

LECTURE NOTE
ON
ENGINEERING MATERIAL
DIPLOMA 3rd SEM



DEPARTMENT OF MECHANICAL ENGINEERING

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B. COURSE OBJECTIVES:

After completion of the course students will have the ability of

- Realizing material requirements
- Realizing application area of ferrous, non ferrous and alloys
- Comprehending micro-structural changes during iron-carbon phase transformation process
- Comprehending effect of heat treatment and its effect towards change in material properties
- Comprehending continuity during evolution in engineering materials and development of modern engineering materials.

1.0 Engineering materials and their properties

1.1 Material classification into ferrous and non ferrous category and alloys

1.2 Properties of Materials: Physical , Chemical and Mechanical

1.3 Performance requirements

1.4 Material reliability and safety

2.0 Ferrous Materials and alloys

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,

3.0 Iron – Carbon system

3.1 Concept of phase diagram and cooling curves

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

4.0 Crystal imperfections

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

5.0 Heat Treatment

5.1 Purpose of Heat treatment

5.2 Process of heat treatment: Annealing, normalizing, hardening, tempering, stress relieving measures

5.3 Surface hardening: Carburizing and Nitriding

5.4 Effect of heat treatment on properties of steel

5.5 Hardenability of steel

6.0 Non-ferrous alloys

6.1 Aluminum alloys: Composition, property and usage of Duralmin, γ - alloy.

6.2 Copper alloys: Composition, property and usage of Copper- Aluminum, Copper-Tin, Babbit , Phosphorous bronze, brass, Copper- Nickel

6.3 Predominating elements of lead alloys, Zinc alloys and Nickel alloys

6.4 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.

7.0 Bearing Material

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

8.0 Spring materials

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

9.0 Polymers

9.1 Properties and application of thermosetting and thermoplastic polymers

9.2 Properties of elastomers

10.0 Composites and Ceramics

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

10.2 Classification and uses of ceramics

Chapter- 1.0

Engineering materials and their properties

Scope of Syllabus:

Engineering materials and their properties

Material classification into ferrous and non-ferrous category and alloys

Properties of Materials: Physical, Chemical and Mechanical

Performance requirements

Material reliability and safety

Introduction

- Materials 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

:Material Classification

Engg. 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 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.

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

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

Appearance

- Metalsthemselveshavegotdifferent appearances e.g.,aluminiumisasilverywhite metal where as copper appears brownish red.
- Appearanceincludelusture, colourandfinishofamaterial.
- Lustureistheabilityyofa materialtorefect light whenfinelypolished. Itisthe brightness of a surface.

Colour

- Thecolourofthe materialis veryhelpfulinidentificationofa metal. Thecolourofa metal depends upon the wavelength of the light that the material can absorb.

Density

- Thedensityistheweightofunitvolumeofamaterialexpressedinmetricunits.
- Densitydependstosomeextent onthe
 - a) Purityofmaterial
 - b) Pour volume
 - c) Treatment,thematerialhasreceived.

Densityhelpsdifferentiatingbetweenlight andheavymetalseveniftheyhavesameshape and any outer protective coating.

Meltingpoint

Meltingpointofa materialisthattemperatureatwhichthesolid metalschange into molten state.

Onemetalcanbedistinguishedfromtheotheronthebasisofitsmelting point.

Porosity

- Ametalissaidtobeporousifithasporeswithin it.
- Porescanabsorb lubricantasinasinteredself-lubricatingbearing.
- It istheratiooftotalporevolume to bulkvolume

Structure

- Itmeansgeometricrelationshipofmaterialcomponents.
- Italso impliesthearrangement ofinternalcomponentsofmatter(electron structure, crystal structure, and micro structure)

Chemicalproperties

- Astudyofchemicalproperties of materials is necessarybecause most ofengineering materialswhentheycome incontact withother substanceswithwhichtheycanreact, 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

Corrosion

- 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

1.2.2 Mechanical Properties of Materials

The mechanical properties of materials define the behaviour 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.

1.2.2 Mechanical Properties of Materials

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 material, 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.
- Heat-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 recalled 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 introduced 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 may be considered the combination of strength and plasticity.

- Manganese steel, wrought iron, mild steel are examples of toughness materials.

6. Brittleness

- The brittleness is 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 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 little 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, aluminium are the good examples of ductile materials.

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.
- Aluminium, copper, tin, lead 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' used 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.

-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.

-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.

1.4.2 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.

SHORT QUESTIONS WITH ANSWERS

1- Define material?[POSSIBLE]

Ans-material is something that consists of matter. Material is the stuff of which something is made. Material comprises a wide range of metals and non-metals which must be processed to form the end product.

2- Classify material?[2008W,2016W,2018W,2018S]

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 that 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 factors affecting selection of material? [2016W, 2018W, 2019 S, 2019 S NEW]

1- Properties of material

1- Performance requirement

2- Material's reliability

3- Safety

4- Physical attributes

5- Define safety of material? [2017W]

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, material that gives off spark when struck is a safety hazard in a coal mine.

LONG QUESTIONS

- 1- Describe various factors affecting selection of material [2016W, 2018W, 2019 S, 2019 S NEW]**
- 2- Describe various mechanical properties of material. [2014W, 2017W NEW, 2018 S]**
- 3- Define physical properties of material. [2015 W, 2019 S]**

Chapter- 2

Ferrous Materials and Alloys

Learning Objectives:

Ferrous Materials and alloys

Characteristics and application of ferrous materials

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

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

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

-Characteristic of ferrous materials:

- Ferrous materials are metals or metal alloys that contain 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 material over a flame. The principal disadvantages of many ferrous alloys is their susceptibility to corrosion.

