PREVIOUS YEAR QUESTIONS & ANSWERS
BRANCH: MECHANICAL
SEMESTER: 3RD
THEORY: 03 (ENGG. MATERIAL)
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Er. S. PANDA

CHAPTER-1

Q-Classify engg. material?2013 1 (a), 2012 1 (a)

Ans:- The engineering material may be classified as

(i) Metal (e.g. iron, aluminum, copper, zinc, lead etc.)

(ii) Non-metal (e.g. leather, rubber, plastics, carbon etc.)

Q- What are the various factors affecting selection of engg. material? 2013 1 (b), 2006 2 (9), 2005 (3), 2007 (3), 2012 1 (b), 2010 (3), 2015 1 (b), 2015 1 (a) (2017-1-b)

Ans :- The various factors affecting selecting of a material are :-

(1) Properties of material.

(a) Thermal properties

(b) Electrical properties

(c) Magnetic properties

(d) optical properties

(e) chemical properties

(f) physical properties

(g) Technological properties

(h) Mechanical properties

(2) Performance requirement

(3) Reliability of materials

(4) Safety

(5) Physical attributes

(6) Environmental conditions

(7) Availability

(8) Disposability and recyclability

(9) Economic factors

(1) **Properties of materials** :- The properties is defined as the response of the material in regard to external stimuli.

The different properties are :-

(a) **Mechanical properties** :- Hardness, Tensile strength, Compressive strength, Shear strength etc.

(b) **Electrical properties** :- conductivity, Resistivity etc.

(c) **Magnetic properties** :- Attraction, Repulsion etc.

(d) **Optical properties** :- Concave, convex

(e) **Chemical properties** :- Reaction, Corrosion, toxicity.

(f) **Physical properties** :- Shape, Size, Colour.

(g) **Thermal properties** :- Temperature gradient.

(2) **Performance requirement** :- The material of which a part is composed must be capable of performing the function without failures.

(3) **Reliability of materials** :- reliability is the degree of probabilities 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 failures.

(4) **Safety :**- A material must perform its function safely without any harm and function in its life period.

(5) **Physical attributes** :- the physical attributes such as configuration , size, weight and appearance sometimes serve functional requirements.

(6) **Environmental conditions** :- The environments in which a product operates strongly influence the service performance . Humidity, water, chemical can cause corrosion and subsequent failure of materials.

(7) **Availability** :- A material must be readily available in large quantity for the intended applications.

(8) **Disposability and recyclability** :- Disposability is an important factors for nuclear fuels material and also plastics. Their intended use of may be recycle.

(9) **Economic factors** :- The most critical driving forces behind the engineering selection is economic. The engineers may design a perfect component, but it should be available at an attractive price to the customer and also earn suitable profits for the company.

CHAPTER-2

Q-What is an alloy? (2014 (W) NEW) (2018-2-a)

Ans :- An alloy is a substance which is composed of two more chemical elements such that metallic atoms predominate in composition of the metallic bond predominates.

Q- Is cast iron an alloy ? Mention its physical properties of application?

Ans :- Cast iron is an alloy or iron & carbon.

Physical properties :-

(1) Hard, brittle &cannot be machined.

(2) Highly resistance to wear.

(3) Tensile strength is good.

(4) Obtained by rapid cooling of metal

(5) Due to its poor fluidity it does not fill the mould freely.

Uses:-

(1) Used for manhole covers & pipes.

(2) Used for parts subjected to excessive wear. (Rim of freight.Car, wheel or railway brake bucks)

Q- Various mechanical properties of materials?

Ans:- Mechanical properties include those character of material that describe its behavior under the action of external forces.

(1) Elasticity	(8) Ductility
(2) Plasticity	(9) Malleability
(3) Toughness	(10) Brittleness
(4) Resilience	(11) Hardness
(5) Tensile strength	(12) Fatigue
(6) Yield strength	(13) Creep
(7) Impact strength	(14) Wear resistance

(1) Elasticity:-Loading a solid will change its dimensions but the resulting deformation will disappear upon unloading. This tending of a deform solid to seek its original dimension upon unloading is the properly caused elasticity.

(2) Plasticity:-Plasticity is that properly of a material by virtue of which it may be permanently deformed when it has been subjected to an externally applied force great enough to exceed the elastic limit.

(3) Toughness:-Toughness is theability of the material to absorb energyduring plastic deformation upto fracture.

(4) Resilience:-It is the capacity of a material to absorb energy when it is elastically deformed & then upon unloading to have this energy recovered.

(5) Tensile strength:-Tensile strength is a measure of the strength & ductility of a material. Ultimate tensile strength refers to the force needed to fracture the material.

(6) Yield strength:- Yield strength of a material represents the stress below which the deformation is almost entirely elastic.

Q- What is the composition of stainless steel ? 2015 -2 (b)

Ans **:-**when 11.5 % or more chromium is added to iron, stainless is formed.

C- 0.03 to 0.25 %

Si- 1 to 2 %

Mn- 2 to 10 %

Cr- 10 to 26 % etc.

Q-What are the alloying elements used for formation of tool steel? Explain properties in brief?

Ans: The alloying elements are – Carbon, Cr, V, W, Mo, Co etc.

Properties:

1. Little risk of cracking during hardening.
2. Good toughness.
3. Good wear resistance.
4. Very good machinability.
5. A definite cooling rate during hardening.
6. Resistance to softening on heating (red hardness).

Q-What is alloy steel, state composition & properties of stainless steel? (CH-2)

[5]

Ans: **Alloy Steel**:- Steel is considered to be alloy steel when the maximum of the range given for the content of alloying elements exceeds one or more of the following limits:

Mn-1.65% Si 0.60% Cu 0.60% on in which a define range on a definite maximum quantity of any of the following elements is specified or required within the recognized field of constructional alloy steel:

Composition & properties of stainless steel:

All stainless steels can be grouped in to 3 metallurgical classes:

a. Austenitic stainless steel.
b. Ferritic stainless steel.
c. Mantensitic stainless steel.

Composition Austenitic	Composition Ferritic	Composition Mantensitic
C- 0.03 to 0.25 %	C- 0.08 to 0.20 %	C- 0.15 to 1.2%
Si- 1 to 2 %	Si- 1 %	Si- 1 %
Ni- 3.5 to 22 %	-	-
Mn- 2 to 10 %	Mn- 1 to 1.5 %	Mn- 1 %

Cr- 16 to 26 %　　Cr- 11 to 27 %　　Cr- 11.5 to 18 %

Properties :-

(1) Highest corrosion resistance.

(2) Greatest strength & scale resistance at high temp.

(3) Non – magnetic

(4) Ferriticstainless steel are magnetic & have good ductility.

(5) Can be cold worked.

Q-Effects of following alloying elements on steel (cr, v, mn, w) ? (Ch-2)

Ans :- An alloying elements is one which added to a metal to effect changes in properties of which remains within the metal.

Chromium :-

- Chromium joins with carbon to form chromium carbide, thus adds to depth hardenability with improved resistance to abrasion of wear.
- Helps preventing corrosion & oxidation.
- Adds some strength at high temperatures.

Vanadium :-

- Vanadium promotes fine grains in steel.
- Increases hardenability (when dissolved)
- Improves strength & toughness to heat treated steel.
- Resists tempering & causes marked secondary hardening.

Manganese :-

- Manganese contributes markedly to strength & hardness (but to a lesser degree than carbon)
- Counteracts brittleness from sulphur.
- Lowers both ductility &weldability if it is present in high percentage with high carbon content in steel.

(W) Tungsten :-

- Increases hardness (also red- hardness)
- Promotes fine grain.
- Resists heat.
- Promotes strength at elevated temp.

Q-Difference between Iron& steel ? (Ch-2) { 2 Marks }

Ans :- Iron is an element directly extracted from the Iron or which is in earth 's crust in the form of PIG Iron. It is the raw material for all iron & steel products.

Steel :- Steel is an alloy of Iron & carbon which dissolves max^m1.8 % to 2 % carbon in iron to form different steels.

