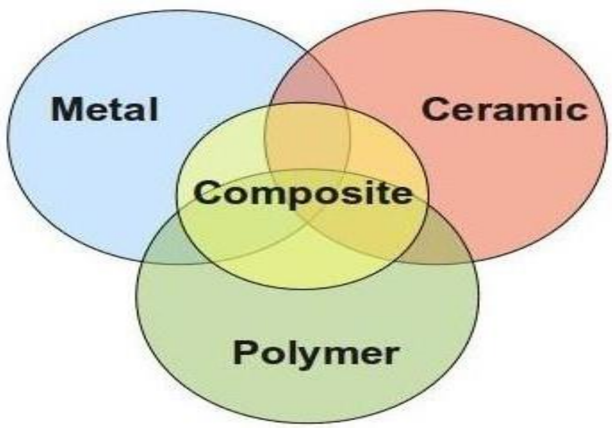
BHADRAK ENGINEERING SCHOOL & TECHNOLOGY
(BEST), ASURALI, BHADRAK

Engineering Material

(Th- 03)

(As per the 2020-21 syllabus of the SCTE&VT, Bhubaneswar, Odisha)



Third Semester

Mechanical Engg.

Prepared By: *Er K K Prusty & Er S Behera*

ENGINEERING MATERIALS

TOPIC WISE DISTRIBUTION PERIODS

Sl No	Topics	No. of periods As per syllabus	No. of periods actually needed	Expected Mark
01	Engineering Materials and their properties	05	06	05
02	Ferrous Materials and Alloys	05	05	10
03	IRON-Carbon System	08	07	15
04	Crystal Imperfection	10	10	12
05	Heat Treatment	10	11	15
06	Non Ferrous alloys	10	10	15
07	Bearing Materials	03	04	10
08	Spring Materials	03	03	10
09	Polymers	03	03	10
10	Composites and Ceramics	03	04	10
	TOTAL	60	63	100

CHAPTER NO. - 01

ENGINEERING MATERIALS AND THEIR PROPERTIES

Learning Objective:

1.1 Definition of Material, Material classification into ferrous and non-ferrous category and alloys

1.2 Understand Factors Affecting Selection of Material Properties of Materials, Physical, Chemical and Mechanical Properties

1.3 Performance Requirements

1.4 Material Reliability and Safety

Introduction

- Material science and engineering plays a vital role in this modern age of science and technology. Various kinds of materials are used in industry, housing, agriculture, transportation, etc. to meet the plant and individual requirements.
- The knowledge of materials and their properties is of great importance for a design engineer
- A design engineer must be familiar with the effects which the manufacturing processes and heat treatment have on the properties of the materials

1.1 Definition of Material, Material classification into ferrous and non-ferrous category and alloys

Material is something that consist matter. Material is the stuff of which something is made. Material comprises a wide range of metals and non metals which must be operated upon to form the end product.

Engineering Materials are classified as follows

1- Metal
 A- Ferrous
 B- Non –ferrous

2-Ceramics

3-Organics

4-Composites

5-Semiconductors

Metals may further be classified as-

Ferrous metals-

The ferrous metals are those which have the iron as their main constituent, such as cast iron, wrought iron etc.

Non-ferrous metals.

The non-ferrous metals are those which have metal other than iron as their main constituent, such as copper, aluminium, brass, tin, zinc etc.

1.2 factor affecting selection of material Properties of Materials, Physical, Chemical and Mechanical properties

Factors affecting selection of material for engineering purpose

1. Properties of material
2. Performance requirement
3. Material's reliability
4. Safety
5. Physical attributes
6. Environmental conditions
7. Availability
8. Disposability and recyclability
9. Economic factors

Physical properties of Materials

- Physical properties are employed to describe the response of a material to imposed stimuli under conditions in which external forces are not concerned.
- Physical properties include.

a) Dimensions,
b) Appearance,
c) Colour,
d) Density,
e) Melting point,
f) Porosity,
g) Structure, etc.

Dimensions

Dimensions of a material imply its size (length, breadth, width, diameter, etc.) and shape (square, circular, channel, angle section, etc.)

Appearance

- Metals themselves have got different appearances e.g., aluminium is a silvery white metal where as copper appears brownish red.
- Appearance includes lusture, colour and finish of a material.
- Lusture is the ability of a material to reflect light when finely polished. It is the brightness of a surface.

Colour

- The colour of the material is very helpful in identification of a metal. The colour of a metal depends upon the wavelength of the light that the material can absorb.

Density

- The density is the weight of unit volume of a material expressed in metric units.
- Density depends to some extent on the

a) Purity of material
b) Pour volume
c) Treatment, the material has received.

Density helps differentiating between light and heavy metals even if they have same shape and any outer protective coating.

Melting point

Melting point of a material is that temperature at which the solid metals change into molten state.

One metal can be distinguished from the other on the basis of its melting point.

Porosity

- A metal is said to be porous if it has pores within it.
- Pores can absorb lubricant as in a sintered self-lubricating bearing.
- It is the ratio of total pore volume to bulk volume

Structure

- It means geometric relationships of material components.
- It also implies the arrangement of internal components of matter(electron structure, crystal structure, and micro structure)

Chemical properties

- A study of chemical properties of materials is necessary because most of engineering materials when they come in contact with other substances with which they can react, tend to suffer from chemical deterioration.
- The chemical properties describe the combining tendencies, corrosion characteristics, reactivity, solubilities, etc. of a substance.

Some of the chemical properties are

1. corrosion resistance
2. chemical composition
3. acidity or alkalinity

1. Corrosion resistance:

- It is the deterioration of a material by chemical reaction with its environment.
- Corrosion degrades material properties and reduces economic value of the material.
- Corrosion attacks metals as well as non-metals. Corrosion of concrete by sulphates in soils is a common problem.

2. Chemical Composition:

The chemical composition of a pure substance corresponds to the relative amounts of the elements that constitute the substance itself. It can be expressed with a chemical formula, such as an empirical or molecular formula.

For example, the chemical formula for water is H2O: this means that each molecule of water is constituted by 2 atoms of hydrogen (H) and 1 atom of oxygen (O). The chemical composition of water may be interpreted as a 2:1 ratio of hydrogen atoms to oxygen atoms.

3. Acidity and Alkalinity:

Alkalinity and acidity are measured by determining the quantity of a solution of acid or base, as appropriate, of known concentration that is required to completely neutralize the acidity or alkalinity of the aqueous solution.

Mechanical Properties of Materials

The mechanical properties of materials define the behavior of materials under the action of external forces called loads.

There are a measure of strength and lasting characteristics of the material in service and are of good importance in the design of tools, machines, and structures.

The mechanical properties of metals are determined by the range of usefulness of the metal and establish the service that is expected.

Mechanical properties are also useful for help to specify and identify the metals. And the most common properties considered are strength, hardness, ductility, brittleness, toughness, stiffness and impact resistance.

The following are the mechanical properties of materials.

1. Strength
2. Elasticity
3. Plasticity
4. Hardness
5. Toughness
6. Brittleness
7. Stiffness
8. Ductility
9. Malleability
10. Cohesion
11. Impact strength
12. Fatigue
13. Creep

1. Strength

- Strength is the mechanical property that enables a metal to resist deformation load.
- The strength of a material is its capacity to withstand destruction under the action of external loads.
- The stronger the materials the greater the load it can withstand.

2. Elasticity

- According to dictionary elasticity is the ability of an object or material to resume its normal shape after being stretched or compressed.
- When a material has a load applied to it, the load causes the material to deform.
- The elasticity of a material is its power of coming back to its original position after deformation when the stress or load is released.
- treated springs, rubber etc are good examples of elastic materials.

3. Plasticity

- The plasticity of a material is its ability to undergo some permanent deformation without rupture(brittle).
- Plastic deformation will take place only after the elastic range has been exceeded.
- Pieces of evidence of plastic action in structural materials are called yield, plastic flow and creep.
- Materials such as clay, lead etc are plastic at room temperature, and steel plastic when at bright red-heat.

4. Hardness

- The resistance of a material to force penetration or bending is hardness.
- The hardness is the ability of a material to resist scratching, abrasion, cutting or penetration.
- Hardness indicates the degree of hardness of a material that can be imparted particularly steel by the process of hardening.
- It determines the depth and distribution of hardness is introduce by the quenching process.

5. Toughness

- It is the property of a material which enables it to withstand shock or impact.
- Toughness is the opposite condition of brittleness.
- The toughness is may be considering the combination of strength and plasticity.
- Manganese steel, wrought iron, mild steel etc are examples of toughness materials.

6. Brittleness

- The brittleness of a property of a material which enables it to withstand permanent deformation.
- Cast iron, glass are examples of brittle materials.
- They will break rather than bend under shock or impact.
- Generally, the brittle metals have high compressive strength but low in tensile strength.

7. Stiffness

- It is a mechanical property.
- The stiffness is the resistance of a material to elastic deformation or deflection.
- In stiffness, a material which suffers light deformation under load has a high degree of stiffness.
- The stiffness of a structure is important in many engineering applications, so the modulus of elasticity is often one of the primary properties when selecting a material.

8. Ductility

- The ductility is a property of a material which enables it to be drawn out into a thin wire.
- Mild steel, copper, aluminum are the good examples of a ductile material

9. Malleability

- The malleability is a property of a material which permits it to be hammered or rolled into sheets of other sizes and shapes.
- Aluminum, copper, tin, lead etc are examples of malleable metals.

10. Cohesion

- It is a mechanical property.
- The cohesion is a property of a solid body by virtue of which they resist from being broken into a fragment.

11. Impact Strength

- The impact strength is the ability of a metal to resist suddenly applied loads.

12. Fatigue

- The fatigue is the long effect of repeated straining action which causes the strain or break of the material.
- It is the term 'fatigue' use to describe the fatigue of material under repeatedly applied forces.

13. Creep

- The creep is a slow and progressive deformation of a material with time at a constant force.
- The simplest type of creep deformation is viscous flow.
- Some metals are generally exhibiting creep at high temperature, whereas plastic, rubber, and similar amorphous material are very temperature sensitive to creep.
- The force for a specified rate of strain at constant temperature is called creep strength

1.3 Performance requirement

- The material of which a part is composed must be capable of embodying or performing a part's function without failure.

  for example – a component part to be used in a furnace must be of that material which can withstand high temperatures.
- While it is not always possible to assign quantitative values to these functional requirements, they must be related as precisely as possible to specified values of most closely applicable mechanical, physical, electrical or thermal properties.

1.4 Material's reliability

- Reliability 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.
- A material if it corrodes under certain conditions, then, it is neither stable nor reliable for those conditions.

Safety

A material must safely perform its function; otherwise, the failure of the product made out of it may be catastrophic in air-planes and high pressure systems. As another example, materials that give off spark when struck are safety hazards in a coal mine.

POSSIBLE SHORT QUESTIONS WITH ANSWERS

1- **Define material.**

Ans-material is something that consist matter. Material is the stuff of which something is made. material comprise a wide range of metals and non-metals which must be operated upon to form the end product.

2- **Classify material. [2008W, 2016 W, 2018 W, 2018 S,2021W, 2022W]**

Ans –Engg.materials are classified as follows

1-Metal

A-Ferrous

B-Non –ferrous

2-Ceramics

3- Organics

4- Composites

5- Semiconductors

3- **Define material reliability and performance requirement.**

Ans- Reliability 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.

- A material if it corrodes under certain conditions, then, it is neither stable nor reliable for those conditions.
- performing a part's function without failure.
- for example – a component part to be used in a furnace must be of that material which can withstand high temperatures

4- **Write four factor affecting selection of material.[2016 W, 2018 W, 2019 S, 2019 S NEW]**
  - Performance requirement
  - Material's reliability
  - Safety
  - Physical attributes

5- **Define safety of material. [2017 W]**

A material must safely perform its function, otherwise, the failure of the product made out of it may be catastrophic in air-planes and high-pressure systems. As another example, materials that gives off spark when struck are safety hazards in a coal mine.

