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, tampering, 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, y- alloy.

6.2 Copper alloys: Composition, property and usage of Copper- Aluminum, Copper-Tin, Babbit , Phosperous 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

ScopeofSyllabus:

Engineeringmaterialsandtheirproperties

Materialclassificationintoferrousandnonferrouscategoryandalloys

PropertiesofMaterials:Physical,ChemicalandMechanical

Performancerequirements

Materialreliabilityandsafety

Introduction

- Materialscienceandengineeringplaysavitalrole inthis modernageofscienceand technology. Various kinds of materials are used in industry, housing, agriculture, transportation, etc. to meet the plant and individual requirements.
- Theknowledgeofmaterialsandtheirpropertiesisofgreat importance foradesign engineer
- Adesignengineer must befamiliarwiththeeffectswhichthe manufacturing processes and heat treatment have on the properties of the materials

:Material Classification

Engg.materialsareclassifiedasfollows

1-Metal
A-Ferrous
B-Non–ferrous

2-Ceramics

3-Organics

4-Composites

5-Semiconductors

Metalsmayfurtherbeclassifiedas-

Ferrousmetals-

The ferrousmetalsarethosewhichhavethe ironastheir mainconstituent,suchascast iron, wrought iron etc.

Non-ferrous metals.

Thenon-ferrousmetalsarethosewhichhave metalotherthanironastheir mainconstituent, such as copper, aluminium, brass, tin, zinc etc.

Factorsaffectingselectionofmaterialforengineeringpurpose

1. Propertiesofmaterial
2. Performancerequirement
3. Material'sreliability
4. Safety
5. Physicalattributes
6. Environmentalconditions
7. Availability
8. Disposabilityand recyclability
9. Economicfactors

-PhysicalpropertiesofMaterials

- Physicalpropertiesareemployedto describetheresponseofa materialtoimposed stimuli under conditions in which external forces are not concerned.
- Physicalpropertiesinclude.

a) Dimensions,
b) Appearance,
c) Colour,
d) Density,
e) Meltingpoint,
f) Porosity,
g) structure,etc.

Dimensions

Dimensionsofa materialimpliesit'ssize(length,breadth, widthdiameter,etc.)and shape(square, circular, channel,angle section, etc.)

Appearance

- Metalsthemselveshavegotdifferent appearances e.g.,aluminiumisasilverywhite metal where as copper appears brownish red.
- Appearanceincludelusture, colourandfinishofamaterial.
- Lustureistheabilityofa materialtoreflect 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.
- Porescanabsorblubricantasinasinteredself-lubricatingbearing.
- It istheratiooftotalporevolume to bulkvolume

Structure

- Itmeansgeometricrelationshipsofmaterialcomponents.
- 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.

- Thechemicalpropertiesdescribethecombiningtendencies,corrosioncharacterstics, reactivity, solubilities,etc.of a substance.

Someofthechemicalpropertiesare

1. corrosionresistance
2. chemicalcomposition
3. acidityoralkalinity

Corrosion

- Itisthedeteriorationofamaterialbychemicalreactionwith itsenvironment.
- Corrosiondegradesmaterialpropertiesandreduceseconomicvalueofthematerial.
- Corrosionattacks metalsaswellas non-metals. Corrosionofconcretebysulphates in soils is a common problem

1.2.2MechanicalPropertiesofMaterials

The mechanicalpropertiesofmaterials definethe behaviourofmaterialsunderthe action of external forces called loads.

Thereareameasureofstrengthand lasting characteristicsofthe materialinservice and are of good importance in the design of tools, machines, and structures.

The mechanicalpropertiesofmetals aredetermined bytherangeofusefulnessofthe metal and establish the service that is expected.

Mechanicalpropertiesarealso usefulforhelptospecifyand identifythe metals.And the most common properties considered are strength, hardness, ductility, brittleness, toughness, stiffness and impact resistance.

1.2.2MechanicalPropertiesofMaterials

The followingarethemechanicalpropertiesofmaterials.