Q-Explain the concept of phase diagram & cooling curve? (Ch-3) { 6 Marks } (2017-2-b) (2018-5-a)

Ans :-A phase diagram is an equilibrium diagrams or constitutional diagrams which exists or shows the equilibrium for any combination of temp & alloy composition. The equilibrium means the state of balance which exists or which tends to be attained $bet^n$the phases in the structure of an alloy after a physical or chemical change has takes place.

Cooling Curve :- When different alloys are very slowly cooled below their Higher critical temp, we set different temperatures at which phase changes (liquid↔ solid) occurs in an alloy system, which consists of the temp as a function of time.

The data obtained (temp & time) in this manner form a cooling curve for each of the alloy.

Q-Effects of heat treatment on properties of steel ? (Ch-5) { 10 Marks }

Ans:- (a) Effect of heat treatment on properties of HSS (Tool)

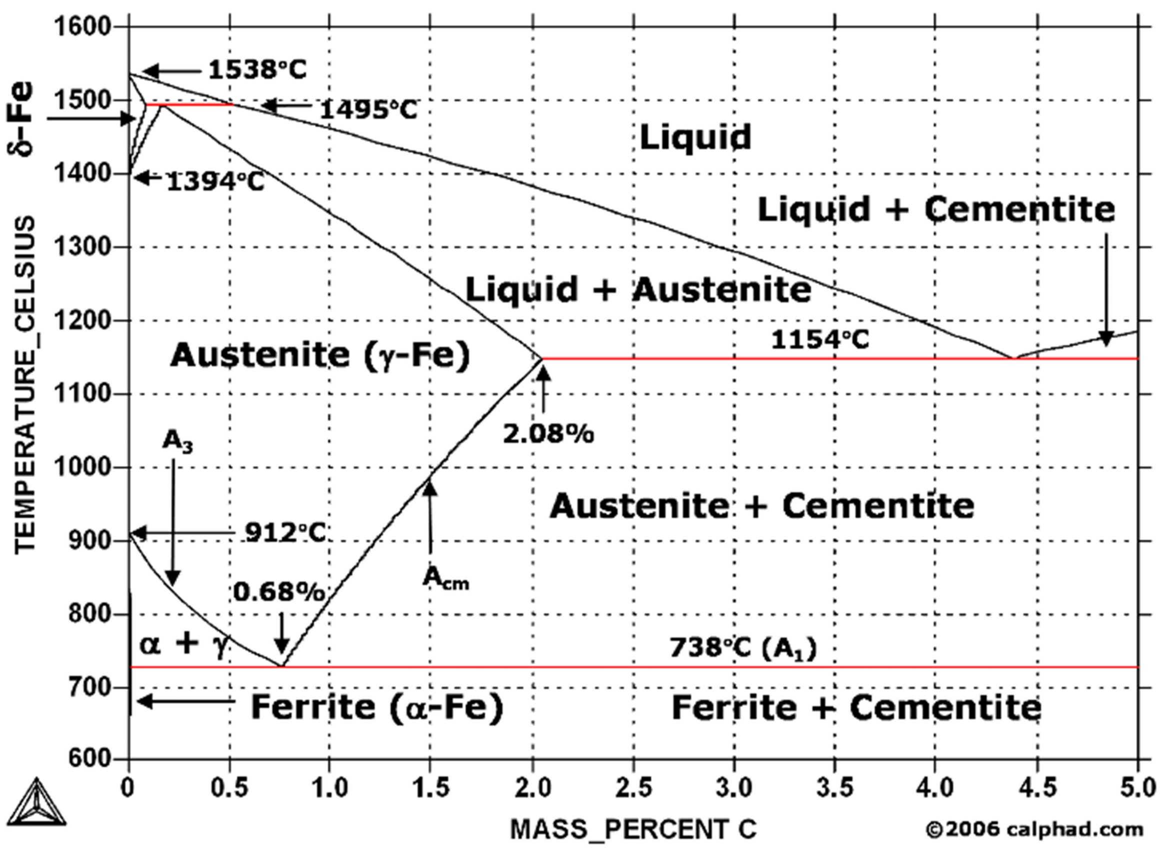
- Increases great hardness.
- Able to resist softening at relatively high working temperatures.
- High speed steel is heated bet^n1150 & 1350° C & must dissolved sufficient carbon in the austenite at this temp for which it attains max^mcutting efficiency.
- When tempering temperature increases beyond 400°C hardness tends to increase.

(b) Effects of heat treatment on properties of stainless steel :-

- Enhances corrosion resistance.
- Enhances scale resistance.
- Enhances mechanical properties at sub zero, room, & elevated temp & as well as their fabricability.
- Restore ductility.
- Improve strength (hardening/ tempering)
- In case of ferritic stainless steels they can be annealed to relieve welding or cold working stresses.

- ferritic steels develop their max^{m}softness ductinity& corrosion resistance in the annealed condition.
- Higher tempering temp reduces hardness, yield strength & tensile strength but increases elongations & impact strength.

Q- Iron-carbon diagram :- [2015- 2 C] (2017-2-c) (2018-4-c)



Q-What do you mean by ideal crystal ?

Ans :- A crystal having no defect of atomic arrangement is perfect is known as ideal crystal.

Q-Describe various point defects ? (2018-3-b)

Ans :- Point defects or zero dimension defects :-

(i) Vacancy

(ii) Schottky defects

(iii) Interstitiallcy

(iv) Impurity (Compositional defect)

(a) Substitutional impurity

(b) Intenstitial impurity

(v) Electronic defects.

(i) Vacancy :-A vacancy is the simplest point defect & involves a missing atom within a metal.

(ii) Schottlkydefects :-It is closely related to vacancy, they involve vacancies of pair of irons of opposite charges.

(iii) Interstitiallcy :-It is the addition of an extra atom within a crystal structure particularly if the atomic packing factor is low. This result in atomic distortion.

(iv) Impurity (Compositional defect) :- when any foreign atom interferes in the atomic place then the defect is known as impurity. Two types :-

(a) Substitutional impurity

(b) Intenstitial impurity

(v) Electronic defects :-Electronic defects are the errors in charge distribution in solids.

Q-Effects of imperfection on material properties?

Ans:- The role of imperfection in the behavior of engineering materials is vital.

➢ The imperfections account for:-

(i) Flow & fracture of characteristics

(ii) Crystal growth

(iii) Electrical properties

(iv) Diffusion mechanism

(v) Oxidation & corrosion

(vi) Yield strength, fracture strength, plasticity thermal conductivity, dielectric strength etc

(vii) Creep characteristics of real metals & alloys.