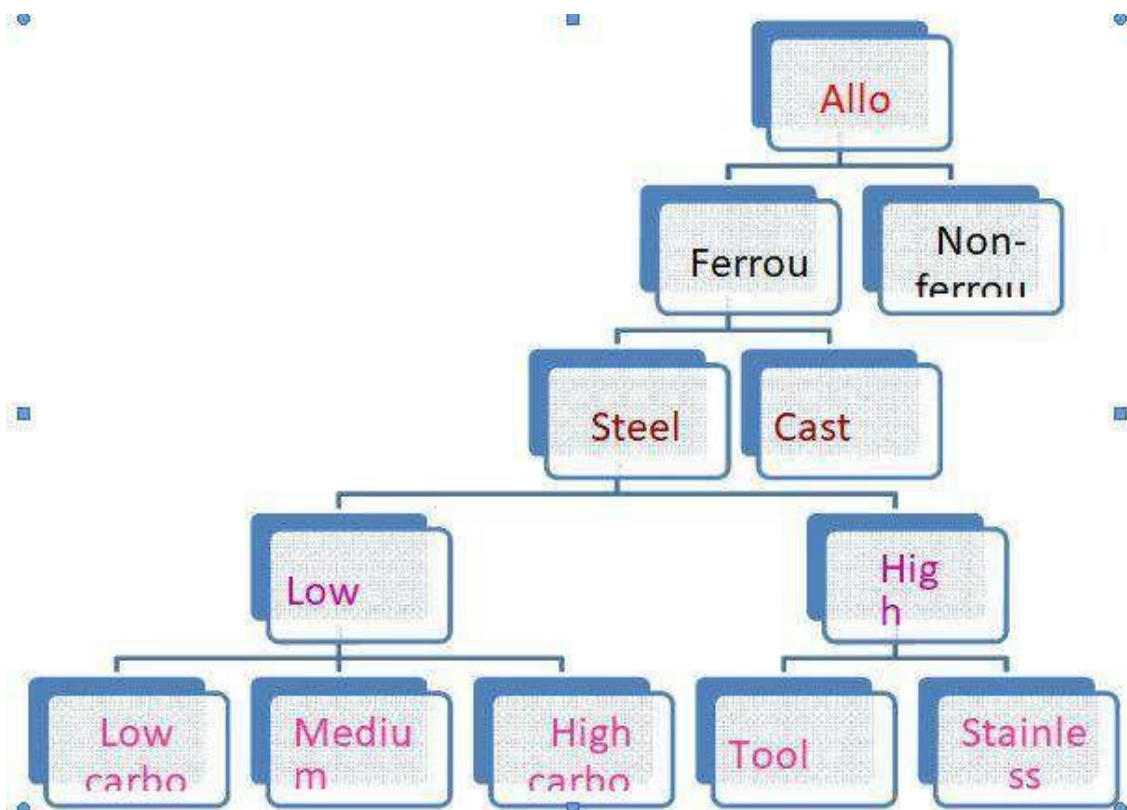
Application:

- 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. Sousedincastings,manholecovers,enginebody,machinebase etc.
- Mild steel is soft, ductile and has high tensile strength. It is used in generalmetalproductslikestructural,workshop,householdfurniture etc.
- Carbonsteelsareusedforcuttingtoolsdue totheirhardness,strength and corrosion resistance properties.

-Classification:

Steel-Itis an alloy of iron and carbon in which carbon content is upto 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.

Types of cast iron:

- Grey, white, nodular, malleable and compacted graphite.

- Low carbon steel-Carbon content in the range of 0–0.3%.
- Most abundant grade of steel is low carbon steel (greatest quantity produced; and least expensive). Not responsive to heat treatment; cold working needed to improve the strength.
- It has good weldability and machinability

Medium carbon steel-

- Carbon content in the range of 0.3 –0.8%. It can be heat treated - austenitizing, quenching and then tempering.
- Most often used in tempered condition –tempered martensite Medium carbon steels have low hardenability
- Addition of Cr, Ni, Mo improves the heat treating capacity Heat treated alloys are stronger but have lower ductility

Typical applications–

- Railway wheels and tracks, gears, crankshafts.

High carbon steel

- High carbon steels –Carbon content 0.8 –2% High C content provides high hardness and strength.
- Hardest and least ductile.
- Used in hardened and tempered condition
- Strong carbide formers like Cr, V, W are added as alloying elements to form carbides of these metals.
- Used as tool and die steels owing to the high hardness and wear resistance property

Tool steel

Tool steel refers to a variety of carbon and alloy steels that are particularly well-suited to be made into tools. Their suitability comes from their distinctive hardness, resistance to abrasion, their ability to hold a cutting edge, and/or their resistance to deformation at elevated temperatures. Tool steel is generally used in a heat-treated state. Many high carbon tool steels are also more resistant to corrosion due to their higher ratios of elements such as vanadium. With a carbon content between 0.7% and 1.5%, tool steels are manufactured under carefully controlled conditions to produce the required quality.

Stainless steel-

Stainless steel does not readily corrode, rust or stain with water as ordinary steel does, but despite the name it is not fully stain-proof, most notably under low-oxygen, high-salinity, or poor-circulation environments. There are different grades and surface finishes of stainless steel to suit the environment the alloy must endure. Stainless steel is used where both the properties of steel and corrosion resistance are required. Stainless steel differs from carbon steel by the amount of chromium present.

Plain Carbon Steel

Plain Carbon Steel is an alloy of iron and carbon with carbon content up to 1.5% although other elements such as Silicon, Manganese may be present. The properties of carbon steel are mainly due to its 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 into three types based 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:

- i) Dead mild steel is used for making steel wire, sheet, rivets, screws, pipe, nail, chain, etc.
- ii) Mild steel containing 0.15 to 0.2% carbon is used for making camshafts, sheets, strips for blades, welded tubing, forgings, drag lines, etc.
- iii) Mild steel containing 0.2 to 0.3% carbon is used for making valves, gears, crank shafts, connecting rods, railway 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, keystone, shafts & brake lever, axle, small & medium forgings, etc.
- Steel containing 0.45 to 0.55% carbon is used for railway coach axles, axles & crank pin on heavy machines, spline 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 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.