1. Strength
2. Elasticity
3. Plasticity
4. Hardness
5. Toughness
6. Brittleness
7. Stiffness
8. Ductility
9. Malleability
10. Cohesion
11. Impactstrength

12. Fatigue
13. Creep

1. Strength

- Strengthisthemechanicalpropertythatenablesametaltoresistdeformationload.
- Thestrengthofamaterialis itscapacityto withstanddestruction under theactionof external loads.
- Thestrongerthematerialsthegreatertheloaditcanwithstand.

2. Elasticity

- Accordingto dictionaryelasticityistheabilityofanobjectormaterialto resume its normal shape after being stretched or compressed.
- Whenamaterialhasaloadappliedtoit,theloadcausesthematerialtodeform.
- Theelasticityofa materialis itspowerofcoming backtoitsoriginalpositionafter deformation when the stress or load is released.
- Heat-treatedsprings, rubberetcaregoodexamplesofelasticmaterials.

3. Plasticity

- Theplasticityofa materialis itsabilitytoundergosomepermanent deformation without rupture(brittle).
- Plasticdeformationwilltakeplaceonlyaftertheelasticrangehasbeenexceeded.
- Piecesofevidenceofplasticactioninstructuralmaterialsarecalled yield,plastic flow and creep.
- Materials suchasclay, leadetcareplasticat room temperature, and steel plastic when at bright red-heat.

4. Hardness

- Theresistanceofamaterialtoforcepenetrationorbendingishardness.
- Thehardnessistheabilityofa materialtoresist scratching,abrasion,cutting or penetration.
- Hardness indicatesthedegreeofhardnessofa materialthat canbe imparted particularly steel by the process of hardening.
- Itdeterminesthedepthanddistributionofhardnessisintroducebythe quenching process.

5. Toughness

- It isthepropertyofamaterialwhichenablesittowithstand shock or impact.
- Toughness istheoppositeconditionofbrittleness.
- Thetoughnessismaybeconsideringthecombinationofstrengthand plasticity.

- Manganesesteel, wroughtiron, mildsteeletcareexamplesoftoughnessmaterials.

6. Brittleness

- Thebrittlenessofapropertyofa materialwhichenables itto withstandpermanent deformation.
- Castiron, glassareexamplesofbrittlematerials.
- Theywillbreak ratherthan bend undershock orimpact.
- Generally,thebrittlemetalshavehighcompressivestrengthbut lowintensile strength.

7. Stiffness

- Itisamechanicalproperty.
- Thestiffness istheresistanceofamaterialtoelasticdeformationor deflection.
- Instiffness, amaterialwhichsuffers light deformationunder loadhasahighdegreeof stiffness.
- The stiffness of a structure is important in many engineering applications, so themodulusofelasticityisoftenoneoftheprimarypropertieswhenselecting a material.

8. Ductility

- Theductilityisapropertyofa materialwhichenables itto bedrawnoutintoathin wire.
- Mildsteel,copper,aluminiumarethegoodexamplesofaductilemateria

9. Malleability

- The malleabilityis apropertyofa materialwhichpermits it tobehammeredorrolled into sheets of other sizes and shapes.
- Aluminium,copper,tin,leadetcareexamplesofmalleablemetals.

10. Cohesion

- Itisamechanicalproperty.
- Thecohesion isapropertyofasolid body byvirtueofwhichtheyresist frombeing broken into a fragment.

11. ImpactStrength

- Theimpactstrengthistheabilityofametaltoresistsuddenlyappliedloads.

12. Fatigue

- The fatigue isthe longeffect ofrepeatedstraining actionwhichcausesthe strainor break of the material.
- Itistheterm‘fatigue’useto describethe fatigueofmaterialunderrepeatedlyapplied forces.