POSSIBLE LONG QUESTIONS

1- Describe various factor affecting selection of material**[2016 W, 2018 W, 2019 S, 2019 S NEW],[w-2022]**

2- Describe various mechanical properties of material**. [2014 W, 2017 W NEW, 2018 S],[w-2021],[w-2022]**

3- Define physical properties of material. **[2015 W, 2019 S]**

CHAPTER NO. - 2

FERROUS MATERIALS AND ALLOYS

Learning Objectives:

2.1 Characteristics and Application of Ferrous Materials

2.2 Classification, Composition and Application of Low Carbon Steel, Medium Carbon Steel and High Carbon Steel

2.3 Alloy steel: Low alloy steel, high alloy steel, tool steel and stainless steel

2.4 Tool steel: Effect of various alloying elements such as Cr, Mn,Ni, V, Mo,

2.1 Characteristics and application of ferrous materials

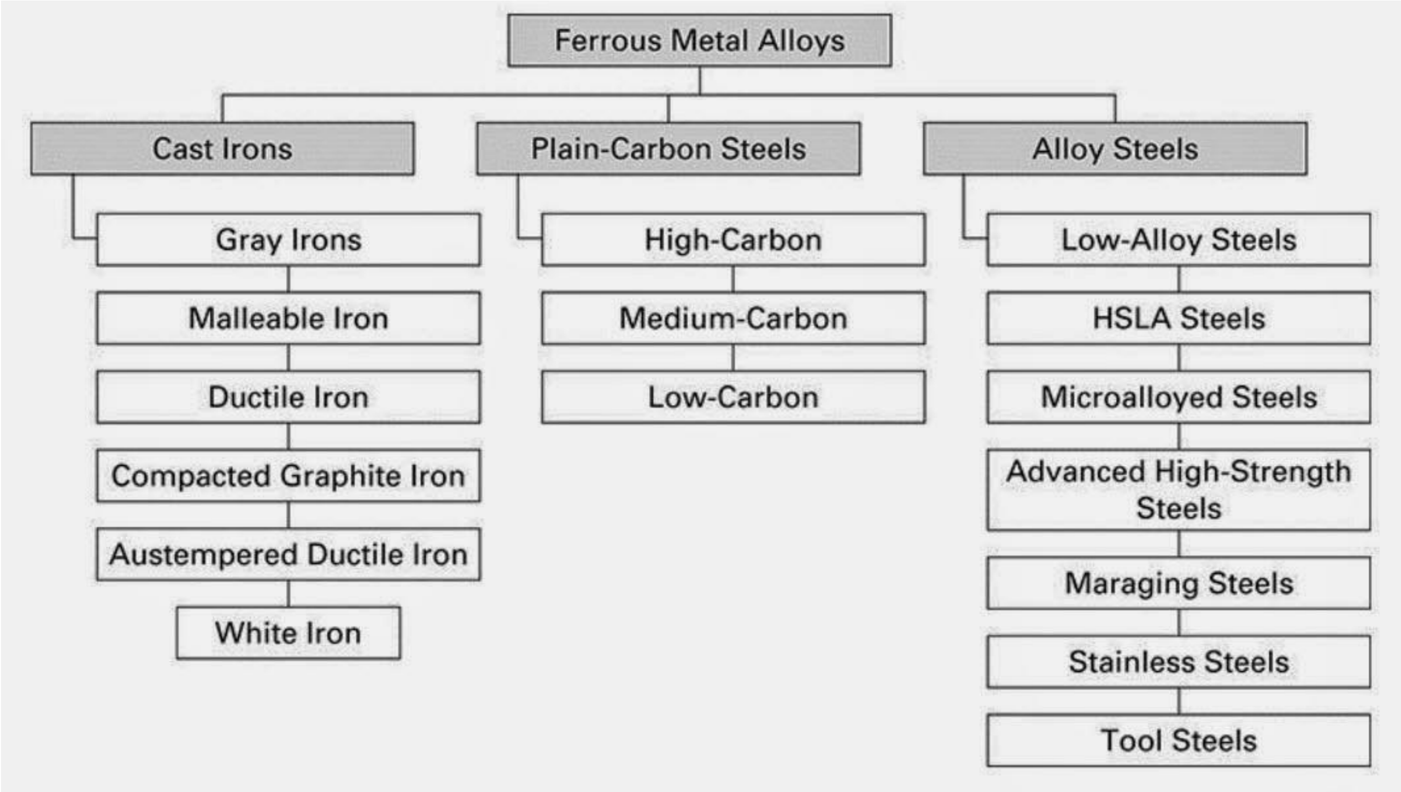
- Ferrous materials are metals or metal alloys that contain the iron as a base material.
- Steel is a ferrous alloy, and there are a number of other alloys that contain iron.
- Ferrous metals are good conductors of heat and electricity.
- Metal alloys have high resistance to shear, torque and deformation.
- The thermal conductivity of metal is useful for containers to heat materials over a flame. The principal disadvantages of many ferrous alloys are their susceptibility to corrosion.

Application:

- Due to the strength and resilience of metals they are frequently used in high-rise building and bridge construction, most vehicles, many appliances, tools, pipes, non-illuminated signs and railroad tracks.
- Corrosion resistance property makes them useful in food processing plants, e.g., steel.
- Cast iron is strong but brittle, and its compressive strength is very high. So used in castings, manhole covers, engine body, machine base etc.
- Mild steel is soft, ductile and has high tensile strength. It is used in general metal products like structural, workshop, household furniture etc.
- Carbon steels are used for cutting tools due to their hardness, strength and corrosion resistance properties.

2.2 Classification, composition and application of low carbon steel, medium carbon steel and High carbon steel

- Steel-It is an alloy of iron and carbon in which carbon content is up to 2%. It may contain other alloying elements.



Cast iron

- In cast iron carbon content is 2% to 6.67%
- Lower melting point (about 300 °C lower than pure iron) due to presence of eutectic point at 1153°C and more carbon content.

Carbon Steel is classified into

- Low carbon steel or Mild steel
- Medium carbon steel
- High carbon steel

Low carbon steel or Mild steel:

Low carbon steel or mild steel is further classified in to three types basing on their composition i-e percentage of carbon.

a) Dead mild steel or mild steel containing 0.05 to 0.15% of carbon.

b) Mild steel containing 0.15 to 0.2% of carbon.

c) Mild steel containing 0.2 to 0.3% of carbon.

Application of Mild Steel:

- Dead mild steel is used for making steel wire, sheet, rivets, screws, pipe, nail, chain, etc.
- Mild steel containing 0.15 to 0.2% carbons is used for making camshafts, sheets, strips for blades, welded tubing, forgings, drag lines, etc.
- Mild steel containing 0.2 to 0.3% carbon is used for making valves, gears, crank shafts, connecting rods, railways axles, fish plates and small forgings, etc

Medium Carbon Steel

Steel containing 0.3 to 0.7% carbon is known as medium carbon steel.

Medium carbon steel are of three categories.

- Steel containing 0.35 to 0.45% carbon is used for connecting rod, wires & rod, spring clips, gear shaft, key stock, shafts & brakes lever, axle, small & medium forgings, etc.
- Steel containing 0.45 to 0.55% carbon is used for railways coach axles, axles & crank pins on heavy machines, splines shafts, crank shafts, etc.
- Steel containing 0.6 to 0.7% carbon is used for drop forging die & die blocks, clutch discs, plate punches, set screws, valve springs, cushion ring, thrust washers, etc.

High carbon steel

Steel containing 0.7 to 0.1.5% carbon is known as high carbon steel. Uses

i) Steel containing 0.7 to 0.8% carbon is used for making cold chisels, wrenches, jaws for vice, pneumatic drill bits, wheels for railway service, wire for structural work, shear blades, automatic clutch disc, hacksaws, etc.
ii) Steel containing 0.8 to 0.9% carbon is used for making rock drills, railway rail, circular saws, machine chisels, punches & dies, clutch discs, leaf springs, music wires, etc.
iii) Steel containing 0.9 to 1.0% carbon is used for making punches & dies, leaf & coil springs, keys, speed discs, pins, shear blades, etc.
iv) Steel containing 1.0 to 1.1% carbon is used for making railway springs, machine tools, mandrels, taps, etc.
v) Steel containing 1.1 to 1.2% carbon is used for making taps, thread metal dies, twist drills, knives, etc.
vi) Steel containing 1.2 to 1.3% carbon is used for making files, metal cutting tools, reamers, etc.
vii) Steel containing 1.3 to 1.5% carbon is used for making wire drawing dies, metal cutting saws, paper knives, tools for turning chilled iron, etc.

2.3 Alloy steel: Low alloy steel, high alloy steel, tool steel and stainless steel

Low alloy steel

1) Steel is considered to be alloy steel when the maximum of the range given for the content of alloying element exceeds one or more of the following limits.
2) Mn-1.65%, Si-0.6%, Cu-0.6% or in which a definite maximum quantity of any of the following elements is specified.
3) Al, B, Cr up to 3.99%, Cu, Mo, Ni,Ti, W, V or any other alloying element added to obtain a desired alloying effect.
4) Low and medium alloy steel: In low and medium alloy steel alloying element is not exceeding 10%.
5) 1st symbol: 100 times the average percentage of carbon.
6) 2nd, 4th, 6th ,etc symbol: Elements
7) 3rd, 5th, 7th, etc. symbol: percentage of elements multiplied by factors as follows.

Element multiplying factor:

Element	Multiplying factor
Cr,Co,Ni, Mn,Si&W	4
Al, Be, V,Pb, Cu,Nb,Ti,Ta, Zr&Mo	10
P,S,N	100

High alloy steel:

- In high alloy steel, total alloying element is more than 10%.
- For example: X10 Cr 18 Ni 9 S3 X- High alloy steel
- 10 %- 0.1 %C Cr18 – 18 % Cr Ni 9 – 9 % Ni
- S 3 – Pickled condition

2.4 Tool steel: Effect of various alloying elements such as Cr, Mn, Ni, V, Mo

Tool steel

Tool steel may be defined as special steel which are used to form, cut or otherwise change the shape of a material in to finished 0r semi-finished product.

Properties of Tool steel:

i) Slight change of form during hardening.
ii) Little risk of cracking during hardening.
iii) Good toughness
iv) Good wear resistance
v) Very good machinability
vi) A definite cooling rate during hardening
vii) A definite hardening temperature
viii) Resistance to de-carburization
ix) Resistance to softening on heating

Classification of Tool steel:

The Joint Industry Conference, U.S.A. has classified tool steel as follows:

Symbol	Meaning
T	W-High speed steel
M	Mo-High speed steel
D	High C, high Cr steel
A	Air hardening steel
O	Oil hardening steel

W Water hardening steel

H Hot work steel

S Shock resistance steel Composition of Tool Steel:

1) W-High speed steel

T1: C 0.7 Cr 4 V 1 W 18

T4: C 0.75 Cr 4 V 1 W 18 Co 5

T6: C 0.8 Cr 4.5 V 1.5 W 20 Co 12

2) Mo-High speed steel

M1: C 0.8 Cr 4 V 1 W 1.5 Mo 8

M6: C 0.8 Cr 4 V 1.5 W 4 Mo 5 Co 12

3) High C, high Cr steel

D2: C 1.5 Cr 12 Mo 1

D5: C 1.5 Cr 12 Mo 1 Co 3

D7: C 2.35 Cr 12 V 4 Mo 1

4) Air hardening steel

A2: C 1 Cr 5 Mo 1

A7: C 2.25 Cr 5.25V 4.75 W 11 Mo 1

A9: C 0.5 Cr 5 Ni 1.5 V 1 Mo 1.4

5) Oil hardening steel

O1: C 0.9 Mn 1 Cr 0.5 W 0.5

O2: C 1.45 Si 1 Mo 0.25

6) Water hardening steel

W2: C 0.6/1.4 V 0.25 W5: C 1.1 Cr 0.5

7) Hot work steel

H10: C 0.4 Cr 3.25 V 0.4 Mo 2.5

H12: C 0.35 Cr 5 V 0.4 W 1.5 Mo 1.5

8) Shock resistance steel

S1: C 0.5 Cr 1.5 W 2.5

S2: C 0.5 Si 1 Mo 0.4

S5: C 0.55 Mn 0.8 Si 2 Mo 0.4

S7: C 0.5 Cr 3.25 Mo 1.4

Stainless Steel:

When 11.5% or more chromium is added to iron, a fine film of chromium oxide forms spontaneously on the surfaces. The film acts as a barrier to retard further oxidation, rust or corrosion. As this steel cannot be stained easily, it is called stainless steel. The stainless steel basing on their micro-structure can be grouped in to three metallurgical classes such as Austenitic stainless steel, Ferritic stainless steel & Martensite stainless steel.