-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 upto 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: X10Cr18Ni9S3X - High alloy steel
- 10% - 0.1% C Cr18 - 18% Cr Ni9 - 9% Ni
- S3 - Pickled condition

-Tool Steel:

Tool steel may be defined as special steel which are used to form, cut or otherwise change the shape of a material into finished or 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 decarburization
- ix) Resistance to softening on heating

Classification of Tool Steel:

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

Symbol	Meaning
T	W-High speed steel
M	Mo-High speed steel
D	High C, high Cr steel
	Air hardening steel
O	Oil hardening steel
	Water hardening steel
H	Hot work steel
S	Shock resistance steel

1) W-High speed steel

- T1: C 0.7 Cr4 V1 W18
- T4: C 0.75 Cr4 V1 W18 Co5
- T6: C 0.8 Cr4.5 V1.5 W20 Co12

2) Mo-High speed steel

- M1: C 0.8 Cr4 V1 W 1.5 Mo8
- M6: C 0.8 Cr4 V1.5 W 4 Mo 5 Co 12

3) High C, high Cr steel

- D2: C 1.5 Cr12 Mo1
- D5: C 1.5 Cr12 Mo1 Co3

D7: C2.35Cr12 V 4Mo1

4) Airhardeningsteel

A2: C 1 Cr5 Mo1

A7: C2.25Cr5.25 V4.75 W11 Mo1

A9: C 0.5Cr5 Ni1.5V1Mo 1.4

5) Oilhardeningsteel

O1: C 0.9Mn1 Cr0.5W0.5

O2: C1.45Si1Mo0.25

6) Waterhardeningsteel

W2: C 0.6/1.4 V0.25W5:C 1.1Cr0.5

7) Hotworksteel

H10:C 0.4Cr3.25 V0.4 Mo2.5

H12:C 0.35Cr5V 0.4 W 1.5Mo1.5

8) Shockresistancesteel

S1: C0.5Cr1.5W2.5

S2: C0.5Si1 Mo0.4

S5: C 0.55 Mn0.8 Si2 Mo0.4

S7: C 0.5Cr3.25 Mo1.4

StainlessSteel:

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 based on their micro-structure can be grouped in to three metallurgical classes such as Austenitic stainless steel, Ferritic stainless steel & Martensite stainless steel.

AusteniticStainlessSteel:

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 scaler 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 & railway 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 11 to 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 conditions & 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:It

- 1) increases toughness & resistance to impact.
- 2) lessens distortion in quenching.
- 3) Lower 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:It

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

Molybdenum:It

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

Tungsten:It

- 1) increases hardness.
- 2) promotes fine grains.
- 3) resists heat.
- 4) promotes strength at elevated temperature.

SHORT QUESTIONS WITH ANSWERS

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

Ans- Low carbon steel is suitable for automobile body, refrigerator body, cams etc. These are also used for nut, bolts, 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- Dairy 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 non ferrous metal.

Ferrous metal- cast iron, steel

Non ferrous metal- aluminium, copper.

LONG QUESTIONS

1. write down the effect of alloying element added to steel. [2018 S]
2. write short note on [2018 S]

A- stainless steel, B- High speed

3- How cast iron is obtained? classify and explain different types of cast iron. [2018 S]

Chapter-03

IRON-CARBON SYSTEM

Learning Objectives:

Iron–Carbon system

Concept of phase diagram and cooling curves

Features of Iron-Carbon diagram with salient micro-constituents of

Iron and Steel

3.1 Concept of phase diagram

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, fcc structure, in liquid form and in gaseous state are 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 exist over a range of composition, temperature and pressure is considered as the same phase.

Equilibrium phase diagrams are normally used to show the stability of different phases in a material as a 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 in a system, then the phase rule can be stated as $f = C - P + 2$

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

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.

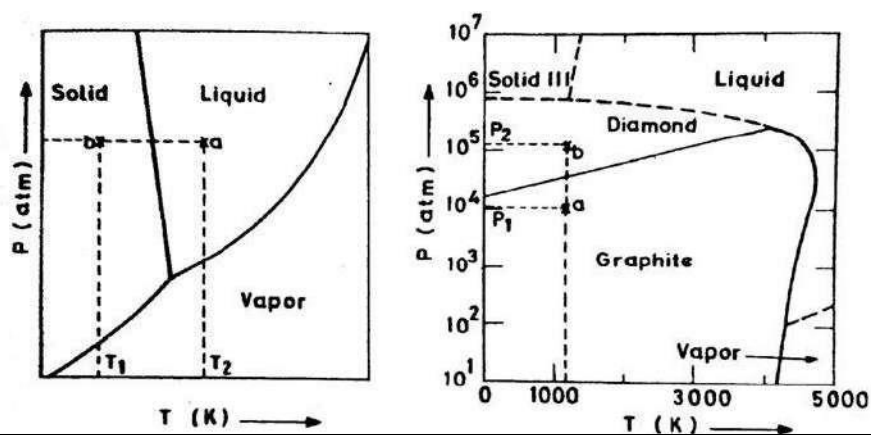


Fig-3.1

(a)

(b)

The fig. 3.1 shows phasediagramsoftwoonecomponentsystem,H₂Oandcarbonasa

functionoftemperatureandpressure.InasinglephaseregionsbothPandTmaybe independently varies.

In twocomponent(binary)systems,thereare threeindependentvariables,i.e,temperature, pressure and relative concentration of one of the component.