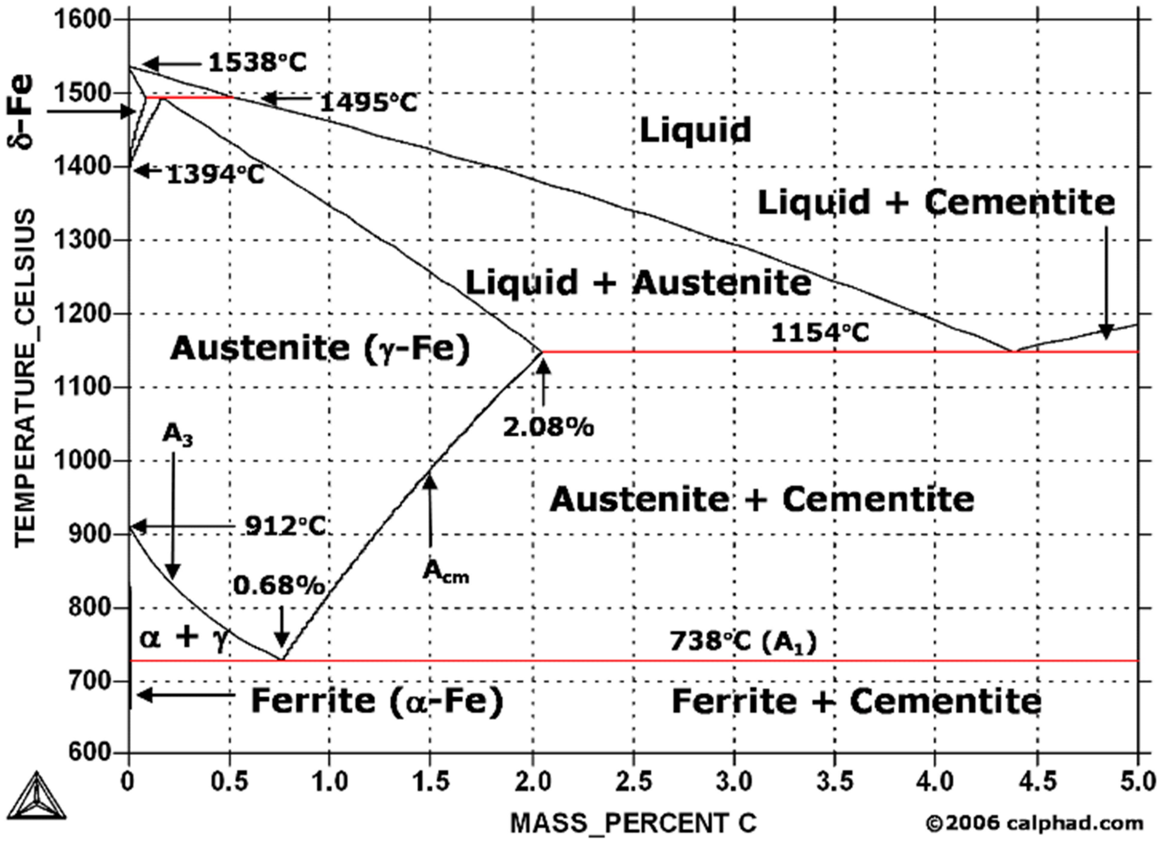
CHAPTER- 3

Q. **Explain the Iron- carbon equilibrium diagram with silent micro constituents of Iron &steel ?**

(Every year compulsory question)

2014(W), 2015 – 2 (C) (

IRON - CARBON EQUILIBRIUM DIAGRAM



Heat

$S \leftrightarrows S_1 + S_2$

A ⇆ Ferrite + Pearlite

L ⇆ S_1+ S_2

L ⇆Cementite + Ledebiurite

There are two types of transformation are represent by this diagram.

(1) Primary Transformation

(2) Secondary transformation

(1) Primary Transformation :-It shows the primary solidification that is the change of alloy from liquid phase to solid phase.

(2) Secondary Transformation :- It is the phase change in solid state.

The steel having upto 0.8 % carbon are called hypereutectoid steel, 0.8 % to 2 % carbon are called hyper eutectoid and containing exactly 0.8 % carbon is called eutectoid steel.

The alloy in the temp. range above the curve A, B, C, D are in liquid state.

- Point 'A' represents the melting point (1539° C) of pure iron.
- Point 'O' represents the melting point (1550° C) of iron carbide (fe_3C) or cementite.
- When temp falls along the curve A, B, C austenite crystal separates.
- The cementite crystal separates along the curve C, D.
- Below 1539 ° C the liquid phase changes to (δ) Delta iron along curve A, B.
- The point 'H' represents the max^{n}solubility of carbon (0.1%) in (δ) Delta iron at 1490°C.
- Then by cooling (υ) Gamma iron separate from (δ) Delta iron at 1404 ° C which is austenite.
- The max^n solubility of carbon in austenite is 1.08 % at 1130 ° C represented by point 'E'.
- At 1100° C when carbon percentage increases from 1.08 %b onwards cementite crystal simultaneously separates from austentite.
- This behavior exists up to 4.3 % carbon.
- The alloy containing exactly 4.3 % carbon completely solidifies at the constants eutectic time of 1130 ° C.
- Below the solidus line C, F the cementite changes its phase to ledeburite.
- At temp. 910 °C Gamma (υ) changes into alpha (α) iron.
- along the line T, S austenite decomposes to ferrite.
- By increasing the carbon percentage below 910° C ferrite decomposes to pearlite.
- The point 'S' at 723 ° C corresponding to 0.8 % carbon in solid phase is known as eutectoid point.

- At this point ferrite and peariite separates from austenite changes to cementite.
- Ferrite is formed by line T, P, R it is solubility of carbon in alpha iron 723 ° C Max^{n}0.025 %.
- Along the line P, R it comes to Room temp.

Eutectic Reaction :-

$$\text{Liquid} \underset{\text{Heating}}{\overset{\text{Cooling}}{\rightleftharpoons}} \text{solid}_1 + \text{solid}_2$$

Eutectoid Reaction :-

$$\text{Solid}_1 \underset{\text{Heating}}{\overset{\text{Cooling}}{\rightleftharpoons}} \text{solid}_2 + \text{solid}_3$$

CHAPTER- 4

Q. **Define crystal & Ideal crystal?** 2013 2(a), 2015 1(b), 2010 1(a), 2014 (w) New

- Crystal is a solid composed of atoms, ions, molecules, arranged in a pattern which is repetitive in these dimensions.

- A Crystal with a perfectly regular atomic arrangement that contains no impurities, imperfections or other defects is known as ideal crystals.

Q. **What is imperfections in crystal & classify various imperfections?**

2013 2(5), 2005 1(b)

Describe any two? 2007 1(b), 2012 1(C), 2006 (3), 2015 3(a) (2017-3-a-b)

Ans:- Types of crystal imperfections:-

All imperfections in crystals can be conveniently classed under the following:-

(i) Point imperfections

(ii) Line imperfections.

(iii) Surface or planner or grain boundaries imperfections.

(iv) Volume imperfections.

(i) Point imperfections:-The point imperfections are also known as zero dimensional imperfections. As the name implies, they are imperfect point like regions in the crystal one or two atomic diameters is the typical size of a point imperfection. A point imperfection comes out due to the absence of a matrix atomthe presence of an impurity atom or a matrix atom in the wrong place. Vacancies interstitialcies, Schottky defects, frankes defects are the examples of most commonpoint imperfections.

(ii) Line imperfections:- If a plane of atoms only partway through a crystal ,the edge of such a plane is a defect in the forms of a line. Line imperfection is used by convention to denote only the line imperfections. Line imperfections are one dimensional imperfections in the geometrical sense. Various type of dislocations are found in crystals, the most common being edge dislocation and screw dislocation.

(iii) Surface or planer or grain boundaries imperfections :-Surfaceimperfections refer to the regions of distortions that lie about a surface having a thickness of a few atomic diameters. They arise from a change in the stocking of atomic planes on or across a boundary. Surface imperfections in geometrical sense.They are of two types, external and internal.

External surface imperfections refer to the imperfections on the outer surface of the crystal. Because the outer most atoms of the crystal surface are not entirely surrounded by others, they possess higher energy than that of internal atoms and therefore, they become distorted.

Internal surface imperfections refers to the imperfections in the inner surface of the crystal and include grain boundaries. Tilt boundaries, twin boundaries.Twin boundaries are stacking faults.

(iv) Volume imperfections :-Volume imperfections are foreign particle inclusions, large voids or pores or non- crystalline regions whichhave the dimensions of at least a fewteas of A°.

Q. **What is slip & twinning?** 2013 4(a, 3), 2007 1(c), 2010 2(c), 2005 1(c) (2018-4-a)

Ans :-**SLIP** :-

Slip is that mechanism of deformation wherein one part of the crystal moves glides or slips over another part alongcertain planes known as slip planes.

A slip plane is a crystallographic plane in which, either the slip is likely to take place or in which slip has (already) taken place.

TWINNING :-

Twin lines are close ended making boat shaped formation. Every atomic plane is involved. Twinning occurs over several crystallographic plane. It takes place in a few micro seconds. Atom movements are much less then the atomic spacing. Twin lines always occur in pairs.Orientation difference takes place occurs the twin plane. Twin line appear during the annealing operation of materials.