Austenitic Stainless Steel:

Properties:

1) They possess austenitic structure at room temperature.
2) They possess the highest corrosion resistance of all the stainless steels.
3) They possess greatest strength and scale resistance at high temperature.
4) They retain ductility at temperature approaching absolute zero.
5) They are non-magnetic.

Composition:

C	0.03 to 0.25%	Mn	2 to 10%	Si	1 to 2%
Cr	16 to 26%	Ni	3.5 to 22%		

P & S Normal Mo &Ti in some cases

Uses:

- Aircraft industry (Engine parts)
- Chemical processing (heat exchangers)
- Food processing (Kettles, tanks)
- Household items (cooking utensils)
- Dairy industries (milk cans)
- Transportation industry (Trailers & railways cars)

Ferritic stainless steel:

Properties:

1) They possess a microstructure which is primarily ferritic.
2) They are magnetic & have good ductility
3) They do not work harden to any appreciable degree.
4) They are more corrosion resistant than martensitic steel.
5) They develop their maximum softness, ductility & corrosion resistance in the annealed condition.

Composition:

C	0.08 to 0.20%	Si	1%	Mn	1 to 1.5%	Cr	11to 27%

Uses:

1) Lining for petroleum industry.
2) Heating elements for furnaces.
3) Interior decorative work.
4) Screws & fittings.
5) Oil burner parts

Martensitic stainless steel:

Properties:

1) They possess martensitic microstructure.
2) They are magnetic in all condition & possess the best thermal conductivity of the stainless types.
3) Hardness, ductility & ability to hold an edge are characteristics of martensitic steels.

4) They can be cold worked without difficulty, especially with low carbon content, can be machined satisfactorily.
5) They have good toughness.
6) They have good corrosion resistance to weather and to some chemicals.
7) They are easily hot worked.

Composition:

C 0.15 to 1.2%Si 1% Mn 1% Cr 11.5 to 18%

Uses:

1) Pumps & valve parts
2) Rules & tapes
3) Turbine buckets
4) Surgical instruments, etc.

Effect of Alloying Elements:

Chromium: It joins with carbon to form chromium carbide, thus adds to depth hardenability with improved resistance to abrasion & wear.

Manganese:

1) It contributes markedly to strength and hardness.
2) It counteracts brittleness from sulphur.
3) Lowers both ductility & weldability if it is present in high percentage with high carbon content in steel.

Nickel:

1) Increases toughness & resistance to impact.
2) lessens distortion in quenching.
3) Lowers the critical temperatures of steel & widens the range of successful heat treatment.
4) strengthens steels.
5) Renders high-chromium iron alloys austenitic.
6) does not unite with carbon.

Vanadium:

1) Promotes fine grains in steel.
2) increases hardenability.
3) imparts strength & toughness to heat-treated steel
4) causes marked secondary hardening.

Molybdenum:

1) promotes hardenability of steel.
2) makes steel fine grained.
3) makes steel unusually tough at various hardness levels.
4) counteracts tendency towards temper brittleness.
5) raises tensile & creep strength at high temperatures.
6) enhances corrosion resistance in stainless steels.
7) forms abrasion resisting particles.

Tungsten:

1) Increases hardness.

2) promotes fine grains.
3) resists heat.
4) Promotes strength at elevated temperature.

POSSIBLE SHORT QUESTIONS WITH ANSWER

1- Write down the application of low carbon steel. [2020 W]

Ans-Low carbon steel are suitable for automobile body, refrigerator body, cams etc. These are also used for unbolts, boiler plates, ship plates etc.

2- Write down the uses of stainless steel. [2019 W]

Ans –stainless steel are used for following purpose

- A-Aircraft industry
- B-Chemical processing
- C-Heating elements
- D-Diary industry
- Screw and fittings

3- what are the different kind of iron ore? [2018 S]

Ans-

- A-Magnetite
- B-Hematite
- C-Limonite
- D-Goethite .

4- Define ferrous and non ferrous metal. [2019 S]

Ans –The metal which contain iron is called ferrous metal and the metal which does not contain iron is called nonferrous metal.

Ferrous metal –cast iron, steel

Non ferrous metal –Aluminium, Copper.

5. Name any two non-ferrous &ferrous metal?[2021W]

Ans- Ferrous metal

Cast iron, steel

Non-ferrous metal

Copper, bronze

6. What is an alloy?[2022W]

Ans- When two or more metal combine with each other and form a new metal is called alloy.

Ex- steel is an alloy of iron & steel

POSSIBLE LONG QUESTIONS

1. Write down the effect of alloying element added to steel. [2018 S]
2. write short note on A-stainless steel, B-High speed[2018 S]
3. How cast iron is obtained? Classify and explain different types of cast iron .[2018 S]
4. State the composition &properties of duralimin &y-alloy? [2021W][2022W]

CHAPTER NO. - 03

IRON-CARBON SYSTEM

Learning Objectives:

3.1 Concept of phase diagram and cooling curves

3.2 Features of Iron-Carbon equilibrium diagram with salient micro-constituents of Iron and Steel

3.1 Concept of phase diagram and cooling curves

A phase in a material is defined as a region of spatially uniform macroscopic physical properties like density, atomic arrangement, crystal structure, chemical composition etc.

Example: Iron in bcc structure, f cc structure, in liquid form and in gaseous state is different phases of iron. In one component materials a phase is stable over a range of temperature and pressure. A homogeneous solution of two or more components that may exists over a range of composition, temperature and pressure is considered as the same phase.

Equilibrium phase diagram are normally used to show the stability of different phases in a material as function of temperature, pressure and composition.

General features of phase diagrams are constrained by conditions of thermodynamic equilibrium. When no chemical reactions occur between different components is a system, then the phase rule can be started as f = C - P + 2

Where, C is number of components in the system; P is number of phases in equilibrium,

Fig.2 represents temperature and pressure as independent variables, f is degree of freedom. It is the maximum number of variables that may be independently varied without changing the number of phases in equilibrium.

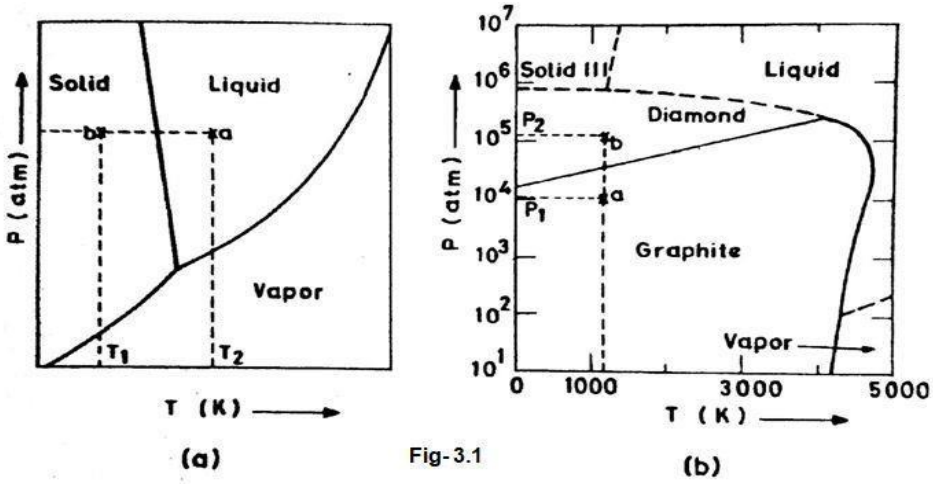


Fig-3.1

Phase diagrams of two one component system, H2O and carbon as a function of temperature and pressure. In a single-phase region both P and T may be independently varies.

In two component (binary) systems, there are three independent variables i.e, temperature, pressure and relative concentration of one of the component.

Concept of Colling Curves

Colling Curves of pure Iron: -

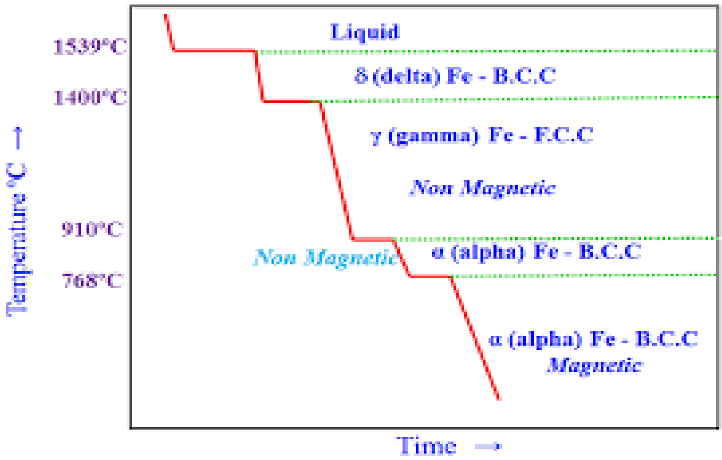
- Iron is a relatively soft and ductile metal.
- Iron has a metaling point of 1539" C
- Iron is allotropic metal, which means that is exists in more than one type of lattice structure (e.g., B.C.C. /F.C.C.) depending upon temperature.

In its normal room temperature state, iron is B.C.C in lattice arrangement, where at 908'c it changes to F.C.C. and then at 1403'C back to B.C.C. again and vice versa.

One another change occurs at about 770'C (called the curie point) at which the room temperature magnetic properties of iron disappear and it becomes non magnetic.

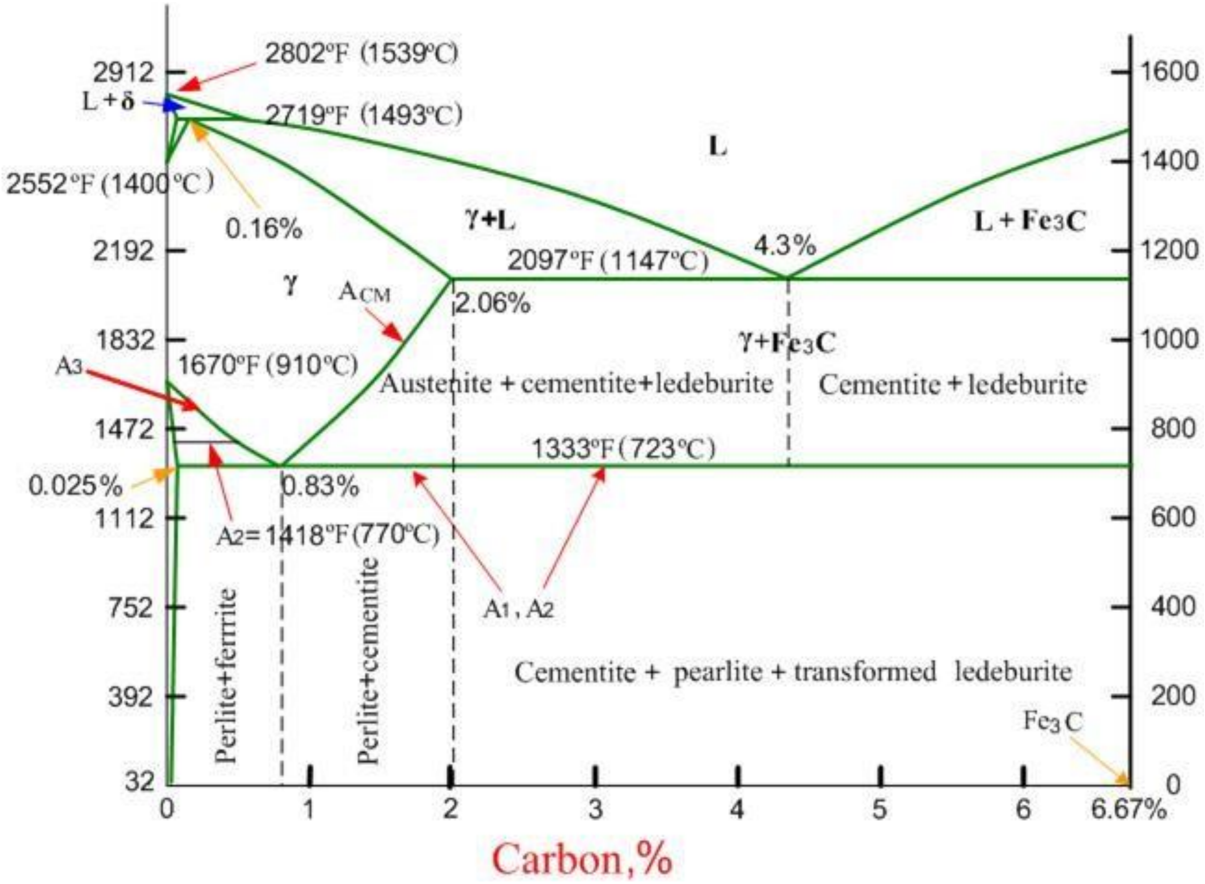
The iron remains non magnetic until the temperature drops back below the curie point upon which its magnetic properties reappear.

