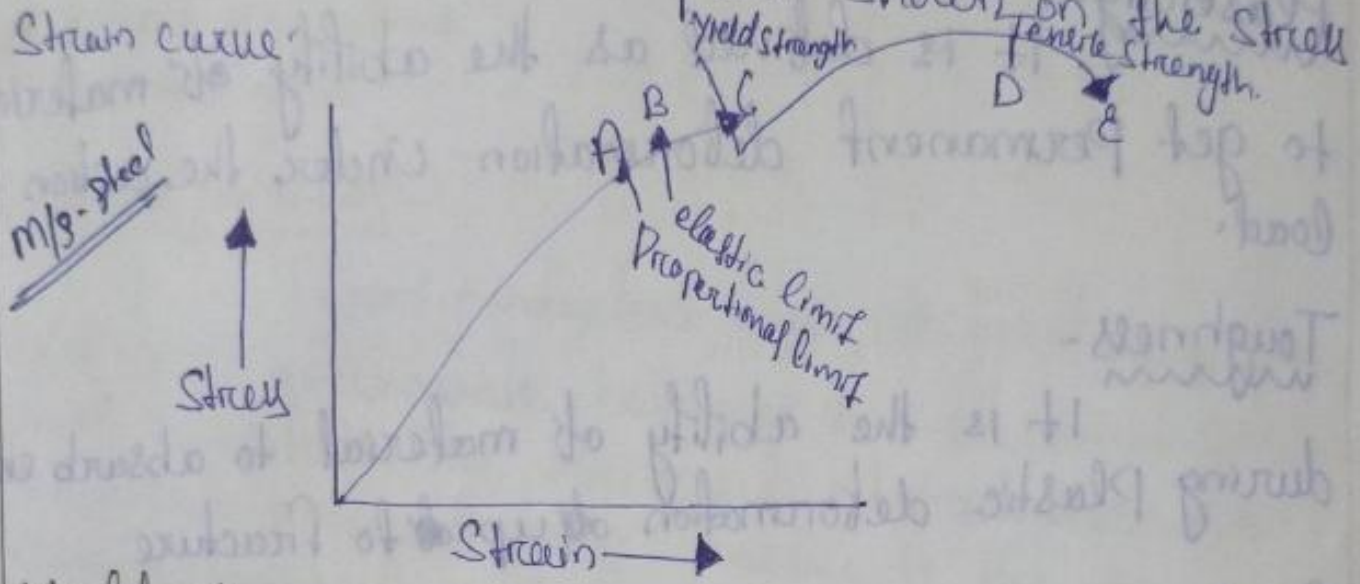
Another Definition of Resilence-

It is the capacity of a material to absorb energy when it is elastically deformed and then upon unload to have this energy recovered.

Tensile Strength - (Tungsten)

→ In a tensile test, the ratio of maximum load to original cross-sectional area is called tensile strength or Ultimate strength

→ It is the maximum Point shown on the Stress Strain curve.



Yield Strength -

→ The Point where the stress Suddenly increase is known as yield Strength of the material

Impact Strength - → Stainless steel.

The capacity of a material to resist or absorb shock energy before it fractures is called impact Strength.

→ It depends upon the structure of a metal during sudden and forceful impact

Ductility → gold.

It is the ability of a material to undergo large permanent deformation in tension.

→ Ppt.

↗ Lead is high malleability / gold is most malleable. Nickel is least malleable metal.

Malleability - It is the ability of a material to undergo large permanent deformation in ~~tension~~ Compression.

Ex- Metal formed by hammering or rolling

Brittleness - It is the ability of a material which can be only slightly deformed without fracture

Hardness - It is the ability of a material to resist very small identification, absorption and deformation.

Stiffness - It is the ability of a material to resist any deformation under stress.

$$\text{Stiffness (k)} = \frac{\text{Resisting force}}{\text{Elongation (Sol/Sl/Sv)}}$$

Fatigue - When a body subjected to fluctuating speed or repeated speed, material tends to develop a characteristics behaviour which is different in under steady load.

Creep - It is defined as the time-dependent and Permanent deformation of materials when subjected to a constant load or stress / slow → slow process (3 stage) of creep

Wear Resistance - It is defined as the ability to resist wear and abrasion

Wear means; the unwanted removal of solid material from rubbing surface (Rough)

Thermal Properties

Heat capacity – It is a property that is inductive of a material ability to absorb heat from external surroundings.

Specific Heat – It is the quantity of heat that must be added to a unit mass of solid to raise its temperature by one degree.

Thermal Expansion – When thermal energy is added to a material a change in its dimensions occurs.

Ex – If a 10cm long rod of mild steel is heated and it is free to expand. Means in increases in length.

This is called thermal expansion.

Melting Point – Highest melting tungsten lowest - lead.

It is the temperature at which a pure metal compound changes from solid to liquid: the temp at which the liquid and the solids are in equilibrium.