Q. **What is dislocation?** 2013 3(a)

Ans :- A dislocation may be defined as a disturbed region between two substantially perfect parts of a crystal.

Two types of dislocations:-

i) Edge dislocation.

ii) Screw dislocation.

Q. State various causes of dislocation? (2018-5-b)

Ans: causes of dislocation: following are few causes which create dislocation.

i) Slip is the most important factor that causes dislocation.

ii) Mechanical phenomena such as strain hardening the yield point, creep, fatigue and brittle fracture causes dislocation.

iii) Introduction or elimination of an extra row of atoms causes crystal dislocation.

iv) Thermal vibration.

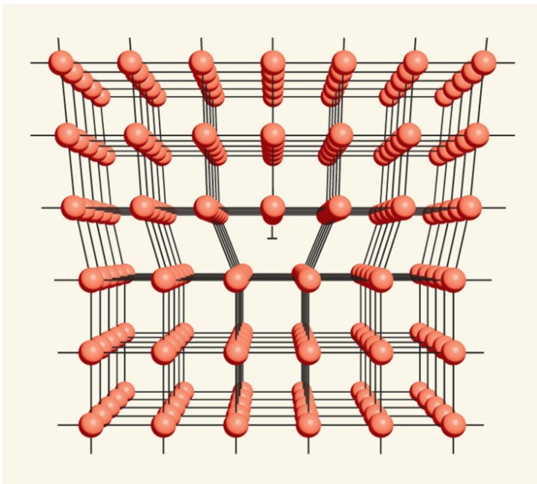
v) Tensile, compressive and shear stress may cause various dislocation.

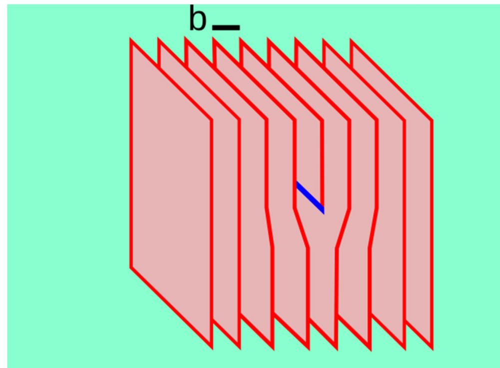
vi) Crystal growth.

Q. Explain briefly edge dislocation & screw dislocation with sketch?

2006 2(c), 2010 2(b), 2013 2(c), 2015 3(c) (2017-3-c)

Ans. (i) **Edge dislocation.**





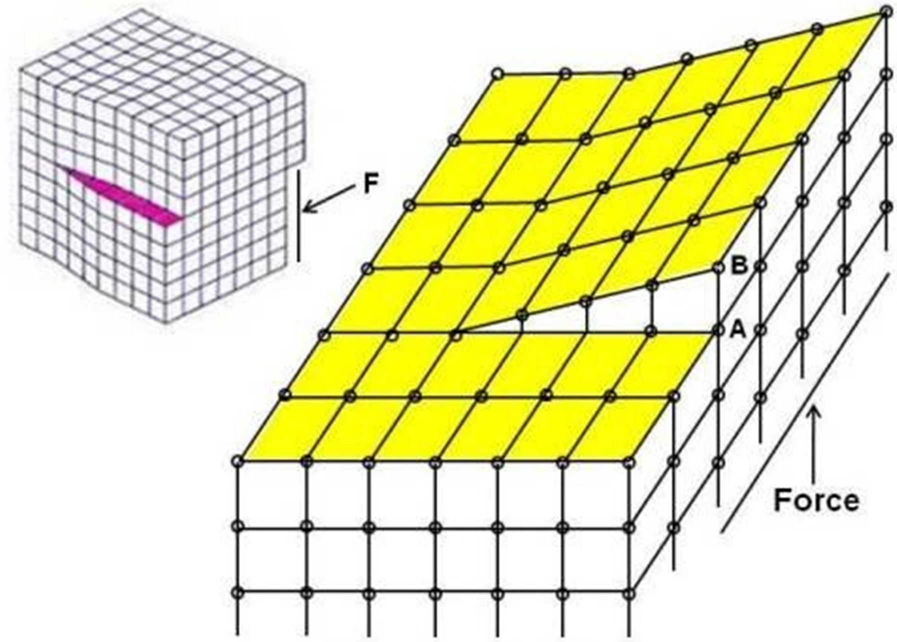
- A screw dislocation does not exhibit climb motion.
- The Following effects of a screw dislocation are of great importance:

i) Plastic deformation is possible under low stress, without breaking the contuinty of the lattice.

ii) The force required to from and move a screw dislocation is probably somewhere at greater than that required to initiate an edge dislocation.

iii) Screw dislocation causes distortion of lattice for a conslberable distance from the centre of the line and takes the form of spiral distortion of the planes. dislocations of both are closely associated with crystallization as well as deformation.

(ii) Screw Dislocation :-A screw dislocation has its displacement of Burger's vector parallel to the liner defect but there is distortion of the plane. Screw dislocation may originate from partial slipping of a section of crystal plane. In this type of dislocation shear stresses are associated.



Screw Dislocation

CHAPTER- 05

Q. What is heat treatment? What is the purpose of heat treatment?

2005, 2006 2(b), 2012 3(b), 2014 (W), 2015 (4-b).,1.A-2018 (2017-4-a)(2018-1-a)

Ans :- Heat treatment may be defined as an operation or combination of operations involving the heating and cooling of a metal to a defined temp. Followed by cooling at suitable rates in order to obtain desired property.

The principle of heat treatment is based on, when an alloy is heated above as certain temp. It under goes a structural adjustment or stabilization when cooled to room temp.

In this operation the cooling rate play and important role on which the structures modification is mainly based.

Purpose of heat Treatment :-

i) To relieve internal stress.

ii) To improve machinability.

iii) To change grain size.

iv) To improve mechanical property like hardness, strength, ductility etc.

v) To improve magnetic & electrical property.

Q. Explain various heat treatment processes like annealing, normalizing, hardening, tempering etc? 2007 (6), 2013 6©, 2006 (7), 2015 4 (c) (2017-4-b) (2018-3-c)(2018-7-b)

Ans ;-**Annealing :-**

It is the process of heating a metal which is a distorted structural state to a temp, which will the instabilities or distortion and then cooling (at a slow rate) to Room temp. which is stable structure and strain free.

Purpose of Annealing :-

i) Inducing a completely stable structure.

ii) Refining & homogenizing the structure.

iii) Reducing hardness.

iv) Improving machinability.

v) Improving cold working, characteristics or properties for facilitating further cold work.

vi) Producing desired microstructure.

vii) Removing residual stresses.

viii) Removing gases.

ix) Improving mechanical, physical, electrical and magnetic properties.

The different type of Annealing are :-

a) Stress Relieving

b) Process Annealing

c) Spheroidise Annealing

d) Full Annealing

e) Stress Relieving

(a) Stress Relieving :-

- Stress relief annealing relieves stresses produced by casting, quenching, machining, cold working, welding etc.
- Stress relief annealing applies equally well to ferrousand non-ferrous metals.

(b) Process Annealing :-

- In this process the effects of cold working are remove that is to soften and permit further cold work as in sheet & wire industries.
- Ferrous alloys are heated to a temp, close to but below the lower critical temp. Limits (550-650 ° C) & then cooling in air to soften the alloy for further cold working.

(c) Spherodise Annealing :-

__**Purpose :-**__

- Improves machinability.
- Improve surface finish
- Prevents cracking of steel during cold forming operations.
- Softens tool steels and some of the air hardening alloy steels.

This process is carried out in two ways:-

(1) In case of steel, steel is heated below the lower critical temp, bet^n (650 ° C to 700 ° C) and holding at this temp, for sufficient time & period.

(2) Heating to a temp, above the lower critical temp, bet ^{n} (730 ° C to 770 ° C) and holding at this temp. for sufficient period and then slow cooling at a rate of (25 ° C - 30 ° C) per hour to 600 ° C.