CollingCurves

CollingCurvesofpureIron:-

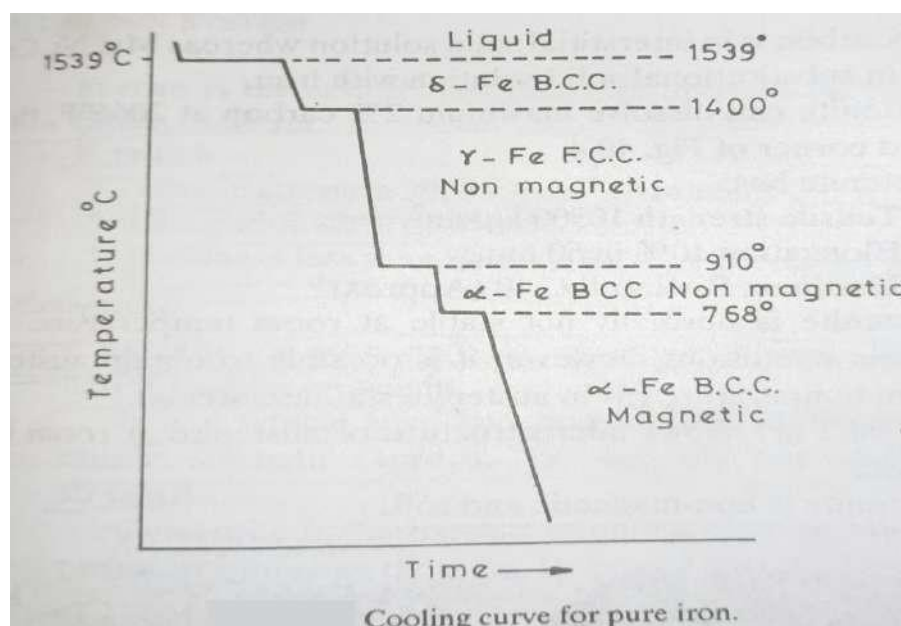
- Ironisarelativelysoftandductilemetal.
- Ironhasametaling point of 1539° C
- Ironisallotropicmetal,whichmeansthatitexistsinmorethanonetypelattice structure (e.g., B.C.C./F.C.C.) depending upon temperature.

In its normalroomtemperature state, iron is B.C.C in lattice arrangement, whereat 908°c it changes to F.C.C. and then at 1403° C back to B.C.C. again and vice versa.

Oneanotherchangeoccursatabout770° C(calledthecuriepoint)atwhichtheroom temperaturemagneticpropertiesofirondisappearanditbecomesnon magnetic.

Theironremainsnonmagneticuntilthetemperaturedropsbackbelowthecuriepoint upon which its magnetic properties reappear.

- Fig. showsacoolingcurveforpureironwithallotropicformsofironmarkedover it.
- Ironis moltenabove1539° C. Itsolidifies intheB.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.

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–Troosite i–Sorbite

a. AUSTENITE

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

- Austenite has:
 - * Tensile strength 10500 kg/cm²
 - * Elongation 10% in 50mm.
 - * Hardness Rockwell C40 (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 austenitic stainless steels). Shows microstructure of austenitic at room temperature. Austenitic is non-magnetic and soft.

(b) 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 2800 kg/cm²
- * Elongation 40% in 50mm
- * Hardness less than Rockwell C0 or Rockwell B90.

(c) Cementite

Cementite or iron carbide, chemical formula Fe_3C contains 6.67% carbon by weight.

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

(d) Ledeburite.

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

(e) Pearlite

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

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

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

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

It is the 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 a needle-like structure.

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

In steel heat treatment, the troosite 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 microstructure consisting of ferrite and finely divided cementite produced on tempering martensite above approximately 450°C.

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

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

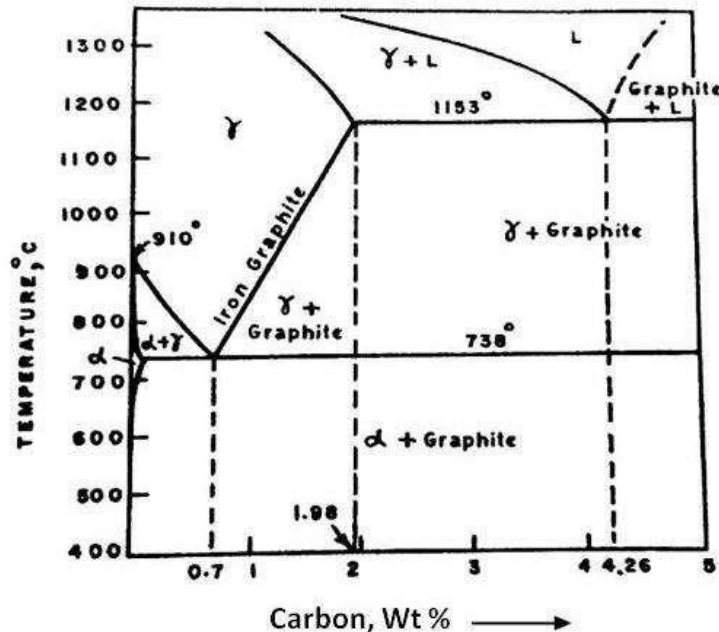


Fig-3.3 –Iron – Carbon phase diagram

At all temperatures, the following reaction takes place : $Fe_3C \text{ cooling } 3Fe + C \text{ (graphite)}$ 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 establish 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 upto 2% of carbon is called steel and the iron which contains 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 contains 2% to 4.3% of carbon is called hypoeutectic steel and which contains 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 occurs approximately at 1500°C and carbon percentage is approximately 0.25%. It may be written

$\Delta + \text{liquid} \xrightarrow{\text{Cooling/Heating}} \text{Austenite}$.