- Fig. shows a cooling curve for pure iron with allotropic forms of iron marked over it.
- Iron is molten above 1539'C. It solidifies in the B.C.C. (delta) form.



On further cooling at 1400'C, a phase change occurs and the atoms rearrange themselves into (gamma) form which is F.C.C. and non-magnetic. On still further cooling at 910'C, another phase change occurs from F.C.C. non magnetic iron to B.C.C. non magnetic (alpha) iron. Finally at 768'C, the alpha – iron (B.C.C.) becomes magnetic without a change in lattice structure.

3.2- Features of iron on carbon diagram with salient Micro-constituents of iron and steel.



At all temperatures, the following reaction takes place: Fe3C cooling 3Fe + C (graphite) At higher temperatures, the graphitization of the iron- carbide occurs.

An equilibrium diagram is a graphical representation of the effects of temperature and composition upon the phases present in an alloy.

An equilibrium diagram is constructed by plotting temperature along y –axis and percentage of carbon along x- axis .and composition with in which the various phase changes are stable.

Iron carbon diagram indicates the phase changes occur during heating and cooling and the nature and amount of the structural component that exist at any temperature besides it establishes a correlation between microstructure and properties of steel and cast iron and provide a basis for the understanding of principle of heat treatment.

Iron which contains up to 2% of carbon is called steel and the iron which contain more than 2% of carbon is called cast iron.

Iron which contains 0.008 to 0.8 % of carbon that is called hypoeutectoid steel ,0.8 to 2% is called hyper eutectoid, iron contain 2% to 4.3% 0f carbon is called hypoeutectic steel and which contain above 4.3% of carbon is called hyper eutectic steel.

There are mainly three reactions occur in iron carbon diagram that is peritectic, eutectic and eutectoid reaction.

Peritectic reaction

This reaction occur approximately at 1500 c and carbon percentage is approximately 0.25%. It may be written as

Delta +liquid ->Cooling /Heating ->Austenite.

Eutectic reaction

This reaction occur approximately at 1149 c and carbon percentage is 4.1 %

It may be written as

Liquid ->heating /cooling Austenite +cementite /ledeburite

Eutectoid reaction

This reaction occur approximately at 727 c and carbon percentage is 0.8%

Solid ->Cooling /heating ferrite +cementite /pearlite.

Micro – Constituents of Iron and Steel

- When steel is heated above the austenitic temperature and is allowed to cool under different conditions, the austenite in steel transforms into a variety of micro constituents discussed below.
- The study of these micro constituents is essential in order to understand Fe-C equilibrium diagram and T.T.T. diagrams.
- Various micro constituents are:

a – Austenite b-Ferrite c- Cementite d-Ledeburite e- Pearlite f-Bainite g-Martensite
h- Troostitei-Sorbite

Austenite

Austenite can dissolve maximum 2% carbon at 2066'F, the left-hand corner.

- Austenite has:
  * Tensile strength 10500kg/cm 2
  * Elongation 10% in 50 mm.
  * Hardness Rockwell C 40 (Approx.)

- Austenite is normally not stable at room temperature. Under certain conditions, however, it is possible to obtain austenite at room temperature, however, it is possible to obtain austenitic at room temperature (as in austenite stainless steels). Shows microstructure of austenitic at room temperature.Austenitic is non-magnetic and soft.

Ferrite

- Ferrite is B.C.C. iron phase with very limited solubility for carbon.

The maximum solubility is 0.025% carbon at 1333'F at extreme left hand corner of and dissolves only 0.008% carbon at room temperature.

-Ferrite has:

*Tensile strength 2800kg/cm2

*Elongation 40% in 50mm

*Hardness less than Rockwell C 0 or Rockwell B 90.

Cementite

Cementite or iron carbide, chemical formula is Fe3C5 Contain 6.67% carbon by weight.

It is a typical hard and brittle interstitial compound of law tensile strength but high compressive strength. Cementite is the hardest structure that appears on the iron carbon equilibrium

Ledeburite.

- Ledeburite is the eutectic mixture of austenite and cementite. It contains 4.3% carbon. It is formed at about 1130'C (2065'F).

Pearlite

- The pearlite micro constituent consists of alternate lamellae of ferrite and cementite.

Pearlite is the product of austenite decomposition by an eutectoid reaction. Thus, pearlite is an eutectoid mixture containing about 0.8% carbon and is formed at 1333'F (723'C) point C.

Pearlite is the white ferrite back ground or matrix which makes up most of the eutectoid mixture contains thin plates of cementite (black).

Bainite-it is the constituent product in a steel when austenite transform at a temperature below that at which pearlite is produced and above that at which martensite is produced.

It is a decomposition product of austenite, consisting of an aggregate of ferrite and carbide.

If bainite is formed in the upper part of the temperature range, its appearance is feathery and it is called feathery bainite and if it is below the temperature range it is called acicular bainite.

Martensite-

Martensite is a metastable phase of steel, formed by transformation of austenite below the temperature.

Martensite is considered to be highly stressed alpha iron which is supersaturated with carbon.

It is a product of quenching and it possesses needle like structure.

Troostite

Troostite is a mixture of radial lamellae of ferrite and cementite and therefore differs from pearlite only in degree of fitness and carbon content which is same as that in austenite from which it is formed.

In steel heat treatment, the troostite that is the microstructure consisting of ferrite and finely divided cementite is produced on tempering martensite below approximately temperature

450 'C

Sorbite

sorbite is the micro structure consisting of ferrite and finely divided cementite produced on tempering martensite above approximately 450 'C.

The constituent also known as sorbite pearlite is produced by decomposition of austenite when cooled at a rate slower than that which will yield a troostite structure and faster than that which will produce a pearlite structure.

POSSIBLE SHORT TYPE QUESTIONS WITH ANSWER

1- **What are the limitations of iron carbon diagram?** [2020W]

Ans –The nonequilibrium martensite does not appear on diagram. The diagram provides no indication to the time temperature relationship.

2- What is Phase Diagram? [2019 W, 2020 W]

Ans –Phase diagram represents the limits of stability of the various phases in chemical system at equilibrium with respect to variable such as composition and temperature.

3- What is an equilibrium diagram? [2018 S]

Ans –An equilibrium diagram is consist of iron containing percentage of carbon on which the properties of iron depends and vary according to it.

4- Name two iron ores and its symbol. [2018 S]

Ans –Hematite-Fe_2O_3, Magnetite –Fe_3O_4

5- What is difference between cast iron and pig iron? [2016 W]

Ans – Cast iron -Pig iron partly refined in cupola produces various grades of cast iron.

Pig iron –It is produced in blast furnace. It is the first product of in process of converting iron into useful **metal.**

6- what is the significance of phase diagram?[2021w]

Ans- there is a strong correlation in between microstructure & mechanical properties &the development of alloy microstructure is related to the characteristics of its phase diagram.

POSSIBLE LONG TYPE QUESTIONS

1- With neat sketch explain iron carbon equilibrium diagram? [2011 W,2009 W,2006 W, 2007 W,2014 W,2017 W, 2018 W,2008 W,2010 W,2015 W, 2016 W,2019 W,2020W]

2- Explain the concept of phase diagram cooling curve? [2018 W, 2019 W]

3- Explain various reaction in iron carbon diagram? [2017 W]

4- Discuss about any two micro constituents of iron & steel [2021 W]

5- briefly explain the cooling curves for a material with neat diagram [2022 W]

CHAPTER NO. - 04

CRYSTAL IMPERFECTIONS

Learning Objectives

4.1 Crystal defines, classification of crystals, ideal crystal and crystal imperfections

4.2 Classification of imperfection: Point defects, line defects, surface defects and volume defects

4.3 Types and causes of point defects: Vacancies, Interstitials and impurities

4.4 Types and causes of line defects: Edge dislocation and screw dislocation

4.5 Effect of imperfection on material properties

4.6 Deformation by slip and twinning

4.7 Effect of deformation on material properties

4.1 Crystal defines, classification of crystals, ideal crystal and crystal imperfections.

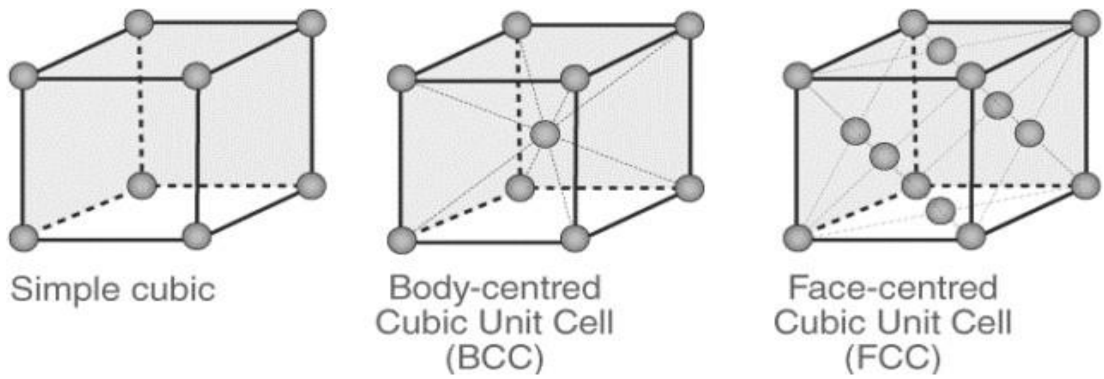
Whenever atoms arrange themselves in an orderly repetitive three dimensional pattern a crystal is formed. It is a solid which consists of atoms arranged in a pattern in 3-D. A perfect crystal is constructed by the infinite regular repetition in space of identical structural units or building blocks. The symmetry is an important characteristic of most of the crystals.

E.g cube and octahedrons are simple form of the crystal.

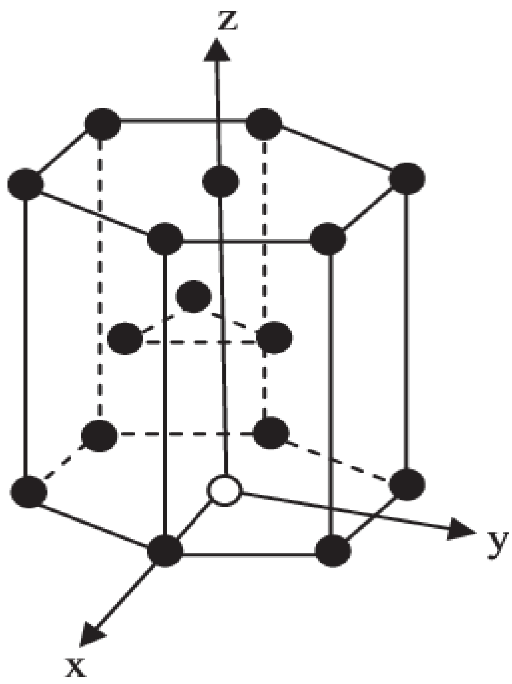
All metals are crystalline, where atoms are arranged in a definite periodic order.

On the basis of periodic arrangement of atoms crystals are grouped into seven systems. The systems are: Cubic, tetragonal, orthorhombic, rhombohedral, hexagonal, monoclinic and triclinic. In the present context, only cubic and hexagonal crystal structures are considered as most of the metals and alloys belong to these two systems. In crystal structure, the smallest unit is one unit cell which characterizes the specific arrangement and location of atoms.

There are three types of unit cells with cubic crystal structure such as SC, BCC, FCC.



Hexagonal Crystal Structure



In ideal crystals, the angles between the faces required to determine the crystal form are same.