(d) Full annealing :-

- In full annealing process ferrous alloys are made austenitizing& then cooling slowly.
- This process involves heating of steel in austenitic zone
- For Hypo-eutectoid steel temp, range is (723 ° - 910 °)
- Full annealing involves heating of steel in the austenitic zone.
- For Hypo-eutectoid steel temp, range is (723 ° - 1130 °C)
- Holding at this temp, for sufficient time depending upon thickness and diameter of the work piece.

Purpose :-

i) Remove strain

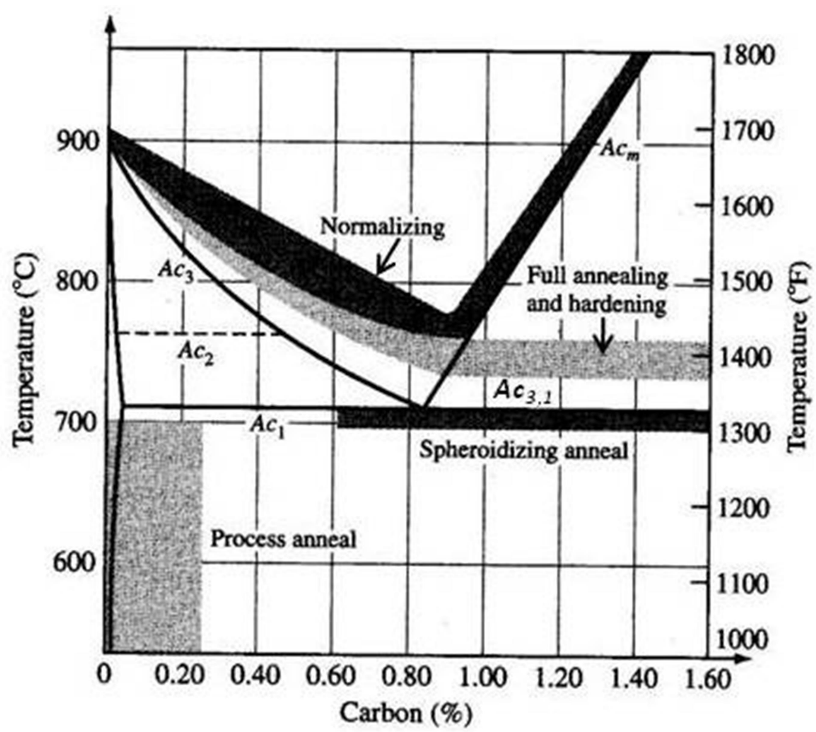
ii) Increasing Induces softness

iii) Improves machinability

iv) Refines grains structure

v) Improves electrical and magnetic properties,

Heat Treatment Range & Processes



Temperature Range for Heat Treatment of Carbon Steels

Normalizing :

- Normalizing is frequently applied as a final heat treatment process to the products which are subjected to relatively high stresses.
- This process consists of heating steel to a point 42 °to 50 ° C above its upper critical temperature, holding at this temp, for a short period or duration& subsequently cooling in still air at room temp.
- This process is also known as air quenching.
- This process is suggested for manufacturing operation like hot rolling and forging which are carried our on steel in the austenitic range.
- Normalizing produces microstructures consisting of ferrite and pearlite for hypo-eutectoid steel and pearlite & cementite for hypereutectoid steels.

Purpose :

i) Yield strength

ii) Ultimate tensile strength

iii) Impact strength

iv) Reduces high stresses

v) Produces a uniform structure

vi) In general improves engineering properties of steels.

Hardening :

- The hardening process is applied to all tools and some important machine parts intended for specially heavy duty service as well as all machine parts made of alloy steel.
- This process consists heating the steel to a temp, above critical point.
- Holding at this temp, for a considerable period.
- Quenching (Rapid cooling) in water, oil or salt both.
- The temp, range for hypo-eutectoidsteel in30 ° to 50 ° C above the higher critical temp.
- For Hypereutectoid steel in 30 ° to 50 ° C above the lower critical temp.
- Alloys steels and speed steels are heated for hardening about 1100 ° - 1300 ° C and cold in air.

Purpose of Hardening :

- Development of high hardness to resist wear & to enables steel to cut other metals.
- Improves strength, elasticity, ductility & Toughness.

- ➢ develops best combination of strength and notch- ductility.

Tempering : (2018-7-c)

This process consist of re-heating the steel after hardening to a temp, below 723 ° C and holding for a consideration period and then slow cooling.

Purpose :

(i) Stabilizes the structure of metal.

(ii) Reduce internal stress produce during previous treatment.

(iii) Reduce hardness.

(iv) Increase ductility**.**

(v) Increase Toughness and shock- resistance**.**

The Tempering process is classified into 3 types according to temp, range.

(1) **Low Temperature Tempering :-**

It is done in the temp, range of 150 ° C to 250 ° C.

Purpose :

- ➢ Relief internal stress.
- ➢ Increase ductility without reducing hardness.

It is applied to →

(a) Law carbon steel

(b) Law alloy steel

(c) Measuring tools

(2) **Medium Temperature Tempering** :

This process is done in the temp, range 350 ° C to 450 ° C.

Purpose:

- ➢ Reducing hardness strength
- ➢ Increases ductility

This process is applied to :-

Those which are subjected to impact loads→

Chisels, hammers, springs etc.

(3) **High Temperature Tempering** :-

It is done in the temp, range of 500 ° C to 650 ° C.

Purpose :-

- Eliminates internal stresses completely.
- Increase high ductility & as well as retain adequate hardness.

It is applied to :-

Those which subjected to high stress & impact machine parts, Gears wheel, shafts, connecting rods etc.

Q. Various surface hardening processes in details ?Ch- 5 [7 marks] (2018-1-c)

Ans :- The various surface hardening processes are

(1) Carburizing

(2) Nitriding

(3) Cyaniding

(4) Carbon nitriding

(5) Flame hardening

(6) Induction hardening

(1) **Carburizing**:- It is a method of introducing carbon into solid Iron base alloys such as low carbon steel in order to produce a hard surface.

(2) **Nitriding** :- It is a method of introducing nitrogen into the surface of steels containing Al & Cr by heating it & holding it at a surface temp in-contact with partially dissociated Ammonia or other suitable medium.

(3) Cyaniding :- It is a method of introducing carbon & Nitrogen into the surface of steel by heating it to a suitable temp & holding itin contact with molten cyanide to form a thin case or surface which is subsequently quench hardened.

(4) **Carbonitriding** :- It is a method of introducing carbon & Nitrogen into a solid ferrous alloy by holding above 723 ° (A_1 line) in an atmosphere containing above hydrocarbon, carbon monoxide (Co) &Ammonia (NH_3).

(5) **FlameHardening** :- It involves rapid heating of the surface of a Heat treatable steel by means of a flame to the austenitic temp range followed by immediate quenching.

(6) **Induction Hardening** :- It involves heating medium carbon steel by means of an alternatively magnetic field to a temp about 750 ° C to 800 ° c followed by immediate quenching.

Q. Why hardening is followed by tempering ? Briefly describe various tempering processes ?Ch- 5 [5 marks]

Ans :- Hardening is followed by tempering :-

Because:-

1) To increase Hardness of steel to resist wear.
2) To enable steel to cut other metals.
3) To improve strength, toughness & ductility

Various tempering processes :-	**Temperature Range**
(1) Low temperature tempering	(150 ° C to 250 ° C)
(2) Medium temperature tempering	(350 ° C to 450 ° C)
(3) High temperature tempering	(500 ° C to 250 ° C)

(1) **Low temperature tempering** :- It increases (i) Toughness(ii) Ductility

(2) **Medium temperature tempering** :- It increases (i) Hardness(ii)Strength

(3) **High temperature tempering** :- (i) Removes internal strength(ii) retains high ductility with hardness.