Eutectic reaction

This reaction occurs approximately at 1149°C and carbon percentage is 4.1%. It may be written

$\text{Liquid} \xrightarrow{\text{heating/cooling}} \text{Austenite} + \text{cementite/ledeburite}$

Eutectoid reaction

This reaction occurs approximately at 727°C and carbon percentage is 0.8%. Solid -> Cooling /heating ferrite + cementite /pearlite .

SHORT QUESTION

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

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

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

Ans - A phase diagram represents the limits of stability of the various phases in a chemical system at equilibrium with respect to variables such as composition and temperature.

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

Ans - An equilibrium diagram consists of iron containing percentage of carbon on which the properties of iron depend and vary according to it.

4- Name two iron ores and their symbols. [2018S]

Ans - Hematite - Fe_2O_3 , Magnetite - Fe_3O_4

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

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

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

LONG QUESTIONS

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

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

3- Explain various reactions in iron-carbon diagram? [2017w]

CHAPTER - 04

CRYSTAL IMPERFECTIONS

Crystal imperfections

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

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

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

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

Effect of imperfection on material properties

Deformation by slip and twinning

Effect of deformation on material properties

Introduction

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 unit or building blocks. The symmetry is an important characteristic of most of the crystals.

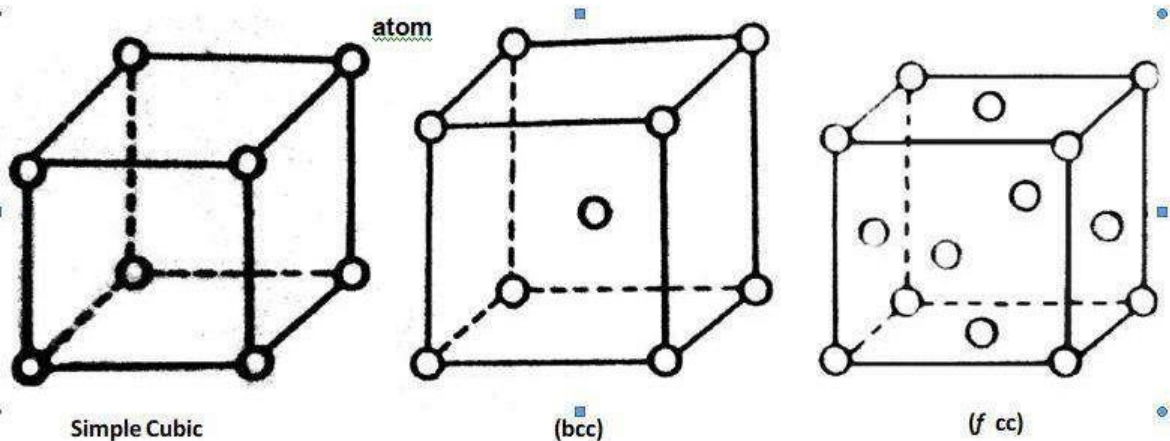
E.g. cube and octahedron are simple forms of the crystal.

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

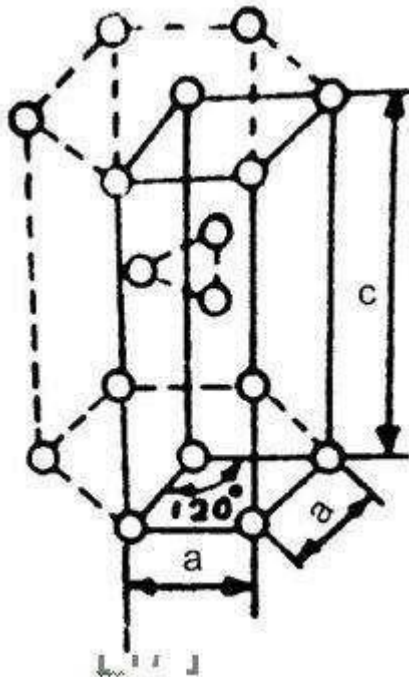
Classification of Crystals

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 the 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 imperfections 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.

Classification of imperfections

Defects are classified into

- 1- point defect
- 2- line defect
- 3- Boundary defect
- 4- volume defect

Types and causes of point defects Point Defects

In a crystal lattice, a point defect is a completely local effect. When a point defect is introduced into a crystal lattice, the internal energy of the crystal increases.

Types

Vacancies, interstitialcies and impurities are examples of point defects.

Causes

A vacant lattice site is a point defect.

Vacancies

A vacant site implies an unoccupied atom position within a crystal lattice and is called a vacancy. 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 metals 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 is 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 an average position on the surface of the crystal.

Interstitialcies

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

When an atom is displaced from a regular site and occupies an interstitial site, an interstitialcy is formed, called a 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, the smaller the defect.