Crystal Imperfections

Crystals are not perfect. An important characteristic which determines some important properties of crystalline materials is the presence of imperfections. Except some ideal crystals most of the crystals have some type of defects or imperfections. All crystals are not composed of identical atoms on identical sites throughout a regularly repeating 3D lattice. These imperfection or defects are used to describe any deviation from an orderly periodic array of atoms and influence the characteristics like mechanical strength, electrical properties and chemical reactions.

Ideal crystal

Ideal crystal is a single crystal with a perfectly regular lattice that contains no impurities, imperfections, or other defects.

4.2 Classification of imperfections

Defects one classified into

- Point Defect
- Line Defect
- Boundary Defect
- Volume Defect

4.3 Types and causes of point defects

In crystal lattice, point defect is completely local in its effect. When point defect gets

introduced in crystal lattice, internal energy of the crystal increases.

Types

Vacancies, interstitials and impurities are example of point defects.

Causes

A vacant lattice site is a point defect.

Vacancies

A vacancy site implies an unoccupied atom position with in a crystal lattice is called vacancies .it may occur during original crystallisation or they may arise from thermal vibration of atoms at elevated temperature.

Vacancies are atomic sites from which the atoms are missing and exist in metal at all temperatures above absolute zero. It plays a great role in diffusion of atoms in the crystal lattice. It arises from thermal vibrations and introduced during solidification.

Schottky defect is closely related to it and is formed when an atom or ion is removed from its lattice site and replaced in average position on the surface of the crystal.

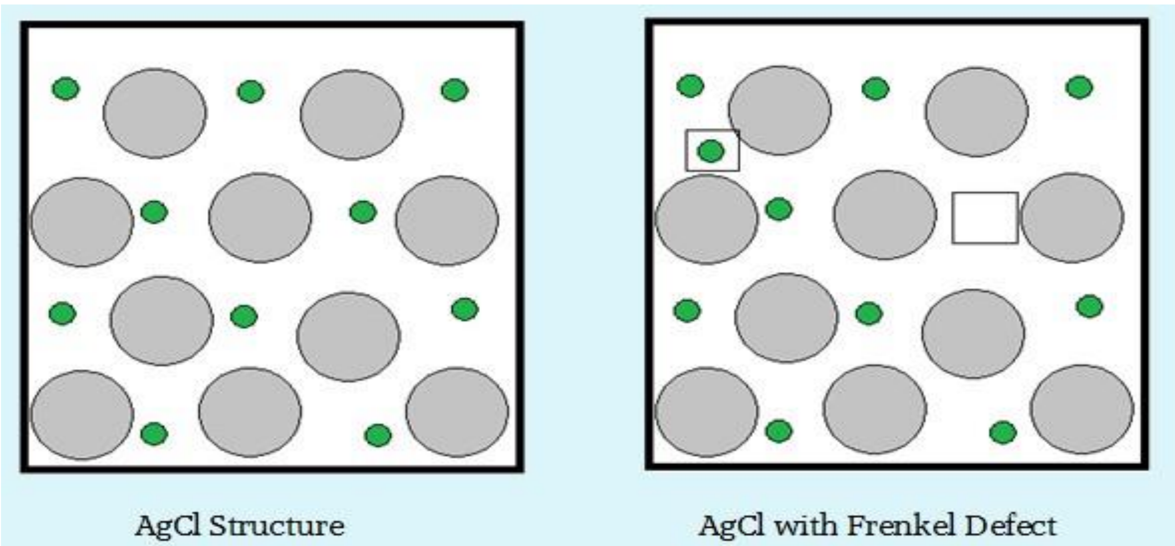
Interstitialcies

When a foreign atom occupies a definite position in lattice that is not normally occupied in perfect crystal is called interstitialcies.

When an atom is displaced from a regular site and occupies an interstitial site, an interstitialcy is formed is called frankel defect. It also gives rise to lattice distortion because interstitial atom tends to push the surrounding atoms apart. The smaller the size of interstitial atoms smaller the defect.

Impurities

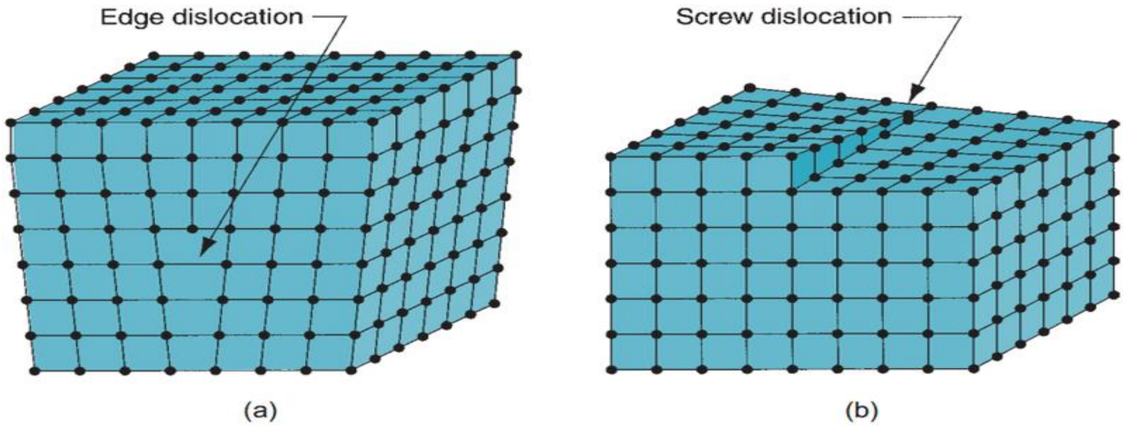
Impurities are foreign atoms which are present in the crystal lattice. Impurity atoms may occupy either interstitial or substitutional position. It is a small atom occupies an interstitial void space between atoms at lattice points of the crystal.



4.4. Types and causes of line defects, Edge dislocation and screw dislocation.

Lined effects

Line defects are also known as dislocations. Dislocation is the region of localized lattice disturbance between slipped and unclipped regions of a crystal. Due to lattice disturbances, elastic strain fields and stresses are associated with dislocations.



Types

Dislocations are of two types: (a) Edge dislocation (b) Screw dislocation

Edge dislocation

In the figure of edge dislocation in which a burger's vector lies perpendicular to the dislocation line. A burger circuit is drawn around the dislocation line and the vector required to close the circuit RS is known as the burger vector of the dislocation. An edge dislocation moves in the direction of the burger vector. It has an extra row of atoms either above or below the slip plane in crystal.

When the extra row of atoms is above the slip plane it is called positive edge dislocation and represented by sign S. When the extra row of atoms is below the slip plane, it is called negative edge dislocation and is represented by sign T. Here the atoms above the edges are in compression and those below are in tension.

Screw dislocation

Here the burger vector is parallel to the dislocation line and distortion is of shear type. It follows a helical path and it may follow right hand or left hand screw rule. Positive and negative dislocations are shown by clockwise and anticlockwise signs, respectively. It shows cross slip, where it moves from one slip plane to another.

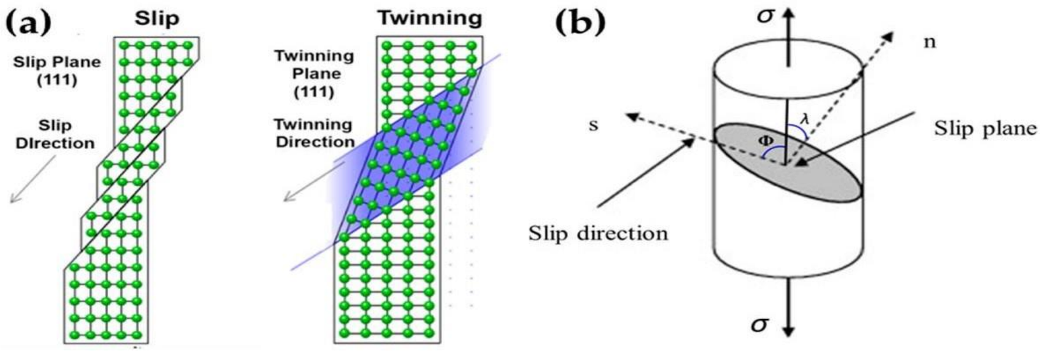
Either edge or screw of opposite signs if present in the same line, attract each other and can annihilate each other.

4.5. Effect of imperfections on material properties.

It affects or influences the characteristics like mechanical strength, electrical properties and chemical reactions. The role of imperfections in heat treatment is very important. Imperfections account for crystal growth, diffusion mechanism, annealing and precipitation, besides this, other metallurgical phenomena, such as oxidation, corrosion, yield strength, creep, fatigue and fractures' are governed by imperfections. Imperfections are not always harmful to metals. Sometimes they are generated to obtain the desired properties. For example, carbon is added to steel as interstitial impurity to improve the mechanical properties and these properties are further improved by heat treatment.

4.6 Deformation by slip and twinning

Slip - Metals deform plastically by slip. Slipping is facilitated in the presence of dislocation.



Slip is defined as the process or mechanism by which a large displacement of one part of the crystal relative to another along particular crystallographic planes takes place.

There may be one or more slip planes and one or more slip directions in each crystal. Slip begins when the shearing stress acting along the slip planes in the direction of slip exceeds a certain value known as critical

 slip planes are planes of high atomic densities while the direction of slip along these planes is always the direction of highest atomic density.

Twins and Twinning

Other than slip, twinning also gives rise to plastic deformation in crystals. It may be called as a special case of slip movement. In twinning, instead of whole blocks of atoms moving different distances along the slipping planes, each plane of atoms concerned moves a definite distance and the total movement at any point relative to the twinning plane is proportional to the distance from this plane. In bcc and hcp it occurs frequently.

4.7. Effect of deformation on material properties

The mechanical properties are greatly affected by deformation i.e. plastic deformation. The deformation process like rolling, forging, extrusion, drawing. Strain hardening takes place, so hardness changes. Elasticity changes, cracking takes place, grain growth takes place. Residual stress is produce in cold working.

POSSIBLE SHORT TYPE QUESTIONS WITH ANSWER

1. What is Schottky defect? [2008 w, 2017 w]

Ans –when vacancies are created by movement of atoms from position inside the crystal to position on the surface of the crystal a Schottky defect is said to be formed

2. Classify crystal imperfection (2016 w, 2017 w)

Ans -Crystal classified into

1- point defect
2- line defect
3- Boundary defect
4- Volume defect.

3. What is point defect? [2009 w, 2011]

When defects occur at any point of a crystal lattice that is called point defect .it is totally local in crystal lattice and its presence increases the internal energy of the crystal.

4. What is line defect?

Ans – When the region of localised lattice disturbance which separate the slip region of the crystal from its unclipped region the line defect occur .The plastic deformation of metals due to slip phenomenon is mainly on account of dislocation only.

5- Define unit cell.[w-2021]

Ans-The smallest group of atom which has overall symmetry of crystal and formed which the entire lattice Can be built.

6- Define crystal and ideal crystal?[w-2022]

Ans-Crystal is a solid which composed of atoms, ions, and molecules are arranged in a high ordered microscopic structure.

POSSIBLE LONG TYPE QUESTIONS

1-Explain edge dislocation and screw dislocation. [2017 w, 2018 s]

2-Define properties changes by deformation. [2010 w, 2011 w 2018 w]

3-Explain various types of point defect. [2006 w, 2009 w, 2018 s]

(i) Annealing
(ii) Hardening

4 .Explain the frankel defect with figure.[w-2021]

5. Differentiate between slip and twinning.[w-2022]

CHAPTER NO.- 05

HEAT TREATMENT

Learning Objectives:

5.0 Definition, classification of Heat treatment

5.1 Purpose of Heat treatment

5.2 Process of heat treatment: methods of Annealing, normalizing, hardening, tampering, stress relieving measures, Age hardening, Surface hardening: Carburizing and Nitriding

5.3 Effect of heat treatment on properties of steel

5.4 Hardenability of steel

5.0 Definition, classification of Heat treatment

Definition

It may be defined as heating and cooling operations applied to metals and alloys in solid state so as to obtain the desired properties.