Q.what is hardenability of steel ?Ch- 5 [2] (2018-4-b)

Ans :- Hardness is a measure of resistance to plastic deformation, hardenability is the ease with which hardness may be attained in the depth direction of an object.

- Hardenability may also be defined as the ability of a steel to became uniformly hard or to harden in depth direction.
- Hardenability is the property that determines the depth & distribution of hardness by quenching in ferrous alloys.

Q.Different types of hardening ?Ch- 5 [6 marks]

Ans :- Hardening is two types :-

(1) Core hardening

(2) Case hardening

(a) Carburizng

(b) Nitriding

(c) cyaniding

(d) Carbo-nitriding

(1) **Core hardening** :- It is the method in which a material is hardended in its depth direction. In this process steels with carbon content 0.35 % to 0.7 % is heated 30 ° C to 50 ° C above UCL. It is held at that temp for 15 to 30 minutes per 25mm of crossection. It is then quenched in a suitable medium like water, oil or brine to achieve the desired rate of cooling & suitably hardened steel.

(2) **Case Hardening** :-

(a) **Carburizng** :- It is a method of introducing carbon into solid iron base alloys in order to produce a hard surface.

(b) **Nitriding** :- It is a method of introducing Nitrogen into the surface of certain steels (containing Al, Cr, V) by heating it & holding at a suitable temp in contact with partially dissociated ammonial or other suitable medium.

(c) **Cyaniding** :- It is a method of introducing carbon & nitrogen into the surface of steel by heating it to a suitable temp & holding it incontact with molten cyanide to form a thin case or surface which is subsequently quench hardened.

(d) **Carbon Nitriding** :- it is a method of introducing carbon & Nitrogen into a solid ferrous alloy by holding above 723 ° C(A_1line) in an atmosphere containing hydrocarbon, carbon monoxide (Co) &Ammonia (NH_3).

CHAPTER – 5

Q-Describe & classify the composition, properties & application of various bearing materials? (2017-6-c) (2018-2-c)(2018-7-a)

Ans: - Classification of bearing materials:-

(i) Cu- based Alloys

(ii) Sn – based Alloys

(iii) Cd- based Alloys

(iv) Al- based Alloys

(v) Ag- based Alloys

Definition:-

The term bronze covers a large number of Copper alloys with varying percentages of Sn, Zn and Pb. Bronze is one of the oldest known bearing materials.

(i) Cu-based Alloys:-

Bronze is the most commonly used Cu base alloy for bearing.

Composition:-

Cu=80%	Cu=85%
Sn=10%	Sn=15%
Pb=10%	

Properties:-

(i) It has easily workable.

(ii) It has good corrosion resistance.

(iii) It has good hardness.

Application:-

(i) It is used for heavy- duty bearing.

(ii) It is used for railways.

(ii) Sn Based Alloys:-

Composition:-Sn=88%

Sb=8%

Cu=4%

Properties:-

(i) It has low co-efficient of friction.

(ii) It has capable of high load and speed.

(iii) It has good corrosion resistance.

Applications:-

(i) I t is used for high speed engines.

(ii) It is used for steam turbines.

Composition:-

Cd=98%	Cd=98%	Cu=94.75%
Ni=2%	Ag=1%	Ni=3%
Cu=1%	Cu=1.5%	Zn=0.75%

Properties:-

(i) It has high compressive strength.

(ii) It has low co-efficient of friction.

(iii) It has high fatigue strength.

(iv) It has high load carrying capacity.

(v) It has low wear.

(vi) It has poor corrosion resistance.

Application:-

(i) It is used for Automobile and Aircraft Industries.

(iii) Al-based Alloys:-

Composition:-

Al=91.5%

Sn=6.5% Sn=6-7%

Cu=1% Si=1.5-2.5%

Ni=1%

Properties:-

- Excellent Corrosion resistance.
- Good ability to embed dirt.
- Good thermal conductivity.
- Good seizure resistance.
- High Co-efficient of expansion.
- Fair Conformability to journal.

Applications:-

- Bearing in diesel engines and tractors.

CHAPTER - 6

Q-Name any 4- Non ferrous alloys?

Ans: - Name of four Non-ferrous alloys are:-

a) Brasses (Copper + Zinc) Copper alloy

b) Bronzes (Copper + tin) Copper alloy

c) Duralumin (Aluminum Alloy

d) Monel Metal (Nickel Alloy)

Q-Composition & properties of duralumin's & y-alloy? (2017-5-a)(2017-5-c) (2018-5-c)

Ans: - Composition & properties of Duralumin:-

Al = 94%

Cu=4%

Mg, Si= 1.5%

Properties:-

(i) It can be forged, cast and stamped.

(ii) It has higher strength.

(iii) Its melting temperature is 650^0C .

(iv) It has a hardness of BHN 100 by edge hardening.

Q-Compositions & Properties of Y-alloy (2017-5-c)

Composition: -Al=92.05%

Cu=4%

Ni=2%

Mg=1.5%

Properties:-

(i) It is much better strength than Aluminum.

(ii) It is high better strength and hardness at high temperature.

(iii) It can be easily cast and hot worked.

Q-What is Babbitt metal with composition?(2017-6-a)

Ans:-Babbitt Metal:-

It is a tin based white metal. It is the most important in Cu-Sn-Sb alloy system.

Composition: - Cu=4% Sn=88% Sb=8%

Properties:-

(i) It is a soft material.

(ii) It has a low coefficient of friction.

(iii) It has low strength.

Q-Describe composition, properties & application of any copper alloys?(2017-5-b)

Ans:- Copper Alloys:-

Following are some Copper alloys describe below regarding their composition, properties and applications.

Brasses:-

Brasses are sub divided into three groups:-

(i) Cu-Zn alloys

(ii) Cu-Pb-Zn alloys or leaded brasses

(iii) Cu-Zn-Sn alloys or tin brasses.

- Brass has high resistance to corrosion and is easily machinable. It also acts as good bearing material.
- Zinc in the brass increases ductility along with strength.
- Brass possess greater strength than Copper, however it has a lower thermal and electrical conductivity.

Types of Brasses are:-

(i) Gilding Metal:-

Composition:- Cu=85-95%
Zn=5-15%

Properties:-

- Ability of Cold Working

Application:-

- Making Coins, medals, tokens etc.
- Fuse caps etc.

(ii) Cartridge Brass:-

Composition: - Cu= 70%
Zn=30%

Properties:-

- Greater Percentage
- Elongation
- High Tensile Strength

- Ability of Cold Working

Applications:-

- Cartridges, caps of electric lamp bulbs, door furniture etc.

(iii) Admiralty Brass:-

Composition: - Cu=71%

Zn=28%

Sn=1%

Properties:-

- Excellent resistance to corrosion.

Application:-

- Decorative, Pump impellers, Architectural applications, screw machine products etc.

(iv) Naval Brass:-

Composition: - Cu=60%

Zn=39.25%

Sn=0.75%

Properties:-

- Added tin improve the resistance to the corrosion.
- Ability of both sand casting and dia castings.

Applications:-

- Naval Brasses are marine condenser plate, propeller shaft, valve etc.

(v) Forging Brass:-

Composition:-Cu=60.5%

Zn=38.5%

Sn=1%

Properties:-

- High melting Point
- High ductility.

Applications:-

- Hot Forgings

- Lambing Works

Q-State the uses of the following

(i) Duralumin
(ii) Babbitt Metal
(iii) Brass
(iv) Phosphor Bronze

(i) Duralumin:-

- Widely used for making sheets, tubes, forgings, rivets, nuts, bolts & similar products.
- Used for making cables.
- Surgical & orthopedic works
- Making non-magnetic instruments.
- Aerospace industries.

(ii) Babbitt Metal:-

- Mainly used in fine bearings.
- Used in low strength applications including low coefficient of friction.

(iii) Brass:-

- Making coins, medals, tokens etc.
- Decorative and architectural applications, heat exchanger components etc.
- Condenser tubes
- Prom works
- Keys, gears, valve parts, pipe unions etc.

