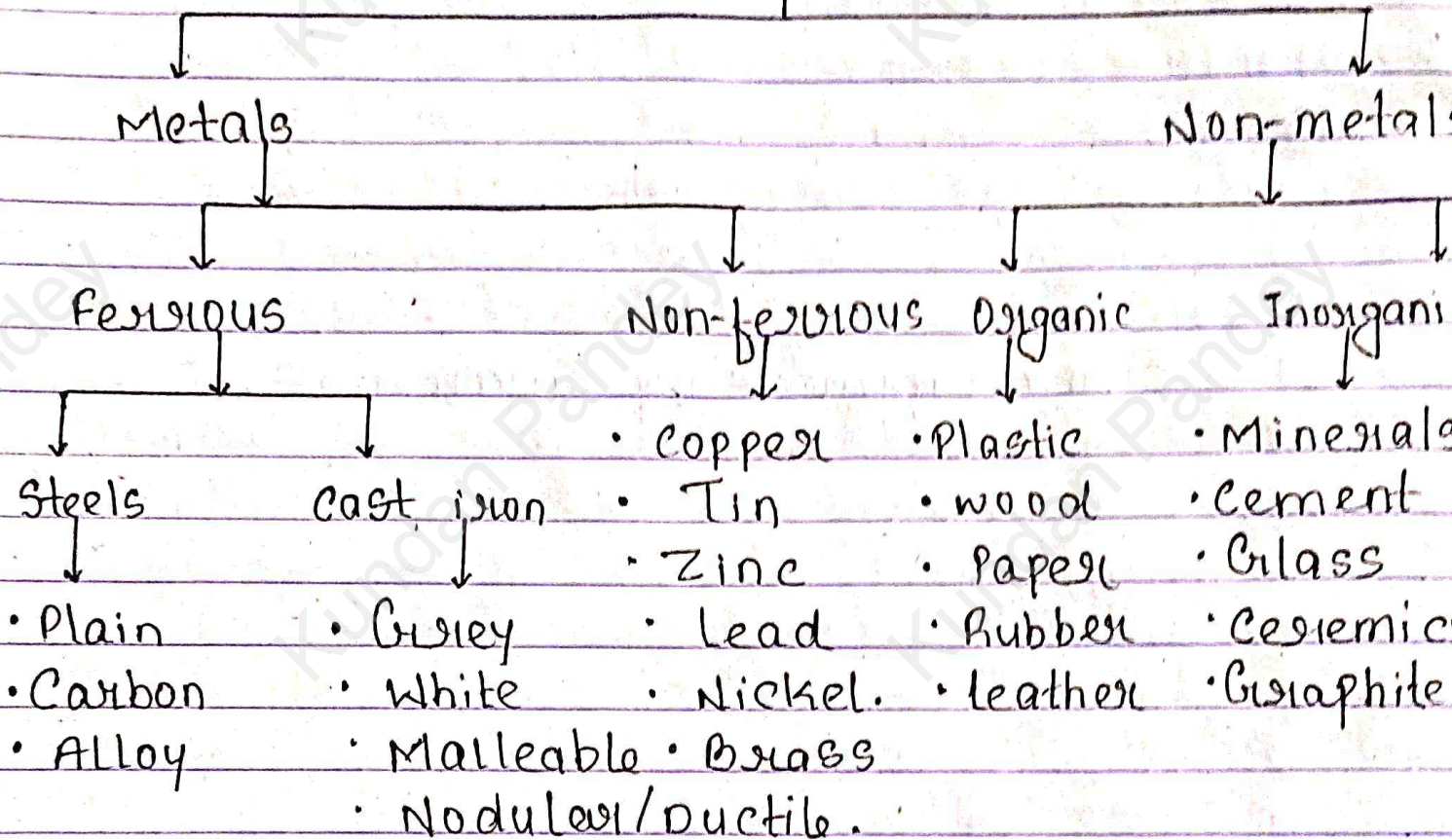


12/04/2024, Friday

* Classification of Engineering Material.

Engineering materials



* Metals :- Metals are the substance having properties like ductility, malleability, lustrous. Normally major metals are in solid at room temperature except Hg.