Impurities

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

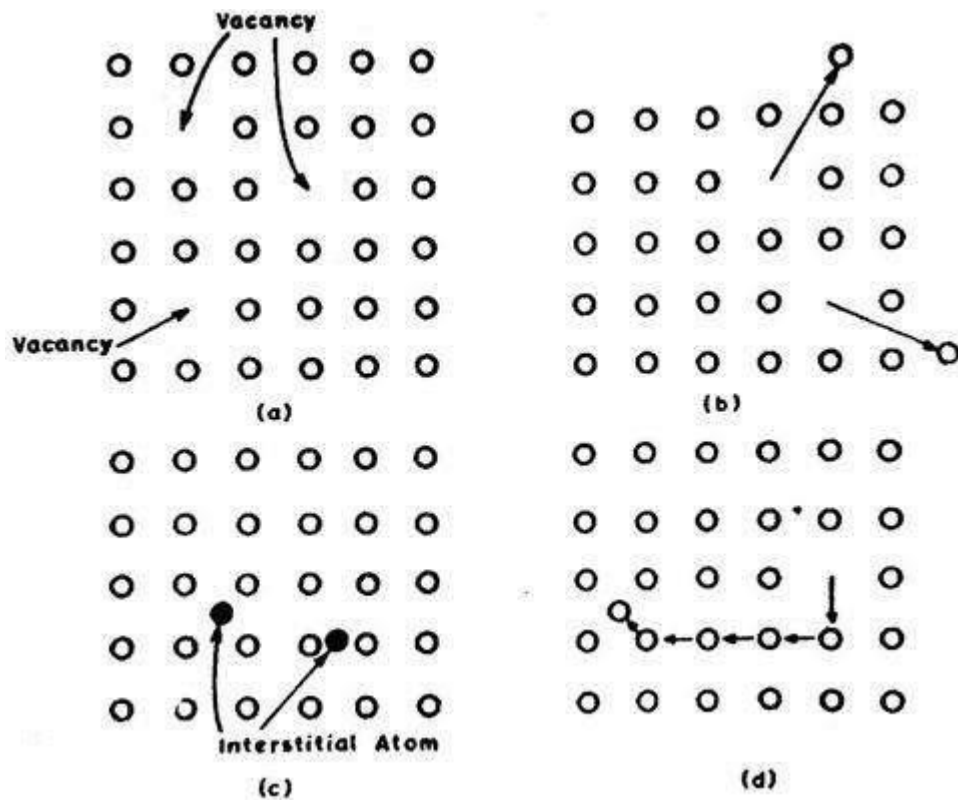


Fig 3.5 Various types of point defects. (a) Vacancy, (b) Schottky defect, (c) Interstitialcy, (d) Frenkel defect.

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

Line Defects

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

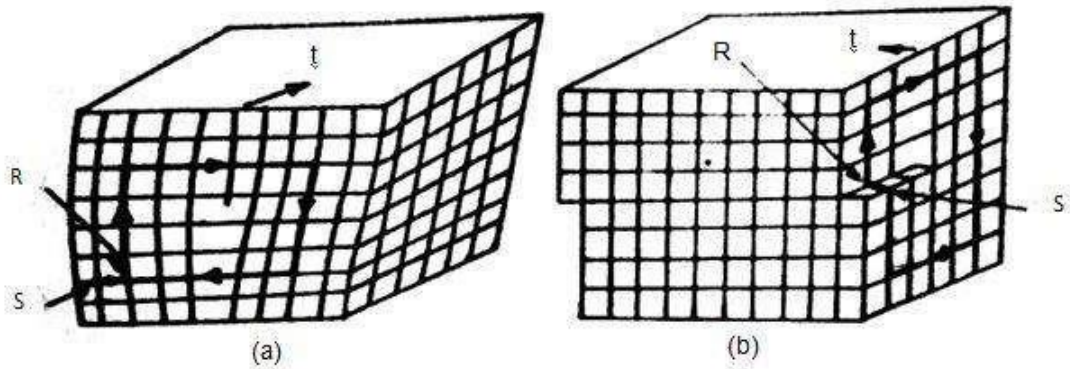


Fig-3.6

Types

Dislocations are of two types: (1) Edge dislocation (2) 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 and is denoted by \oplus . To understand this notice, visit:

sign \ominus When the extra row of atoms is below the slip plane, it is called negative edge dislocation and is represented by sign \ominus . 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 screw 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.

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.

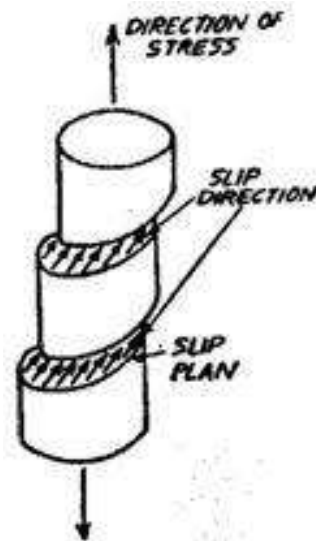


Fig. 3-2 Mechanism of slip

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 stresses are produced in cold working.

SHORT QUESTIONS WITH ANSWERS

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

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 (2016w, 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 a defect occurs at any point of a crystal lattice that is called a 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 there is a region of localised lattice disturbance which separates the slip region of the crystal from its unslipped region, the line defect occurs. The plastic deformation of metals due to slip phenomenon is mainly on account of dislocation only.

LONG QUESTIONS

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

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

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

CHAPTER-5.0.

HEAT TREATMENT

Learning Objectives:

Heat Treatment

Purpose of Heat treatment

Process of heat treatment: Annealing, normalizing,

hardening, tempering, stress relieving measures

Surface hardening: Carburizing and Nitriding

Effect of heat treatment on properties of steel

Hardenability of steel

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.

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

Process of heat treatment Annealing

Annealing involves heating to a predetermined 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 are 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 40-50°C 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 – 50°C above the critical temperature whereas eutectoid and hyper eutectoid steels are heated to about 30 – 50°C above the lower critical temperature.

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 wear resistance of the hardened steel marginally. The higher the tempering temp, the more is the restored ductility and toughen the steel. Proper tempering treatment results in optimum combination of mechanical properties. Elastic properties are affected by this. Hardening followed by tempering will improve elasticity.

5.3-Surface Hardening

- In order to process considerable strength to withstand 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 remainings soft. Surface hardening or case-hardening provides a hard 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.

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 an 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 0.5 mm in 90 minutes. The process is extremely flexible and easily controlled. The reaction in the bath is $2\text{Na}_2\text{CO}_3 + \text{SiC} \rightarrow \text{Na}_2\text{SiO}_3 + \text{Na}_2\text{O} + 2\text{CO} + \text{C}$.