(iv) Phosphor Bronze:-

- Bearings
- Pump Parts
- Propellers
- Linings
- Springs etc.

Q-Name the alloys used in Nuclear Power Plant

(i) Fuel Materials – Uranium, Uranium Oxide, Thorium, Thorium Oxide.
(ii) Reactor Control Materials- Hafnium, Cadmium, Boron
(iii) Moderator Materials- Heavy Water, Graphite, Beryllium, Niobium
(iv) Cooling Materials- Liquid Na-K alloys, Mercury, Pb-Bi alloy

(vi) Shield Materials- RCC, Lead, Boron, Iron, Tantalum

(vii) Cladding Materials- Zirconium

(viii) Materials for Structure- Silicon Carbide, Stainless Steel, Nickel Alloys

Q-What is Creep?

- Creep is the tendency of a solid material to move slowly or deform permanently under the influence of mechanical stresses.

Q-Define Crystal & Ideal Crystals. [ch-4]

- Crystal is a solid composed of atoms, ions, molecules, arranged in a pattern which is repetitive in these dimensions.
- A Crystal with a perfectly regular atomic arrangement that contains no impurities, imperfections or other defects is known as ideal crystals.

CHAPTER-7

Q-What is Polymer? List properties & applications of thermo plastic & thermosetting plastic with example? (2010, 2012, 2005, 2007, 2006, 2014) (2018-2-b)

Ans: - Polymer:-

The Polymers are the large group of engineering materials of steadily increasing importance in industrial applications is composed of natural and synthetic organic polymers.

Properties and Applications of Thermo-plastic polymer:-

Properties:-

(i) They are relatively low in cast.

(ii) Do not absorb moisture.

(iii) Flexible over a wide temperature range.

(iv) Chemically Resistant.

(v) Di-electric losses and dielectric constant are low.

(vi) High resistivity and dielectric strength.

(vii) They are like in appearance, translucent, odorless and one of the lightest plastics.

Applications:-

(i) Moisture Proofing

(ii) Coating Ice-cube trays.

(iii) Fan and blower casing (gas filled polythene)

(iv) Packaging.

(v) High Voltage (upon 30 KV) applications.

(vi) Coaxial Cables

(vii) Lining for lagoons to avoid seepage of polluted water into the underground.

(viii) Pipes and tanks for submarine cables and radar lines.

Example of thermoplastics are:- ABS plastics, Acetyls, Acrylics.

Properties and applications of thermosetting plastics:-

(i) It has good resistance to heat and most chemicals except strong acid and alkali.

(ii) It has effected by sunlight.

(iii) It has high bonding strength with or without pressure curing.

(iv) It has light amber shrinkage.

(v) It has high toughness elasticity and chemical resistance.

Applications:-

(i) Safety helmets

(ii) Automobile body components.

(iii) Paints

(iv) Binders for glass fiber.

(v) Insulating materials.

(vi) Abrasives for joining work casting materials.

Examples of thermosetting are:-

Allycics, Epoxies, Melamine

Q-What are the different forms of Aluminum?

Ans: - Different forms of Aluminium:-

(1) Duralumin

(2) Y-alloy

Q-What are different imperfections found in the metal?

Imperfections are also known as defects.

The different types of defects found in metal crystals are classified as:-

(1) Point Defect
    (a) Vacancy
    (b) Interstitially
    (c) Impurity
    (d) Electric Defect

(2) Line defect
    (a) Edge Dislocation
    (b) Screw Dislocation

(3) Surface Defect
    (a) Tilt Boundary
    (b) Twin Boundary

(4) Volume Defect

Q-Classify spring materials based in its compositing & properties? (2017-7-a-b)(2018-3a)

Ans: -(1) Iron Based Spring materials

(2) Copper based spring materials

(3) Nickel based Spring Materials

(1) Iron based Spring Materials:-

1. EN45- Composition – C – 0.5, Cr-0.2 to 0.9

Mn-1.0, V- 0.12

Fe - remaining

2. EN60- Composition – C- 0.5 to 7.5 %

Mn- 0.6 to 1.2%

Fe- remaining

3. Piano Wines – Composition – C- 0.7 to 1.0 %

Mn – 0.3 to 0.6%

Fe- remaining

4. Stainless Steel – Composition- Cr- 18%

Ni- 8%

C-0.1 to 0.2%

Fe- remaining

Q-What are the basic characteristics of a bearing material?

A bearing material should exhibits low co-efficient of friction should provide a hard & wear nesting surface, should have high compressive & fatigue strength.

(b) Properties of Iron base spring material?

(1) It possesses high modules of electricity.

(2) High elastic limit.

(3) High fatigue strength.

(4) High Creep Strength.

(5) Good resistance to Corrosion.

(6) Magnetic Properties.

Q-Mention present day uses of Ceramics?

The present day uses of Ceramics are:-

(i) As tiles & sanitary wires.

(ii) As high & low voltage electrical Insulators.

(iii) Cutting & Abrasive tools.

(iv) In high frequency electrical applications.

(v) In electronics industries as semiconductors, dielectrics, ferroelectrics & piezoelectric crystals.

(vi) Used as heat resisting glass pares for windows.(Ex:- Ytnalox)

(vii) Used in nuclear controls & shielding.(Ex:- UO_2, UC, UC_2)

(viii) As pyrometer burners & burner tips.

Q-Materials used for high temp services? [2014 (w)]

Nickel, Cobalt & Iron based alloys provide the necessary high temp mechanical properties along with corrosion resistance required for special engineering applications. The other alloys additions include refractory metals like Nb, Mo, W, Ta, Cr& Ti.

The Alloy used for wish temperature services are:-

(1) Nickel- Copper alloys(Monels)

(2) Ni-Cr, Ni-Cr-Fe alloys (Inconels)

(3) Stainless Steels:-

(a) Martensitic Stainless Steels.

(b) Feritic Stainless Steels

(4) High Temperature Composites:-

Co, Nb& Ni matrix composites.

(5) Glass Ceramics:-

Pyroceram Glass

(6) Si+Al+N (Sialon):-

Specially used for gas turbine blades.

Q-Describe Creep?

Ans:-When a material is subjected to Constant stress at wish temperature for a longer period of time, it will undergo slow & permanent determination known as Creep.

Q-What is the difference between Ferrous & Non-ferrous Metals?

Ans:- Ferrous metals are those metals in which Iron present as a base metal.

But Non-ferrous metals are those metals in which Iron is not as a same metal. It may be alloyed or not.

Q-Classify different types of Carbon steel in order of Carbon with their uses? (2017-1-c)

Plain Carbon Steels are classified as:-

(1) Low Carbon Steel

(2) Medium Carbon Steel

(3) High Carbon Steel

(1) Low Carbon Steel (upto 0.25% Carbon):-

This class of plain carbon Steel is more widely known as mild steels.

Use:-

- Mild Steels are mostly used for structural applications like Grills, gates, windows, frames, cabinets etc.
- The Mild Steel at higher carbon levels i.e. in the range of 0.2-0.3 wt% Carbon for making bridges, ships & other heavy structural components.

(2) Medium Carbon Steels (0.25-0.55% Carbon):-

- Medium carbon steels find a wide range of applications. Most of the automobile & machine tool components are manufactured from this class steel.

(3) High Carbon Steels (From 0.55 upto 1% Carbon):

- This class of steel has restricted applications compared to medium carbon steels because of their higher cost, poor formability & weld ability.
- This class of steel is mainly used for tool application such as wood cutting tools, knives, razor blades, hacksaw blades, chisels, hammers, axe etc.

Q-What do you mean by Elastomers?

Ans:-

Elastomers are the material which has elasticity property is maximum. It is also called as Rubber. By applying force it can be stretched twice its original length & after releasing stress it comes into its original length.

Q-Describe the classification, application & Properties of Ceramic Materials?

Ans:-

Mechanical Property:-

1) They are hard & brittle.
2) They are wear resistant.
3) They have low ductility & low impact strength.
4) They are rigid & stiff.