Various heat treatment processes can be classified as follows:

1. Annealing.

2. Normalizing.

3. Hardening.

4. Tempering.

5. Martempering.

6. Austempering.

7. Maraging.

5.1- Purpose of heat treatment

The object of this process is to make the metal better suited, structurally and physically, for some specific applications. Heat treatment may be undertaken for the following purposes.

i) Improvement in ductility
ii) Relieving internal stresses
iii) Refinement of grain size
iv) Increasing hardness or tensile strength and achieving changes in chemical composition of metal surface as in the case of case-hardening.

Also compress machinability, alteration in magnetic properties, modification of electrical conductivity, improvement in toughness and development of re-crystallized structure in cold-worked metal.

5.2. Process of heat treatment

Annealing

Annealing involves heating to predetermine temperature, holding at this temperature and finally cooling at a very slow rate. The temperature to which the steel is heated and the holding time is determined by various factors such as chemical composition of steel, size and shape and final properties required. The various purposes for this treatment are to

i) Relieve interval stresses developed during solidification, machining, forging, rolling or welding.
ii) Improve or restore ductility and toughness.
iii) Enhance machinability.
iv) Eliminate chemical non-uniformity.
v) Refine grain size.
vi) Reduce the gaseous contents in steel.

Normalizing

- Normalizing is a process of heating steel to about 40-500C above upper critical temperature, holding for proper time and then cooling in still air or slightly agitated air to room temperature. After normalizing the resultant microstructure should be pearlite.
- This is important for some alloy steels which are air hardening by nature. Better dispersion of ferrite and cementite in the final structure results in enhanced mechanical properties. The grain size is finer and refinement of grain size. Rolled and forged steels possessing coarse grains due to high temperatures involved are subjected to normalizing. Normalized steels are generally stronger and harder than fully annealed steels.

Hardening

- Hardening consists of heating to hardening temperature, holding at that temperature, followed by rapid cooling such as quenching in water oil or salt baths. High hardness developed by this process is due to phase transformation with rapid cooling.
- For plain carbon steels, it depends on carbon content. Hypoeutectoid steels are heated to about 30 – 500C above the critical temperature whereas eutectoid and hyper eutectoid steels are heated to about 30 – 500C above the lower critical temperature.

Surface Hardening

- In order to process considerable strength to with stand forces acting on them and to withstand wear on their surface, the parts must be made of tough materials and provided with a hard surface by introducing carbon or nitrogen on its surface with core remaining soft. Surface hardening or case-hardening provides us a hand and wear resistant surfaces, close tolerance in machining parts and tough-core combined with a higher fatigue limit and high mechanical properties in core.

It is carried out by following operations

(a) Carburising (d) Cyaniding

(b) Nitriding (e) Induction hardening

(c) Carbonitriding (f) Flame hardening.

Tempering

The process which consists of heating hardened steel below the lower critical temperature, followed by cooling in air or at any other desired rate, is known as tempering. This treatment lowers hardness strength and wears resistance of the hardened steel marginally. The higher the tempering temp, the more is the restored ductility and toughens the steel. A proper tempering treatment result is optimum combination of mechanical properties. Elastic properties are affected by this. Hardening followed by tempering will improve elasticity.

Stress Relieving measures

Stress Relieving is the treatment of a metal or alloy by heating to a predetermined temperature below its lower transformation temperature followed by cooling in air. The primary purpose is to relieve stresses that have been absorbed by the metal from processes such as forming, straightening, machining or rolling.

Age Hardening

- The process of age hardening is executed in a sequence of three steps. First the metal is treated with a solution at high temperatures. All the solute atoms are dissolved to form a single-phase solution. A large number of microscopic nuclei, called zones, are formed on the metal. This formation is accelerated further by elevated temperatures.
- The next step is the rapid cooling across the solvus line so that the solubility limit is exceeded. The result is a super saturated solid solution that remains in a metastable state. The lowering of temperatures prevents the diffusion. Finally, the supersaturated solution is heated to an intermediate temperature in order to induce precipitation. The metal is maintained in this state for some time.

Age hardening requires certain parameters for the process to be successfully completed. These requirements are listed below:

- Appreciable maximum solubility
- Solubility must decrease with fall of temperature
- Alloy composition must be less than the maximum solubility.

Advantages of Age Hardening

Some of the advantages that age hardening offers are listed below:

- Imparts high tensile and yield strength to the metal
- Enhances wear resistance
- Age hardening facilitates easy machinability
- Does not cause distortion to the part.

Carburising

- It is the process of producing a hard surface on low carbon steel parts. There are three methods of carburising such as (a) pack or solid carburising (b) Gas carburising (c) Liquid carburising.

- Liquid carburising is performed in activated bath of calcium cyanamide, sodium or potassium cyanide and other controlling chemicals which govern the decomposition of the cylinders. The baths are operated at 815.50C to 898.850C produce a case of depth of 0.5mm in 90 minutes. The process extremely flexible and easily controlled. The reaction in the bath is 2Na2CO3 + SiC – Na2SiO3 + Na2O + 2CO + C.

Nitriding

The introduction of nitrogen into the outer surface of steel parts in order to give an extremely hard, wear resisting surface is called nitriding. It is provided by placing the article in ammonia vapour a temperature between 4500C and 5500C for 10 hours. The core should be brought to its

original toughness before nitriding by quenching in oil from about 9000C and tempering from about 6000C to 6500C. It is used for various automotive, airplane and diesel engine parts like cylinders, sleeves, liners etc.

5.3 Effect of heat treatment on properties of steel

1. Thermal Expansion

As metals are heated, their volume, surface and length will expand. The term for these actions is thermal expansion. Each metal will have a different rate of expansion when exposed to the heat.

2. Structural Alterations

Another effect that heat treatments have on metals is that the structure of them will go through a transformation. This is due to the fact that heat displaces the allotrope atoms in metals and causes them to reform in a different configuration. For this reason, this action is called the allotropic phase transformation. It not only can change the structural shape of the metal, but it also can alter its strength, ductility and hardness of it.

3. Makes the Metals Resistant to Electrical Current

A heat treatment can effectively make a metal have a certain level of electrical resistance. The reason that this happens is that when metals are heated, their electrons can absorb addition energy and makes them move faster than normal.

4. Reduces a Metal’s Magnetism

Magnetic metals such as nickel, cobalt and iron can lose some of their magnetism by undergoing a heat treatment. In some cases, they are no longer magnetic at all.

All heat treatments involve heating and cooling metals to change them in some fashion. The most popular reasons for performing these treatments is to increase a metal’s toughness, hardness, strength, corrosion or electrical resistance, and ductility. The following are the most common methods for performing these treatments:

• Annealing softens the metal through heating to make it workable and to increase its ductility. The metal is heated to the appropriate temperature to alter its microstructure and then, it is slow-cooled. It also increases the metal’s electrical conductivity.

• Hardening improves the mechanical properties of steel and other alloys. During this process the metal is heated to a high enough temperature to dissolve a portion of the carbon in it, prior to the appropriate quenching medium being applied. Hardening can increase wear resistance and strength but can also increase brittleness at times, so it is not recommended for some engineering applications.

• Normalising is used on alloys to provide them with a uniform composition and grain.

• Tempering is used on steel to improve its ductility. Steel that does not undergo this process is extremely hard but too brittle to use in many applications.

While there are many other details to learn about how heat treatments affect the properties of metals, the above information gives you a start on your education about this topic. Ensure that your metals receive the appropriate heat method to achieve your purposes.

5.4 Hardenability of steel

It is defined as property of a steel to be hardened by quenching and determined the depth and distribution of hardness throughout a section obtained by quenching.

Factors are as follows

The main factors affecting hardenability are:

- Alloying elements
- Carbon content
- Grain size of steel
- The homogeneity of starting steel
- Homogeneity obtained in the austenite before quenching by increasing carbon content

POSSIBLE SHORT TYPE QUESTIONS AND WITH ANSWER

1. What is heat treatment? [2018 W,2019 W].

Ans –Heat treatment is a process in which a metal is heated to certain temperature and cooled in a particular manner to alter its internal structure for obtaining desire degree of physical and mechanical properties such brittleness, hardness and softness.

2. Define annealing? [2019 w,2019 S].

Ans –Annealing is defined as heating of metal or steel to a temperature at or near critical temperature, holding there for a proper time and then allowing it to cool slowly. the temperature for annealing varies with different steel.

3. Define hardening? [2007w]

Ans –hardening is defined as heating the steel to temperature wit or above its critical temperature and held at this temperature for a considerable time to ensure proper penetration of temperature inside the component and then allowed cool by quenching in water, oil etc.

4. What is normalising? [2009 w, 2008 w 2019 w].

Ans –normalising or air quenching consist of heating steel to about 40 -50 c above its upper critical temp. And if necessary, holding it at that temperature for a short time and cooling in still air at room temp.

5. What is tempering? [2019 w ,2007 w ,2020 w].

Ans- it is a process of reheating a quench hardened steel to reduce its internal stress and to increase its toughness. Reheating is done to a temperature varying from 250 c to 650 c depending upon the reheating temperature. this process is called tempering.

4. What is heat treatment? [2021W] [2022W]

Ans- heat treatment is a process in which a metal is heated to a certain temp & then cooled in a particular manner to obtain for desire degree of physical & mechanical properties such as brittleness, hardness & softness

POSSIBLE LONG TYPE QUESTIONS

1. Explain the purpose of heat treatment? [2009 w, 2007 w, 2006 w, 2017 w, 2020 w, 2010 w.]
2. List the effects of heat treatment on the properties of steel. [2010 new,2008 w, 2018 w]
3. Describe various type of heat treatment process. [2010 new, 2017 w].
4. Describe annealing. [2009w.]
5. Describe hardenability of steel. [2007w, 2018 w].
6- Explain surface hardening heat treatment process? [2021W]
7- Explain in the following heat treatment processes [2022W]

CHAPTER NO. - 06

NON - FERROUS ALLOYS

Learning Objectives:

6.1 Describe composition properties and uses of Aluminium alloys,

Duralumin, y- alloy. Copper alloys: Composition, property and usage of Copper Aluminium such as copper aluminium, Copper- tin Antimony

6.2 Copper Tin Phosphorous, copper Zinc Copper Nickel

6.3 Predominating elements of lead alloys

6.4 Predominating elements of Zinc alloys

6.5 Predominating elements of Nickel alloys

6.6 Low alloy materials like P-91, P-22 for power plants and other high temperature services. High alloy materials like stainless steel grades of duplex, super duplex materials etc.

6.1 Describe composition properties and uses of Aluminium alloys, Duralumin, y- alloy. Copper alloys: Composition, property and usage of Copper Aluminium such as copper aluminium, Copper- tin Antimony

Duralmin

It is one of the oldest and best known alloys of aluminium widely used for aircraft parts. Its composition is 3.5-4.5% copper, 0.4-0.7% manganese, 0.4% silicon and sometimes contain 0.4- 0.7%, magnesium and below 0.5% iron.It developed maximum properties as a result of heat treatment and age hardening which can be worked readily about 5000C and after quenching ages over a period of 4 to 5 days. Its tensile strength increase from 1.55-1.86ton/cm2 yield point from 1.04-2.325 t/cm2 and hardness from 65 brinell to 95 brinell.Used for highly stressed structural components, aircrafts and automobile parts like front axle, levers, bonnets, connecting rods, chassis from, girders for ships, aeroplane air screws, spares, clips, fitting, levers etc.Also used for surgical and orthopaedics works for non magnetic and other instrument parts.

Y-alloys

Y-alloys are of the best alloys of this groups is a high strength costing alloy which retains its strength and hardness at high temperature.

Its percentage composition is 4% copper, 1.5% magnesium and 2% nickel, each of silicon, manganese is 0.6%. In the cost and heat treated from its ultimate strength is 2.12 tons/cm2 but chill costing after heat treatment show a strength of 3.1 tonnes/cm2. Heat treated forged alloys give an ultimate strength of 3.565 – 4.185 ton/cm2 an elongation of 17 – 22% and brinell hardness of 100-105.

It is extensively used for pistons, cylinder heads and crank case of internal combustion engine.

Copper- Aluminium alloys

Aluminium gets hardened and strengthened by the addition of copper. The most extensively used alloys for castings are those containing 4,5,7,10 and 12% of copper and with ultimate strength ranging from 1.12 – 4.185 t/cm2. It is employed in industry for light casting requiring greater strength and hardness than ordinary aluminium.