Ex – mild steel melting point = 1500°C

Copper = 1080°C

Aluminium – 650°C respectively

gold. 1060°C
lead – 327
silver. 961
steel – 1405 - 1540
Tungsten – 3400°C

Thermal Conductivity :- The rate at which heat can flow through a material under the given temp gradient, is known as thermal conductivity.

(Aluminium)

Heat Resistance :- It is the ability of a material, properties are remain stable with changes in temperature.

Electrical Properties :-

Resistivity :- It is that electrical property of a material which resists the flow of electricity through it.

Conductivity :-

It is that type of electrical property of a material which provides an easy path for the flow of electricity through it.

(i) Dielectric strength :-

The dielectric strength means the insulating capacity of a material against high voltage.

Thermo electricity :-

If two dissimillar metals are joined and this junction is then heated a small voltage in the millivolt range is produced & this is known as thermo electricity

Magnetic Properties :-

It is the ratio of magnetic induction to the intensity of magnetizing field.

Ex :- common ferromagnetic steels have permeability up to about 20,000.

Chemical Properties :-

Most of the engineering metals, when they come in contact with other substances with which they can react, tends to suffer from chemical deterioration so, that we can study chemical properties of a material.

Some of the chemical properties are;

1. Corrosion resistance
2. Chemical composition
3. Acidity

Note :-

Corrosion :- (i) It is the deterioration of a material by chemical reaction with its environment.

(ii) Corrosion degrades material properties and reduces ecomic value of the material.

(iii) Corrosion attacks metals as well as non-metals. Corrosion of concreate by sulphate in soils in a common problem.

Optical Properties

Refractive index :- It is defined as the ratio of angle of incidence i and the angle of refraction r.

$$\text{Mathmatically } (n) = \frac{\sin i}{\sin r}$$

Absorptivity :-

The energy incident on any material gets partly transmitted, reflected and absorbed. The decimal fraction transmitted is termed the transmittance (T), the decimal fraction reflected is called reflectance (R) and decimal fraction absorbed is known as the absorptivity (A).

Reflectivity :-

Reflectivity may be calculated by using following equation.

$$\text{Reflectivity}(R,\%) = \frac{(n-1)^2+k^2}{(n+1)^2+k^2} \times 100$$

where, n = refractive index

k = Absorption co-efficient

Physical properties

(a) Dimension :- Dimension of a material implies it's size i.e. breath, width, length, diameter) and shape ie. (section → square, circular, channel, angles) etc.

(b) Appearance :- (i) Different materials have different looks. A metal looks clearly from wood or plastic.

(ii) Even metals themselves have got different appearances e.g. aluminium is a silvery white metal whereas copper appearance brownish red.

(iii) Appearence includes luster, colour and finish when finely polished.

(c) Colour :- (i) The colour of the material is very helpful in identification of a metal.

(ii) Colour of a material depends upon the wave length of the light that the material can absorb.

(iii) Colour is that type of aspect of appearance of a material that depends on the composition of the light reaching the retina on the eyes and on the light's temporal distribution.

Metal	Colour
Aluminium	white
Copper	reddish
Iron	Grey
Zinc	bluish white
Lead	soft grey
Silver	lustrous white
Tin	silvery white

(D) Density :- (i) It is define as the ratio of mass or weight per unit volume.

Mathematically Density = $\frac{\text{mass}}{\text{volume}}$

(ii) Density depends to some extends on the
- (a) Purity of the material
- (b) Volume
- (c) Treatment, the metal has received.

(iii) Different metals posses different densities.

metal	Density
Al	2.7 gm/cc
Cu	8.7 gm/cc
Fe	7.2 gm/cc
Zn	6.87 gm/cc
Sn	7.42 gm/cc
Si	10.5 gm/cc

(e) Melting Point :-

One metal can be distinguish from the other on the basis of it's melting point. Melting point of a metal is that temperature at which the solid metals changes into the molten state.

(f) Porosity :-

A material said to be porous if it has pores within it. It can absorb lubricants.

(g) Structure :- (i) It means geometric relationships of material components.

(ii) Structure also implies the arrangement of the internal components of matter. i.e. electron structure, crystal structure and microstructure.

Technological Properties :-

Technological properties are those which have application on processing of metals and their alloys.

(a) castability
(b) Machinability
(c) Weldability
(d) Solderability
(e) formability

Performance Requirement :-

→ The material of which a part is compased must be cable of performing a parts function without failure.
Ex:- a component part to be used in a furnace must be of that material which can withstand high temperature.

→ While it is not always possible to assign quantative value to be these functional requirements. They must be related as possible to specified values of some properties ie. mech, physical, electrical or thermal property.

Materials Reliability

A material in a given application must be reliable. Simply stated, reliablity is the degree of probability that a product and the material of which it is made, will remain stable enough to function in service for the intended life of the product without failure.

Safety :-

A material must perform it's function otherwise the failure of the product made out of it may be catastrophic as in airplanes, turbines, high pressure system. The material that gives of spark when struck are hazardous for use in coal mines.

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