- All metals are having high thermal and electrical conductivity.
- Some examples of metal :- Silver, copper, Gold, Aluminium, Iron, Zinc, Lead etc.

1/10

∴ Metals can be further divided into two groups :-

a) Ferrous Metals :- The ferrous metals are those which have the iron as their main constituents, such as cast iron, wrought iron and steel.

b) Non-ferrous Metals :- The non-ferrous metals are those which have a metal other than iron as main constituents, such as copper, aluminium, brass etc.

* Non-Metals :- Non-metals are the substance ~~having properties~~ which are generally brittle, dull and non-sonorous.

• Non-metals are bad conductors of heat and electricity.

Example :- Plastics, Rubber, leather etc.

• Non-metals have very high resistivity.

* Alloys :- Alloys are the composition of two or more metals or metal and non-metal together. Alloys are having good mechanical strength.

ex:- Steels, Brass, Bronze, Gunmetal etc.

* Ceramic materials :-

:- Ceramic materials are non-metallic solids. These are made of inorganic compounds such as oxides, nitrides, silicates and carbides.

These ceramic materials are now extensively used in different engineering fields.

Example :- Silica, glass, cement, concrete etc.

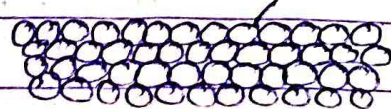
* Organic materials :-

:- All organic materials are having carbon as a common element. In organic materials carbon is chemically combined with oxygen, hydrogen and other non-metallic substances.

ex :- plastics, PVC, synthetic, Rubber etc.

* Crystal structure :-

- Crystal :- A crystal is a solid whose atoms are arranged in a "highly ordered" repeating pattern in all direction.



- Unit cell :- A unit cell is the smallest repeating structure in a crystal lattice that represent the overall arrangement of atom or molecules in a solid material. It is a building block that when repeated in three dimensions, generates the entire ~~different~~ crystal structure.