Thermal Property:-

1) Very high melting Point.
2) An intermediate thermal conductivity.
3) Thermal Expansion.
4) Thermal Shock resistance.
5) Chemical Resistance.

CHAPTER-10

Q-Describe the classification and application of Ceramics? (2017-7-c)

- Ceramics are inorganic, non-metallic materials that are processed and/or used at high temperatures.
- Ceramics are classified as:-

1. Glasses
   A-glasses
   B-glass ceramics
2. Clay Products
   A-structural clay
   B-white wares
3. Refractory
   A-fire clay
   B-silica
   C-basic
   D-special
4. Abrasives
5. Cements
6. Advanced Ceramics

Application of Ceramics:-

- Tiles and Staining wares
- High and low voltage electrical insulators.
- High frequency electrical applications.

- Chemical Industries.
- Refractories for metallurgical Industries.
- Cutting Abrasive tools.
- Nuclear power plants.

Q-Describe Properties of Elastomers?

Resilience & Hysteresis:-

- Resilience is a measure of elastomers capacity to store energy. It is the ratio of energy output to energy input and expressed as a percentage.
- The loss of energy in form of frictional heat is known as hysteresis.

Hardness:-

- Hardness is the most widely used property in the specification of rubbers.
- Elongation decreases as hardness of rubbers increases.
- Tense strength increases with hardness, but above 50 it decreases.

Tensile Strength:-

- Tensile strength below 1000 psi means poor mechanical properties.
- Values above 2000 psi points to good mechanical properties.

Tear Resistance:-

- Elastomers have low tear strength which after abrasion resistance.

Abrasion Resistance:-

- Abrasion resistance improves with increase in hardness.

Resistance:-

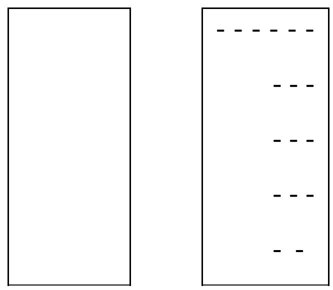
- Resistance to oil is an important criteria as it includes applications in an environment of hydrocarbon fluids like oil and gasoline.

Q-Explain particle Reinforced & fiber reinforced composites & properties? (2018-6-c)

The most important composite are those in which the dispersed phase is in the form of a fiber. Design goals of fiber reinforced composites often include high strength & for stiffness on a weight basis. Fiber reinforced composites with exceptionally high specific strengths & module have seen produced that utilize low-density fiber & matrix materials. The arrangement or orientation of the fibers relative to one another, the fiber concentration & the distribution all have a significant influence on the strength & other properties of fiber reinforced composites. Some critical fiber length is necessary for effective strengthening & stiffening of the composite material. The Critical length L_c is dependent on the fiber dia (d) &

its ultimate (or tensile) strength & on the fiber matrix bond strength: - Z_C= Shear yield strength of the matrix

$$Z_C = \frac{\sigma_f \,.\, d}{\tau_c}$$



Particle Rein forced Composite:-

Large particle & distension strengthened composites are the two sub classifications of particle-reinforced composites. The distinction between these is based upon reinforcement or strengthening mechanism. The dispersed phase for particle – reinforced composites is equiaxed (i.e. - particle dimensions are approximately the same in all directions.

Large Particle Composites:-

The term large is used to indicate that particle-matrix interactions cannot be treated on the atomic or molecular level, rather continuum mechanics is used. For most of these composites, the particulate phase is harder & stiffer than the matrix. The degree of behavior depends on strong bonding at the matrix- particle interface. Large particle composites are utilized with all three material types (metals, polymers & Ceramics).

Properties:-

1. High tensile Strength.
2. Higher toughness.
3. Tear & abrasion resistance.
4. High specific strength.
5. High Corrosion resistance etc.

Q-What is Composite Material? (2018-6-a)

Composite materials are those produced by combining two or more dissimilar materials into a new material that is better than any of the individual components as regards their strength, heat resistance and stiffness.

Q-What is the purpose of industrial Painting? What are the methods adopted for industrial painting?

Purpose:-

(i) Corrosion protection of the material.

(ii) Camouflage of any material.

(iii) Increase visibility of the material.

(iv) Chemical Resistance.

(v) Identification of the equipment.

Methods:-

- In Industrial painting a variety of methods are used to coat surfaces with paint.
- Preparation is usually the key for long lasting paint applications. If the previous paint does not exist then the process is easier. If a coat exists then removal is usually required.
- Surfaces can be prepared by using ultra high pressure water jets. It has both washing and blasting effect which removes grit, dust as well as any other loose particles.
- Abrasive preparation is also used which can be dry, wet or a combination of wet and dry. In this way rust, grit, dust and chemicals are removed and a clear surface is ready for paint applications.
- Not only brush & rollers are used in industrial painting. Power coating is a process where particles of dry paint have an electrostatic change applied before being positioned on a grounded surface. The particles heat is then applied which allows the powder coating to flow together and be cured in place.
- Coil coating also known as roll coating is a high speed method of applying a coating of paint to a metal surface.
- It is a continuous and fast process.
- It is also the most cost effective and energy efficient.
- Spray coating is a more common way of painting which delivers and sealants effectively under pressure.

Q-What is galvanizing?

Galvanizing is the process of applying a protective zinc coating to steel or iron to prevent rusting.

Q: write 4 examples of ferrous material? (2017-1-a)

A: carbon steel, stainless steel, cast iron, tool steel.

Q: difference between iron and steel? (2017-2-a)

A: Primarily, **iron** is an element while **steel** is an alloy comprising of **iron** and carbon. However, in this alloy **iron** is present in a greater quantity. You can add various other metals to **steel** so as to produce alloys that have different properties.

Q: composition and use of super duplex material?(2017-6-b)

A: Composition

C = 0.03% (max.)
Cr = 24% - 26%
Ni = 5.5% - 8%
Mo = 3% - 5%
Mn = 1.5%
Si = 0.8%
N = 0.2% - 0.35%
S = 0.02%
P = 0.035%
Cu = 0.5% - 3%

Applications:

→ Desalination plants
→ Sea water systems
→ Flue gas cleaning
→ Storage tanks and pressure vessels
→ Oil, gas, paper industries
→ Marine applications
→ Chemical plants etc.

Q: effect of various alloying elements on steel? (2018-1-b)

Chromium (Cr)

This is the most important alloying element and it gives stainless steels their basic corrosion resistance. All stainless steels have a Cr content of at least 10.5% and the corrosion resistance increases the higher chromium content. Chromium also increases the resistance to oxidation at high temperatures and promotes a ferritic microstructure.

Nickel (Ni)

The main reason for adding nickel is to promote an austenitic microstructure. Nickel generally increases ductility and toughness. It also reduces the corrosion rate in the active state and is therefore advantageous in acidic environments

Molybdenum (Mo)

Molybdenum significantly increases the resistance to both uniform and localized corrosion. It slightly increases mechanical strength and strongly promotes a ferritic microstructure

Manganese (Mn)

Manganese is generally used to improve hot ductility. Its effect on the ferrite/austenite balance varies with temperature: at low temperature manganese is an austenite stabilizer, but at high temperatures it will stabilize ferrite. Manganese increases the solubility of nitrogen and is used to obtain high nitrogen contents in duplex and austenitic stainless steels

Aluminum (Al)

If added in substantial amounts aluminum improves oxidation resistance and is used in certain heat-resistant grades for this purpose. In precipitation hardening steels, aluminum is used to form the intermetallic compounds that increase the strength in the aged condition.

Vanadium (V)

Vanadium forms carbides and nitrides at lower temperatures, promotes ferrite in the microstructure, and increases toughness. It increases the hardness of martensitic steels due to its effect on the type of carbide present. It also increases tempering resistance. It is only used in stainless steels that can be hardened.

Tungsten (W)

Tungsten is present as an impurity in most stainless steels, although it is added to some special grades, for example the superduplex grade 4501, to improve pitting corrosion resistance.