It is used for automobile piston, crank cases, cylinder heads, connecting rods.

Copper-Tin-antimony

These bearing alloys containing greater proportion of tin with copper and antimony and known as white metals.

Another alloys of this type having composition of 86% tin, 10.5% antimony, 3.5% copper has a tensile strength of 0.996 t/cm2, elongation 7.1% with brinell hardness of 33.3 and compressive yield point of 4.3.

It is used in main bearings of motors and aero-engines.

Babbitt

It is a general white metal alloy with soft lead and tin base metals covering a range of alloy having similar characteristics varying composition. Its actual composition is 82.3% tin, 3.9% copper, 7.1% antimony.

A cheaper Babbitt metal used for bearings subjected to moderate pressure has composition as 59.54% tin, 2.25 to 3.75% copper, 9.5 to 11.5% antimony, 26% lead, 0.08% iron, 0.08% bismuth.

They are use as liners in bronze or steel backing and are prepared for higher speed, ex Tcoerelmleovnet this notice, visit: embeddability, conformability, ability to deform plastically used in IC engine bearing, general machinery purpose bearings.

6.2- Copper –tin –phosphorous (Phosphorous bronze), copper zinc, copper nickel.

Copper –tin –phosphorous (phosphorous bronze)

The phosphorous bronzes are the alloys of copper and tin with 0.1 to 1.5% phosphorous. Phosphorous is added both for deoxidising the tin oxide and developing the structure and general properties of the metal. In the form of casting phosphorous bronze gives and ultimate strength of about 18 tonnes /cm2 with elongation of 4% brinell hardness number 80-100. It is used for heavy compressive loads and is used for gear wheels and slide values. Phosphorous bronze in wrought alloy form containing 10% tin, 0.1 – 0.35% phosphorous has a tensile strength 3.72 t/cm2, Bhn 100

– 130. It has good corrosion resistance to sea water and is used for spring and turbine blades.

Copper- zinc (Brass)

These are the alloys of copper and zinc with varying percentage of two metals. If small amount of one or more metals are added they provide more specific properties like colour, strength, ductility, machinability.

- Brasses- 36% zinc and 64% cu.

- brasses – 40 to 44% zn and 64 to 55% cu.
- brasses possess good tensile strength, good ductility, suitable for producing sheet, strips, tubes, wires etc.
- brasses are used for hot pressings, stampings.

Copper-Nickel

Nickel forms with copper in varying properties a large number of alloys. The addition of even a small amount of nickel to copper has a marked effect upon its mechanical properties and increase its corrosion resistance.

Cupro-Nickel has a nickel content between 10 – 30% has remarkable drawing properties with tensile strength of 6.2 t/cm2 used for sheaths or envelopes of rifle bullet.

A 70/30 cupro nickel used for condenser tubes produced by extrusion process. 8 t/cm2 elastic limit, 5.9 t/cm2 ultimate strength, Bhn 140.

6.3- Predominating elements of lead alloys

The tin is replaced by lead base alloys and contains 10 – 15% antimony, 15% Cu, 20% Tin and 60% Lead. These alloys are cheaper than tin base alloys, but not strong and do not possess the lead carrying capacity strength decreases with increasing in temperature. An alloy containing 80% lead, 15% antimony and 5% tin or 20% antimony generally used for long bearings with medium loads.

Binary copper lead alloys- lead 10 – 20%, 20 – 30% and above 30%.

6.4- Predominating elements of Zinc alloys

These alloys used in the form of tooling plate and easy and speed of fabrication. Brasses – Alloys of Cu and Zn.

6.5-Predominating elements of Nickel alloys

Nickel is one of the most important metals which is used as a pure metal and alloyed with other elements.Nickel copper, nickel copper silicon alloys. Nickel copper tin, sometimes with lead.

Nickel chromium- with iron or cobalt. Nickel molybdenum-also with chromium. Nickel silicon.Nickel manganese, nickel aluminium.

6.6 Low alloy materials like P-91, P-22 for power plants and other high temperature services, high alloy materials like stainless steel grades of duplex, super duplex materials.

Low alloy materials

Which possess slowly cooled micro structures, similar to those of plain carbon steel in the same condition namely pearlite, pearlite plus ferrite. These low alloys also known as pearlite alloy steel.

High alloy steel

Which possess slowly cooled micro structure, consisting either of martensite, austenite or ferrite plus carbide particle. It is more than 8% in the case of steels.

POSSIBLE SHORT TYPE QUESTIONS WITH ANSWERS

1- Give two examples of nonferrous alloys [.2017 w, 2018 w.]

Ans – Aluminium alloy, Copper alloy

2- **What is alloy?**

Ans. When two or more metal combine with each other and form a new material that is called alloy. steel is the alloy iron and steel.

3- Give two examples of ferrous and nonferrous materials. [2017w].

Name two ferrous materials – Cast iron, Steel.

Nonferrous materials –Copper,Bronze.

4 – What is brass? [2019w]

Ans: Brass is an alloy of copper and zinc

Copper -64, Zinc -36.

POSSIBLE LONG TYPE QUESTIONS

1. Describe composition and properties and application of zinc? [2010 w]

2. Describe composition, properties and use of aluminium alloys, tin base bearing materials. [2008 w,2014 w ,2015 w ,2019 w,2022W]

3. What are the effect of various alloying elements such as C,Ni,Mn,Mo,v and w. [2019 w 2020 w]

4. Write down the composition of duralumin. [2020 w]

5. Give some examples of nickel alloy and write down preparation of inconel. [2019 w]

CHAPTER NO.- 07

BEARING MATERIAL

Learning Objectives:

7.1 Classification, composition, properties and uses of Copper base, Tin base, Lead base and Cadmium base bearing materials

Introduction

When a lubricant film cannot completely separate the moving parts of a bearing, friction and wear increase. The resulting frictional heat combined with high pressure promotes localized welding of the two rubbing surfaces. These welded contact points break apart with relative motion and metal is pulled from one or both surfaces decreasing the life of the bearing. This friction and welding is most common when like metals, such as steel or cast iron, are used as bearings – they easily weld together. Compatibility of bearing materials, therefore, and absorption of lubricant upon the bearing surface, is necessary to reduce metallic contact and extend bearing life.

Babbitt In 1839, Isaac Babbitt received the first patent for a white metal alloy that showed excellent bearing properties. Since then, the name babbitt has been used for other alloys involving similar ingredients. Babbitts offer an almost unsurpassed combination of compatibility, conformability, and embeddability. They easily adapt their shapes to conform to the bearing shaft and will hold a lubricant film. Foreign matter not carried away by the lubrication is embedded below the surface and rendered harmless. These characteristics are due to babbitt's hard/soft composition. High-tin babbitts, for example, consist of a relatively soft, solid matrix of tin in which are distributed hard copper-tin needles and tin-antimony cuboids. This provides for "good run-in" which means the bearing will absorb a lubricant on the surface and hold the lubricant film. Even under severe operating conditions, where high loads, fatigue problems, or high temperatures dictate the use of other stronger materials, babbitts are often employed as a thin surface coating to obtain the advantages of their good rubbing characteristics.

7.1. Classification, composition, properties and uses of Copper base, Tin base, Lead base and Cadmium base bearing materials:

A. Copper base Bearing Material:

Name	Composition (Wt %)	Uses
Tin Based Babbitt	85Sn-10Sb-5Cu	High speed bearing bushes in steam and gas turbine, electric motor, blower, pumps etc.
Lead Based Babbitt	80Pb-12Sb-8Sn	Railway Wagon bearing.

Cadmium Based	95cd-5ag & small amount of iridium	Medium loaded bearing subjected to high temperature
Copper Based	80Cu-10Pb-10Si	Heavy duty bearing.

A bearing metal should possess the following important properties.

I. It should have enough compressive and fatigue strength to possess adequate load carrying capacity.
II. It should have good plasticity for small variations in alignment & fittings.
III. It should have good wear Resistance to maintain a specified fit.
IV. It should have low co-efficient of friction to avoid excessive heating.
V. The material should resist vibration.
VI. It should have high Thermal conductivity so as to take away the heat produced due to friction between two moving parts.
VII. It should have the properties to from a continuous thin film of lubricant between the shaft & bearing to avoid direct contact between two rotating surface.

SHORT QUESTIONS WITH ANSWERS

1. Classify bearing material. [2010 w]

Ans –Bearing material are classified as follows

- a-tin base
- b-lead base
- c –cadmium base
- d –copper base.

2. Write down the composition of lead base bearing material. [2009 W .2019 W]

Composition

- Pb -80 %
- Sn -8 %
- Sb -12 %

3. **Write any four desirable properties of bearing material. [2009 w, 2014 w**]

Ans –

- Posses low coefficient of friction.
- Have high compressive strength.
- Have high fatigue strength.
- Should bear shock and vibration.

4- what is the function of bearing[2021W]

Ans- Bearing are part that assist object rotations. They support shaft that rotate inside the machinery

POSSIBLE LONG QUESTIONS

1. Describe the composition, properties and uses of copper base and tin base bearing material. [2010 w, 2008 w,2014 w ,1018 w]

2. Classify bearing material with example [.2007 w]
3. State the properties of cadmium base bearing material. [2006 w]
4. Explain lead alloys with composition, properties and uses [2007 w]
5. Discuss about different bearing materials [2021W]

CHAPTER NO.- 08

SPRING MATERIAL

Learning Objectives:

8.1 Classification, composition, properties and uses of Iron-base spring material

8.2 Classification, composition, properties and uses of copper base spring material

Introduction

Springs are fundamental mechanical components found in many mechanical systems. Developments in material, design procedures and manufacturing processes permit springs to be made with longer fatigue life, reduced complexity, and higher production rate. Most springs are linear which means the resisting force is linearly proportional to its displacement. Linear springs obey the Hooke's Law, F = k× Dx

Where F is the resisting force, k is the spring constant, and Dx is the displacement. Depending on load characteristics spring may be classified as:

8.1 Classification, composition, properties and uses of Iron-base spring material

Most springs are made with iron- based alloy (high-carbon spring steels, alloy spring steels, stainless spring steels), copper base spring alloys and nickel base spring alloys.

i) High Carbon Spring Steel –(C 0.7-1.0, Mn 0.3-0.6& remaining Fe) these spring steels are the most commonly used of all spring materials because they are the least expense, are easily worked, and are readily available. They are not suitable for springs operating at high or low temperature or for shock or impact loading.

ii) Alloy Spring Steel –EN-45(C 0.5, Mn 1.0, Cr 0.2-0.9, V0.12 &remaining Fe), EN-60(C0.5-0.75, Mn0.6- 1.2& remaining Fe). These spring steels are used for conditions of high stress, and shock or impact loadings. They can withstand a wider temperature variation than high carbon spring steel and are available in either the annealed or pre-tempered conditions.

iii) Stainless Spring Steel – (Cr18, Ni8, C 0.1-0.2&remaining Fe) The use of stainless spring steels has increased and there are compositions available that may be used for temperatures up to 288°C. They are all corrosion resistant but only the stainless 18-8 compositions should be used at sub-zero temperatures. They are suitable for valve springs.

8.2 Classification, composition, properties and uses of copper base spring material

Copper base alloys are more expensive than high carbon and alloy steels spring material. However they are frequently used in electrical components because of their good electrical properties and resistance to corrosion. They are suitable to use in sub-zero temperatures. i) Brasses (Cu67, Zn33): Switch control, electrical application.

ii) Nickle Silver (Cu56, Ni18, Zn18): Electrical relays. iii)Pb Bronze (Cu92, Sn8, Pb 0.1): Bushes.

Iv) Beryllium Copper (Cu98, Be2.0): Relays and Bushes

POSSIBLE SHORT QUESTIONS WITH ANSWERS

1. **Write down types of spring materials**. [2019 new]

   Ans.

   - Iron base
   - Nickel base
   - Copper base.

2. **What is iron base spring material**? [2019 w 2020 w]

   Ans. The spring material in which iron is used as main constituent is called iron base spring material. Example. Hard drawn spring wire.

3. **Write down 4 properties of spring material**.

   Ans:

   - Posses' high modulus of elasticity.
   - High elastic limit
   - Good resistance to corrosion
   - High electrical conductivity.