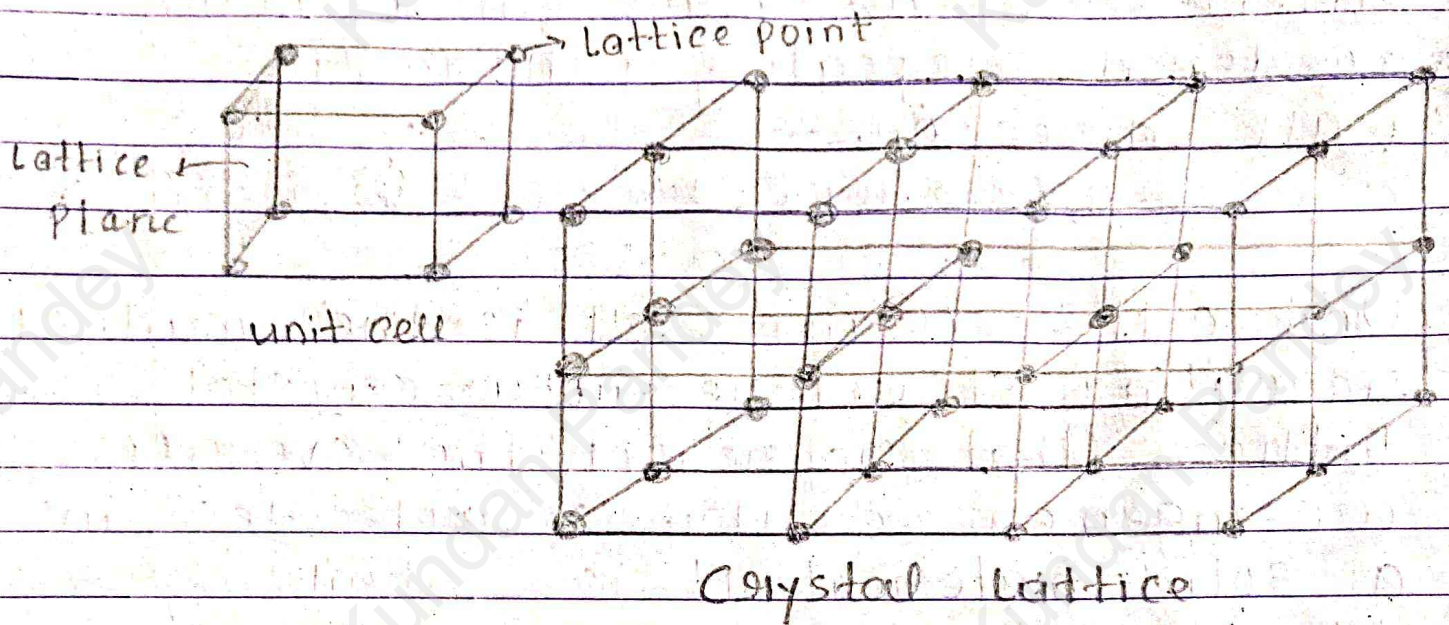
• Crystal lattice :-

The crystal lattice is the symmetrical three dimensional structural arrangement of atom, ions or molecules inside a crystalline solid as point.

:- Characteristics :-

- ① In a crystal lattice each atom is represented by a single point.

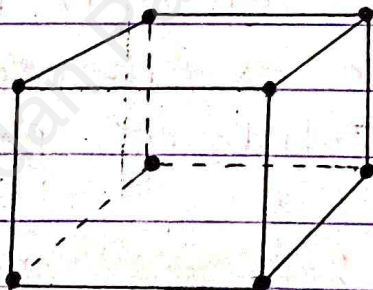
- ② These points are called lattice points.
- ③ Lattice points are together joined by a straight line in a crystal lattice.



* Simple cubic structure :- (SCC)

In this, one atom is located at each of the eight corners of the cube. Therefore it contains eight atoms.

ex:- polonium. (Po)



* Average no. of atom per unit cell (N)

$$N = \frac{A}{8} + \frac{B}{2} + \frac{C}{1}$$

where,

A = No. of atom at corners

B = No. of atom on faces.

C = No. of centre atom.

$$\textcircled{1} \quad N \text{ in SC} = \frac{A}{8} + \frac{B}{2} + \frac{C}{1}$$

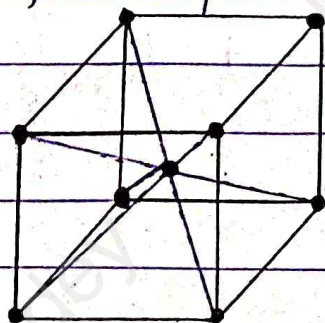
$$= \frac{8}{8} + \frac{0}{2} + \frac{0}{1}$$

$$= 1$$

* Body Centred Cubic structure (BCC) :-

In BCC structure there is one atom at each corner of the cube and one atom at the body centre of the cube. ~~Each~~

Therefore, the BCC structure contain nine atom. This type of unit cell found in metal like lithium, sodium, potassium, Iron, barium, vanadium, molybdenum etc. tungsten.



$$N = \frac{A}{8} + \frac{B}{2} + \frac{C}{1}$$

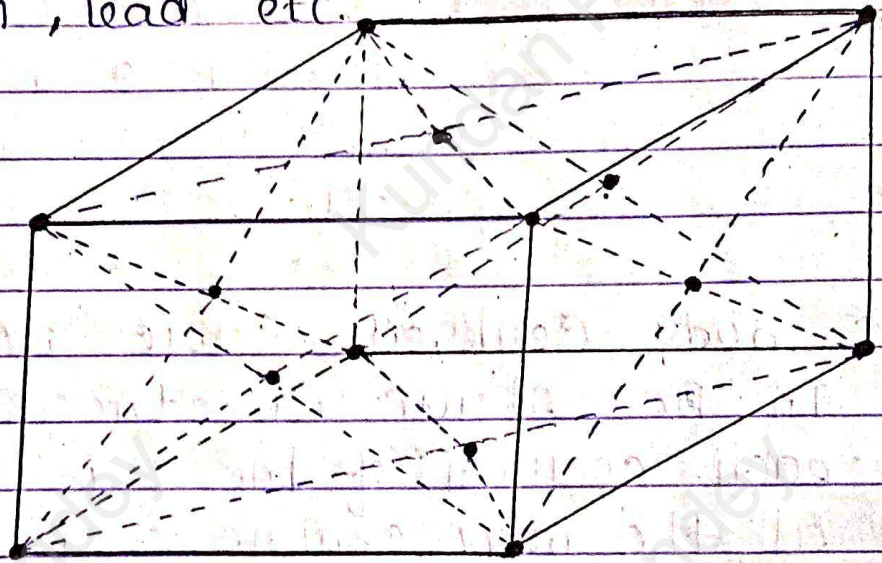
$$= \frac{8}{8} + \frac{0}{2} + \frac{1}{1}$$

$$= 1 + 1 = 2$$

* Face-centred cubic structure (FCC)