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 at a temperature between 450C and 550C for 10 hours. The core should be brought to its original toughness before nitriding by quenching in oil from about 900C and tempering from about 600C to 650C. It is used for various automotive, airplane and diesel engine parts like cylinders, sleeves, liners etc.

Hardenability

It is defined as a 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, hardness can be

SHORT QUESTIONS AND WITH ANSWERS

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

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 desired degree of physical and mechanical properties such as brittleness, hardness and softness .

2. Define annealing? 2019w, 2019S.

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 a temperature with 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 to cool by quenching in water, oil etc .

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

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

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

Ans–it is a process of reheating a quenched 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 .

LONG QUESTIONS

1. Explain the purpose of heat treatment? 2009 w, 2007w, 2006w, 2017w, 2020w, 2010 w .

2. List the effects of heat treatment on the properties of steel? 2010new, 2008w, 2018 w

3. Describe various types of heat treatment processes? 2010new, 2017 w.

4. Describe annealing? 2009w.

5. Describe hardenability of steel? 2007w, 2018w.

CHAPTER- 6

NON-FERROUS ALLOYS

Learning Objectives:

Non-ferrous alloys

Aluminum alloys: Composition, property and usage of

Duralmin, γ -alloy.

Copper alloys: Composition, property and usage of Copper-

Aluminum, Copper-Tin, Babbit, Phosphorous bronze,

brass, Copper- Nickel

Predominating elements of lead alloys, Zinc alloys and Nickel alloy

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 Composition, Properties and Uses of Aluminium Alloys, Duralumin, γ - Alloy

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 500°C and after quenching ages over a period of 4 to 5 days. Its tensile strength increase from 1.55-1.86 ton/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 frame, 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 alloy of this group 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 casting 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 and elongation of 17 – 22% and brinell hardness of 100-105.

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

6.2-Copper alloys

(a) 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, crankcases, cylinder heads, connecting rods.

(b) Copper-Tin

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

Another alloy 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.

(c) Babbot

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 babbot 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 used as liners in bronze or steel backing and are prepared for high speed, excellent properties in this notice, visit: embedability, conformability, ability to deform plastically used in IC engine bearing, general machinery purpose bearings.

(d) 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 an 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 valves. 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 seawater and is used for spring and turbine blades.

(e) 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, zinc alloys and nickel alloys. 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 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%.

Zinc alloys

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

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.

6.4- 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 alloy 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.

SHORT QUESTIONS WITH ANSWERS

1- Give two examples of nonferrous alloys. 2017w 2018w. Ans –

Aluminium alloy, Copper alloy

2- What is an alloy?

Ans. When two or more metals combine with each other and form a new material that is called alloy. Steel is the alloy of iron and carbon.

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? 2019 w?

Ans: Brass is an alloy of copper and zinc

Copper -64, Zinc -36.

LONG QUESTIONS

1. Describe composition and properties and application of zinc? [2010w]
2. Describe composition, properties and use of aluminium alloys. [2008w, 2014w, 2015w, 2019w]
3. What are the effects of various alloying elements such as C, Ni, Mn, Mo, and V. [2019w 2020 w]
4. Write down the composition of duralumin. [2020 w]
5. Give some examples of nickel alloy and write down preparation of Inconel. [2019w]

CHAPTER-

07.BEARING MATERIAL

Learning Objectives:

Bearing Material

Classification, composition, properties and uses of Copper

base, Tin Base, Lead base, 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 embedability. They easily adapt their shape 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 of Bearing Material

1. Tin Based Babbitt
2. Lead based Babbitt
3. Cadmium Based Bearing Material
4. Copper based Bearing Material (Cinthered Metal)

Composition and uses of different type of Bearing material.

Name	Composition(Wt%)	Uses
TinBased Babbitt	85Sn-10Sb-5Cu	High speed bearing bushes in steam and gas turbine, electric motor, blower, pumps etc.
LeadBased Babbitt	80Pb-12Sb-8Sn	Railway Wagon bearing.
CadmiumBased	95cd-5ag & small amount of iridium	Medium loaded bearing subjected to high temperature
CopperBased	80Cu-10Pb-10Si	Heavy duty bearing.

Properties of Bearing Material

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 coefficient 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 form a continuous thin film of lubricant between the shaft & bearing to avoid direct contact between two rotating surfaces.

SHORT QUESTIONS WITH ANSWERS

1. Classify bearing material. [2010w]

Ans– Bearing materials 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. [2009W .2019W]

Composition

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

3. WRITE ANY FOUR DESIRABLE PROPERTIES of bearing material. [2009w, 2014 w]

Ans–

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

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 [.2007w]

3. State the properties of cadmium base bearing material . [2006 w]

4. Explain lead alloys with composition, properties and uses [2007w]

CHAPTER NO- 08

SPRING MATERIAL

Learning Objectives:

Spring materials

8.1 Classification, composition, properties and uses of Iron-base and 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, $F = k \times D_x$

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

Classification properties and uses of 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.

Iron-based Spring material

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 expensive, 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, V 0.12 & remaining Fe), EN-60 (C 0.5-0.75, Mn 0.6-1.2 & 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 – (Cr 18, Ni 8, 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.

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

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

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 a main constituent is called iron base spring material. Example. Hard drawn spring wire.

3. Write down 4 properties of spring material.

Ans :

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

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]

Chapter No-09

POLYMERS

Learning Objectives:

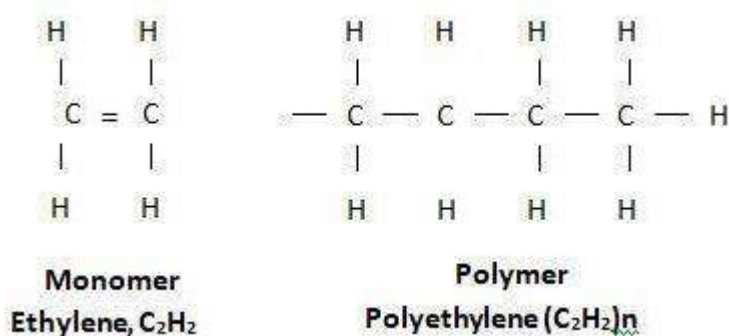
Polymers

Properties and application of thermosetting and thermoplastic polymers

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.