4. What is an iron base spring material?[2020W]
Ans – The spring material in which iron is used as main constituent is called iron based spring material.
Ex- hard drawn spring
5. State two properties of spring material?[2021W]
Ans- (i) High strength
(ii)High elastic limit

POSSIBLE LONG QUESTIONS

1. Write down the composition, properties and uses of iron base materials. [2016 w, 2017 w .2018 w .2019 w.]

2. List the properties of copper base spring materials. [2018 w ,2019 s]

3. Write down the composition, properties and uses of copper and tin base spring materials. [2019 s]

4. What is spring? Discuss about different spring material [2021W]

5. Describe the composition, properties and uses of copper base and tin base spring material?[2022W]

CHAPTER NO. -09

POLYMERS

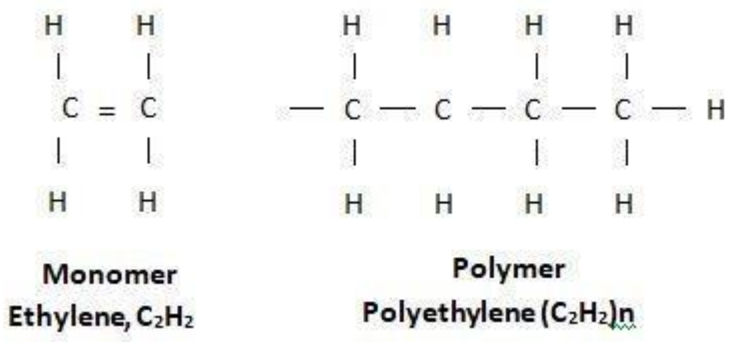
Learning Objectives:

9.1 Properties and application of thermosetting and thermoplastic polymers

9.2 Properties of elastomers

Introduction

The plastic is an organic substance and it consists of natural or synthetic binders or resins with or without moulding compounds. The plastic is manufactured by the polymerization. A polymer consists of thousands of monomers joined together.



Monomer:

The simplest substance consisting of one primary chemical are known as the monomer.

Polymerization:

- Monomers are to be combined to form polymers by the process known as polymerization.
- The polymer molecule is also called a macromolecule.
- A polymeric material consists of a large number of these long chain molecules.
- The properties such as strength, rigidity and elasticity are considerably improved by the polymerization and it further leads to the manufacture of plastics in an economy way.

Classification Of Plastics

The classification of plastics can be made by considering various aspects and for the purpose of discussion, they can be classified according to their

1. Behaviour with respect to heating.

2. Structure and
3. Physical and chemical properties.

As case-1 is the topic of our discussion we will concentrate on that.

9.1 Properties and Application of thermosetting and thermoplastic polymer

According to this classification the plastics are divided into two groups:

I. Thermo-Plastic
II. Thermo-Setting

The above classification is based on the inherent characteristics of each group. These two groups can further be divided into several distinct sub-divisions. These sub-divisions are based on the raw materials from which plastics are prepared. It is interesting to note that each of above group contains several hundred different products and with the advance of plastic industry, the number of sub-divisions under each category is constantly increasing.

(i) Thermoplastic polymer

The thermo-plastic or heat nonconvertible group is the general term applied to the plastics which become soft when heated and hard when cooled. The process of softening and hardening may be repeated for an indefinite time. Provided the temperature during heat is not so high as to cause chemical decomposition. It is thus possible to shape and reshape these plastics by means of heat and pressure. One important advantage of this variety of plastics is that the scrap obtained from old and warn-out articles can be effectively used again

Application of thermoplastic polymer.

1- Used to make sports equipments.

2- Used to making toys.

3- Used in automobile parts.

4- Used in making CDs and DVDs.

5- Containers like shampoo bottle, drinking bottles, food storage are made up of thermoplastic polymer.

(ii) Thermosetting polymer

The thermosetting or heat convertible group is the general term applied to the plastics which become rigid when moulded at suitable pressure and temperature. When they are heated in temperature range of 1270C to 1770C, they set permanently and further application of heat does

not altered their form or soften them. But at temperature of about 3430C, the charring occurs. This charring is a peculiar characteristic of the organic substances.

The thermo setting plastics are soluble in alcohol and certain organic solvents when they are in thermo-plastic stage. This property is utilised for making paints and varnishes from these plastics.

These plastics are durable, strong and hard. They are available in a variety of beautiful colours. They are mainly used in engineering application of plastics.

Application of thermosetting polymer

1- They are used for manufacturing permanent parts in wide array of industry.

2- These are used for producing electrical goods such as panels and insulator.

3- Since they tend to heat resistant, thermo sets are used for manufacturing of heat shield.

4- In automobile thermosets are used for producing brake piston.

5- These are also used for various agricultural equipments that include motors and feeding troughs.

9.2 Properties of Elastomers:

Following are the properties of elastomers:

- **Temperature:** The specific working temperature of elastomers vary depending on the factors like media compatibility, seal design, and the dynamic and static operation.
- **Low-temperature flexibility:** The rate of recovery of elastomeric material can be studied by subjecting the material to low-temperature retraction.
- **Hardness:** The measurement of the material's resistance towards the deforming force for a defined length of time is done by measuring the hardness. It differs from material to material. The soft compounds deform easily and have high friction while the harder compounds have high resistance and low friction.
- **Ageing:** This property helps to understand the behaviour of a material when exposed to heat. If the elastomers are pushed beyond their ageing resistance, they will suffer from hardening, cracking, and splitting.
- **Colour:** Colouring is used mainly to differentiate between the compound grades based on their usage.
- **Elongation at break:** This property is used for testing the moment of rupture when the material is under tensile stress.

POSSIBLE SHORT QUESTIONS WITH ANSWERS

1- What is elastomer? [2007 w,2008 w, 2011 w ,2012 w ,2019w,2022W]

Ans: An elastomer is a polymeric material that may be experience large and reversible elastic deformation .elastomers are generally refers to as rubbers .they are essentially non crystalline in structure.

2- Write down two properties of elastomer. [2020 w]

Ans.

- High chemical resistance.
- Good fuel, oil and ozone resistance.

3. What is thermo setting polymer? [2014 w]

Ans. The polymer which once harden and soft and then do not soften with application of heat is called thermosetting polymer.

Example –Radio and TV cabinet.

4. Define polymerization?[2021W]

Ans- It is a process in which relatively small molecules called monomers, combine chemically to produce a very large molecules called polymerization

POSSIBLE LONG QUESTIONS

1- Explain the application and properties of thermoplastic polymers? [2008 w, 2019 w]

2- Difference between thermoplastic and thermosetting polymers. [2015 w, 2016 w, 2019 w, 2021W]

3. Write the properties of elastomers. [2009 w, 2015 w]

4. Write down properties thermosetting polymers.[2018 w]

5. What is elastomer, write down the properties & application of thermosetting &thermoplastic polymer? [2021W]

6. Discuss about various properties of plastic? [2021W]

CHAPTER NO. - 10

COMPOSITE AND CERAMICS

Learning Objectives:

10.1 Classification, composition, properties and uses of particulate based composites

10.2 Classification composition, properties and uses of fibre reinforced composites, Classification and uses of ceramics

10.1 Classification, composition, properties and uses of particulate based composite

Classification

The composite materials are shortened as composites. They are formed by combining two or more different materials to make better use of their virtues and by minimizing their deficiencies. Each material retains its physical or chemical properties separate and distinct within the finished product.

Composition

The composites are made from two main constituent materials.

1. Strong load carrying material known as reinforcement or reinforcing fibres.

2 - Weaker material known as matrix.

Particle reinforce composite material

1- Example of particle reinforce composite material is concrete.
2- It consists of two phase that is matrix and reinforcement phase.
3- In this type of composite material cement works as matrix phase and chips, soil etc works as reinforcement phase.
4- The matrix phase that is cement binds and holds the reinforcement phase that is chips and soil.
5- The reinforcement phase like chips and soil works as reinforcement to strengthen the composite material.

10.2 Classification composition, properties and uses of fiber reinforced composites, Classification and uses of ceramics

Following are the functions of reinforcing fibres:

(i) It provides strength and rigidity.
(ii) It helps to support structural load.

There are three most common types of reinforcing fibres.

(i) Glass fibres
(ii) Carbon fibres
(iii) Aramid fibres

Glass fibers are the heaviest having greatest flexibility and the lowest cost. Aramid has moderate stiffness and cost.

Carbon is moderate to high in cost, slightly heavier than aramid but lighter than glass fibres. Carbon is the strongest.

Matrix

Following are the functions of matrix.

(i) It works as a binder
(ii) It maintains the position and orientation of the reinforcement.
(iii) It balances the loads between the reinforcement.
(iv) It protects the reinforcement degradation.
(v) It provides shape and form to the structure.

1- Example of fibre reinforce composite material is tyre.

2- It consists of two phase that is matrix and reinforcement phase.

3- In this type of composite material rubber act as matrix phase and nylon wire or steel wire acts as reinforcement phase.

4- The matrix phase that the rubber binds and holds the reinforcement phase.

5- The reinforcement phase like nylon wire or steel wire strengthen that composite material.

Classification and Uses of Ceramics

The term ceramics is used to indicate the potter's art or articles made by the potter. The ceramics are divided into the following three categories.

1. Clay products
2. Refractories
3. Glass

Clay products

The clay products which are used are tiles, terra-cotta, porcelain, bricks, stoneware's & earth wares.

Tiles are of two types

a. Common tile
b. Encaustic tiles

Types of common tiles

(i) Drain tiles
(ii) Floor or paving tiles
(iii) Roof tiles

Types of roof tiles

Allahabad tiles, corrugated tiles, Flat tiles, Flemish tiles, Guna tiles, Mangalore tiles, pan tiles.

Refractories

The term refractories are used to indicate substances that are able to resist high temperatures.

Classification

- According to chemical properties.
- According to resistance to temperature.

According to chemical properties

(a) Acidic

(b) Neutral and

(c) Basic

(a) Acidic

Fire clay: It is used for the manufactured of fire bricks, crucibles, hollow tiles. Quartzite- For making the silica bricks.

Silica- Coke over and lining for glass furnaces.

Neutral refractory materials

Bauxite- For tire bricks

Carbon- Lining material for furnaces

Chromites- Powerful neutral refractory material.

Forsterite- Used in furnaces for melting copper.

Basic Refractory materials

Dolomite- For making refractory bricks. Magnesia- Magnesia bricks.

According to resistance to temperature

(a) Low quality

(b) High quality

High quality - Used in modern aeroplanes, rockets, jets etc. Molybdenum, tungsten, zirconium and their alloys are used as the refractory materials.

Cermet - Refractory material containing a combination of clay and metal.

Surface Preparation and Industrial Painting

SHORT QUESTION WITH ANSWERS

1- What is composite material? [2012 w,2011w,2008 w,2019 w,2018 w,2021w]

Ans – Composite material can be defined as the material made up of two or more dissimilar. composite material does not occur naturally as an alloy but are separately manufactured before they are combined together mechanically or metallurgical.

2- Write application of ceramics. [2011w, 2010 w, 2008 w, 2019 s, 2018w, 2020 w,2021w.]

Ans: Ceramics material can be used as sand, glass, brick, cement etc. ceramic materials are corrosion resistance and can be used as concrete, refractories and plaster.

3-Define composite and alloys. [2017 w]

Composite materials are made by two or more metallic and non metallic elements but the alloys are made by two or more different types of metals.

Example –

Composite material –tyre

Alloys –zinc alloy

Aluminium alloy.

4. Classify composite material. [2010 w]

1-particle reinforced

- A-large particle
- B-dispersion strengthen

2-fiber reinforced

- A-continuous
- B-discontinuous

3-Structural

- A-laminates
- B-sandwich panel

5. Write two characteristics of duralumin?[2021W]

Ans- 1. Strong

2 light weight

.

POSSIBLE LONG QUESTIONS

1- Explain particle reinforce and fibre reinforce composite material? [2012 W, 2011 W, 2009W, 2020 W 2018 W,2020W.]

2- Classify and state application of ceramic materials. [2019w, 2020 w, 2012 w, 2008 w]

3- Mention present day uses of ceramics. [2014 w]

4- Describe classification and uses of ceramic. [2015 w]

5. Classify composite material. Discuss about dispersion strength composites?[2021W]

6. Give a brief classification of ceramics & write down their uses?[2022W]