In this unit cell, an atom is located at each corner of the cube and in addition, one atom is located at the centre of each of the six faces of the cube. Each corner atom is shared by eight adjoining cubes. Each face-centred atom is shared by only two cubes. This type of unit cell is found in metal like copper, silver, gold, calcium, aluminium, lead etc.

$$APF = 0.74$$



$$N = \frac{A}{8} + \frac{B}{2} + \frac{C}{1}$$

$$N = \frac{8}{8} + \frac{6}{2} + \frac{0}{1}$$

$$N = 1 + 3$$

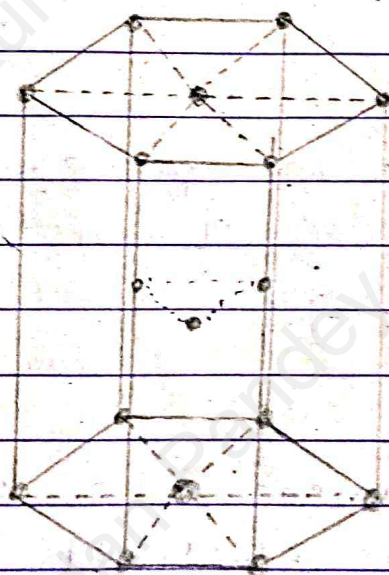
$$N = 4$$

* Hexagonal close Packed structure (HCP):

!- The HCP structure contain

i) one atom at each corner of the hexagon.

ii) one atom each at the centre of the two hexagonals faces and three atoms in the form of a triangular midway between the two basal planes.



$$N = \frac{A}{6} + \frac{B}{2} + \frac{C}{1}$$

$$N = \frac{12}{6} + \frac{2}{2} + \frac{3}{1}$$

$$= 2 + 1 + 3$$

$$= 6$$

* Microscope :-

It is an instrument which is used to see small object.

:- Types of microscope :-

① Simple microscope :- A simple microscope is defined as the type of microscope that uses a single lens for the magnification of the sample. A simple microscope is a convex lens with small focal length. (1990)

$$m = 1 + \frac{D}{F}$$

Where

m = magnification power

D = least distinct vision.

F = focal length.

• Application :-

- ① It is common among the watchmakers as they can view smallest parts.
- ② It is also used by the jewellers
- ③ Educational institutions in their laboratories

* Compound microscope :-

A compound microscope is defined as the type of microscope that has more than one lens. It has a combination of lenses and two optical parts known as an objective lens and an eyepieces.

$$m = \frac{D}{f_o} \times \frac{L}{f_e}$$

Where, D = Least distance.

L = Length of microscope tube.

f_o = Focal length of objective lens

f_e = Focal length of eyepiece.

* ~~Electron microscope~~ :-

• Application :-

i) The study of bacteria and viruses is possible with the help of a compound microscope.

ii) A compound microscope ~~found~~ finds application in forensic laboratories.

iii) It is also used in laboratories.

* Electron microscope :-

An electron microscope is defined as the type of microscope in which the source of illumination is the beam of accelerated electrons. It is a special type of resolution microscope with a high resolution of image as the image can be magnified in nanometers.

• Tungsten is used in electron microscope.

• Types :-

i) Scanning Electron microscope :-

• It is used to see 3D images.

ii) Transmission Electron microscope

• It is used to study different parts inside the cell.

• Applications :-

i) The study of metals and crystals become easy with the introduction of an electron microscope.

* Important parameters:-

i) Magnification:- It is the ratio of image size to the original size.
or zooming capacity.

ii) Resolution:- It is the measure of clarity of the image.

iii) Contrast:- It is the difference in brightness and i.e. light and dark.