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 the above groups 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 worn-out articles can be effectively used again.

(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 127°C to 177°C, they set permanently and further application of heat does

not alter their form or soften them. But at temperature of about 343°C, the charring occurs. This charring is a peculiar characteristic of the organic substances.

Properties

The thermosetting 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.

Properties of plastics

1. Appearance: Transparent
2. Chemical resistance: The plastics offer great resistance to moisture, chemicals and solvents, excellent corrosion resistance.
3. Dimensional stability.
4. Ductility: The plastic lacks ductility. Hence its members may fail without warning.
5. Durability: The plastics are quite durable, if they possess sufficient surface hardness.
6. Electric insulation : They are far superior to ordinary electric insulators.
7. Finishing: Any surface treatment may be given to the plastics.
8. Fire resistance: All plastics are combustible.
9. Fixing: Can be easily fixed in position.
10. Humidity: PVC plastics offer great resistance to the moisture.
11. Maintenance: It is easy to maintain plastic surfaces. They do not require any protective coat of paints.
12. Melting point: Most of the plastics have low melting point and MP of some plastics is only about 500C.
13. Optical property: Several types of plastics are transparent and translucent.
14. Recycling : It does not give a serious problem to pollution as generated by a host of other industries. The plastics used for soft drink bottle, milk and juice bottles, bread bags, syrup bottles, coffee cups, plastic utensils etc can be conveniently recycled into carpets, detergent bottles, drainage pipes, fences, handrails, grocery bags, car battery cases pencil holders, benches, picnic tables, roadside posts etc.
15. Sound absorption: The acoustical boards are prepared by impregnating fibre-glass with phenolic resins. This material has absorption coefficient of about 0.67.
16. Strength: The tensile members are generally made of plastics as their strength to weight ratio in tension very nearly approaches to that of metals.
17. Thermal property: The thermal conductivity of plastics is low and it can be compared with that of wood.
18. Weather resistance: Certain plastics are seriously affected by sunlight, but other plastic can resist weather which is prepared from phenolic resins.
19. Weight: The plastics, whether thermo-plastic or thermo-setting have low specific gravity being 1.30 to 1.40.

Applications:

The typical use of plastics in building areas follows :

1. Bath and sink units.
2. Cistern ball floats.
3. Corrugated and plain sheets.

4. Decorative laminates and mouldings.
5. Electrical conduits.
6. Electrical insulators.
7. Floor tiles.
8. Foams for thermal insulation.
9. Jointless flooring.
10. Lighting fixtures.
11. Overhead water tanks.
12. Paints and varnishes.
13. Pipes to carry cold water.
14. Roof lights.
15. Safety glass.
16. Wall tiles.

Properties of Elastomers:

These plastics are soft and elastic materials with a low modulus of elasticity. They deform considerably under load at room temperature and return to their original shape, when the load is released. The extensions can range up to ten times their original dimensions.

SHORT QUESTIONS WITH ANSWERS

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

Ans : An elastomer is a polymeric material that may experience large and reversible elastic deformation. Elastomers are generally referred 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 thermosetting polymer? [2014 w]

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

Example—Radio and TV cabinet.

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]

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

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

Chapter - 10

COMPOSITE AND CERAMICS

Learning Objectives:

Composites and Ceramics

Classification, composition, properties and uses of particulate based and fiber reinforced composites

Classification and uses of ceramics

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.
1. Reinforcing fibres

Fiber reinforced composite material

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 fibres 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.

2. 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.

The most common type of matrix is thermosetting resins.

Epoxy resins are the most widely used thermosetting resins in advanced composites. Other resins used as a matrix are polyester, vinyl ester, phenolic, bismaleimide, epoxy novolac.

Examples:

Composites natural

Wood- Cellulose fibres plus polysaccharide.

Bones, teeth and mollusc shells = Hard ceramic + organic polymer
Man made composites

1. Mud + straw
2. Bricks made up straw + mud
3. Plywood
4. Concrete, plastic, MMC, CMC

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 & earthen wares.

Tiles are of two types

- (1) Common tile
- (2) 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, Gun tiles, Mangalore tiles, pan tiles.

Refractories

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

Classification

- (i) According to chemical properties.
- (ii) 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 manufacture of fire bricks, crucibles, hollow tiles. Quarzite - For making the silica bricks.

Silica-Coke over and lining for glass furnaces.

(b) Neutral refractory materials

Bauxite - For fire bricks

Carbon - Lining material for furnaces

Chromite - Powerful neutral refractory material. Forsterite - Used in furnaces for melting copper.

(c) 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? [2012w, 2011w, 2008w, 2019w, 2018w]

Ans– Composite material can be defined as the material made up of two or more dissimilar composite materials. 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, 2010w, 2008w, 2019s, 2018w, 2020w.]

Ans: Ceramic 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. [2017w]

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. [2010w] 1-

particle reinforced

- A-large particle

- B-dispersionstrengthen

2-fiber reinforced

- A-continuous
- B-discontinuous

3-Structural

- A-laminates
- B-sandwichpanel.

LONGQUESTION

1-Explainparticlereinforceand fiberreinforcecomposite material? [2012W,2011 W,2009W ,2020 W 2018 W.]

2-Classifyandstate applicationofceramicmaterials.[2019w,2020w,2012w,2008w]

3- Mentionpresentdayusesofceramics.[2014 w]

4- Describeclassificationandusesofceramic.[2015w]