Note:-

$$\text{Resolution} = \frac{1}{\lambda}$$

Resolution is inversely proportional to the wavelength, so electron have much smaller wave length than visible light so resolution power of EM is higher.

* Specimen preparation procedure.

:- Preparation of metallographic specimens generally requires five major operations.

i) Sectioning / cutting :-

:- Cutting of specimen from a material

:- Sectioning becomes necessary when studying parts that have failed in service where specimen has to be taken from a large block of material.

ii) Mounting :-

:- The primary purpose of mounting is to make it convenient to handle specimen of small sizes during various step of metallographic sample.

iii) Grinding :-

After the specimen has been cut to shape, or cut to shape and mounted, it is made plane by grinding wheel.

• Grinding is accomplished by abrading the specimen surface through a sequence of operations using progressively finer abrasive grits.

* Polishing :-

:- Polishing entails the complete removal of scratches and the production of mirror finish surface.

Polishing is done by rotating wheel with sylvet cloth and alumina powder of 1 to 2 μ grades. The speed of wheel and amount of water and alumina powder are all determined by trial and experience.

* Etching :-

:- Etching is used to reveal the microstructure of the metal through selective chemical attack. It also remove the thin, highly deformed layer introduced during grinding and polishing.

* Properties of Metal :-

i) Mechanical properties :-

a) Strength :-

:- It is the ability of a material to resist the external forces without breaking.

- Various types of strength like tensile, compressive, shear etc.

b) Rigidity :-

:- It is the ability of a material to resist deformation under the action of external forces.

- Rigidity is measured by elasticity.

c) Elasticity :-

:- It is the ability of a material to return to its original shape and size after removal of deforming force.

:- Material possessing this property is known as elastic material.

D) Plasticity :-

:- It is the ability of a material to be deformed permanently without fracture after removal of deforming force.

- Plastic deformation will take place only when it exceeds the elastic limit.
- This property is desirable for stamping on coins and ornaments.

E) Ductility :-

It is the property of a material which enables it to be drawn into thin wires under tensile force.

- Gold, silver, copper, aluminium etc are ductile materials.

F) Malleability :-

It is the property of a material by virtue of which materials can be drawn into thin sheet on hammering.

- Gold, silver, copper, lead etc.
- A malleable material may not be ductile. i.e lead.

G) Brittleness :-

- A material is said to be brittle if it cannot undergo elastic or plastic deformation but it breaks under the external force.

- Glass, cast iron etc. are brittle.

H) Hardness :-

It is the ability of material to resist scratching, wear and abrasion.

- Hardness is the ability of material to cut another material.
- This property is used to selection of cutting tool material.
- Hardness is measured by Brinell test, Rockwell test etc.

I) Toughness :-

- It is the property of a material to resist fracture due to high impact loads like hammer blow and to absorb a certain energy.

- It is measured in terms of energy absorbed per unit volume before it fractures.

- Cast iron, high carbon steel, ceramics etc.

1) Resilience :-

It is the ability of a material to absorb or store energy when it is subjected to impact loads and shocks.

- Materials releases the stored energy on removal of load.

- This property is necessary for spring material.

2) Corrosion Resistance :-

:- Corrosion is the gradual destruction of the metal due to its exposure to moisture, acids and other chemicals.

:- Corrosion resistance is the property of a material to resist the corrosion.

* Thermal Properties of Metals:-

:- Thermal properties are those properties of a material which is related to its conductivity of heat. In other words, these are the properties that are exhibited by a material when the heat is passed through it.

i) Thermal Expansion :-

:- Thermal expansion is defined as the change in dimension due to ~~an~~ increase in temperature of the body is called thermal expansion.

There can be change in the area, volume, and shape of the material.

For example:- Railway tracks often expand and as a result, get misshapen due to extreme heat.

iii) Thermal Conductivity :-

:- It is the property of a material to conduct heat through itself. Materials with high thermal conductivity will conduct more heat than one with low conductivity.

Example:- An iron rod will conduct more heat than normal window glass.

iii) Thermal stress :-

:- Thermal stress is the stress produced by any change in the temperature of the material.

iv) Specific Heat capacity :-

:- The amount of heat required to change the temperature of a material by a certain amount.