13. Creep

- Thecreep isaslowandprogressive deformationofa materialwithtimeat aconstant force.
- Thesimplesttypeofcreepdeformationisviscous flow.
- Some metalsaregenerallyexhibitingcreepat hightemperature,whereasplastic, rubber, and similar amorphous material are verytemperature sensitive to creep.
- The forcefor aspecifiedrateofstrainatconstanttemperatureiscalledcreepstrength

-Performancerequirement

- The materialofwhichapartiscomposedmustbecapableofembodying or performingapart’sfunctionwithoutfailure.
  forexample–acomponent parttobeused ina furnace must beofthat materialwhich can withstand high temperatures.
- While it is not always possible to assign quantitative values to these functional requirements,theymust berelatedaspreciselyaspossibleto specified valuesofmost closely applicable mechanical, physical, electrical or thermal properties.

-Material’sreliability

- Reliabiliyisthedegreeofprobabilitythat aproduct, andthe materialofwhichit is made, will remain stable enough to function in service for the intended life of the product without failure.
- Amaterialifit corrodesundercertainconditions,then, it isneitherstablenorreliable for those conditions.

1.4.2Safety

Amaterialmust safelyperformits function, otherwise, thefailureoftheproductmadeoutof it may be catastrophic in air-planes and high pressure systems. As another example, materials that gives off spark when struck are safety hazards in a coal min

SHORTQUESTIONSWITHANSWERS

1- **Definematerial?[POSSIBLE]**

Ans-materialis somethingthatconsist matter. Materialisthestuffofwhich something something is made .material comprise a wide range of metals and non metals which must be operated upon to form the end product .

2- **Classifymaterial?[2008W,2016W,2018W,2018S]**

Ans–Engg.materialsareclassifiedasfollows

1-Metal

A-Ferrous

B-Non–ferrous

2-Ceramics

3- Organics

4- Composites

5-Semiconductors

3- **Definematerialreliabilityandperformancerequirement?**

Ans-Reliabiliyisthedegreeofprobabilitythataproduct,andthe materialofwhichit is made, willremain stable enough to function in service for the intended life of the product without failure.

- Amaterialifit corrodesundercertainconditions,then, it isneitherstablenorreliable for those conditions.

- performingapart'sfunctionwithoutfailure.
- forexample–acomponent parttobeused ina furnace must beofthat materialwhich can withstand high temperatures

4- Writefourfactoraffectingselectionofmaterial? [2016W,2018W, 2019 S, 2019 S NEW]

1- Propertiesofmaterial

1- Performancerequirement

2-Material's reliability
3- Safety
4- Physicalattributes

5- Definesafetyofmaterial?[2017W]

Amaterialmust safelyperformitsfunction,otherwise,the failureoftheproduct made outofit maybe catastrophic inair-planesand high pressure systems. Asanother example, materialsthatgivesoffsparkwhenstruckaresafetyhazardsinacoalmine.

LONG QUESTIONS

1. Describevariousfactoraffectingselectionofmaterial **[2016W,2018W,2019 S, 2019 S NEW]**
2. Describevariousmechanicalpropertiesofmaterial.[2014W,2017WNEW,2018 S]
3. Definephysicalpropertiesofmaterial.[2015 W,2019 S]

Chapter- 2

FerrousMaterialsandAlloys

LearningObjectives:

FerrousMaterialsandalloys

Characteristicsandapplicationofferrousmaterials

Classification, composition and application of low

carbonsteel,mediumcarbonsteelandHighcarbonsteel

Alloysteel:Lowalloysteel,highalloysteel,toolsteeland

stainlesssteel

Toolsteel:EffectofvariousalloyingelementssuchasCr,Mn, Ni, V,

Mo,

-Characteristicsofferrous materials:

- Ferrous materialsaremetalsormetalalloys thatcontaintheironasa base material.
- Steelisa ferrousalloy,andthereareanumberofotheralloysthat contain iron.
- Ferrousmetalsaregoodconductorsofheatandelectricity.
- Metalalloys havehighresistancetoshear,torqueanddeformation.
- The thermal conductivity of metal is useful for containers to heat materialsoveraflame.Theprincipaldisadvantagesofmanyferrous alloys is their susceptibility to corrosion.

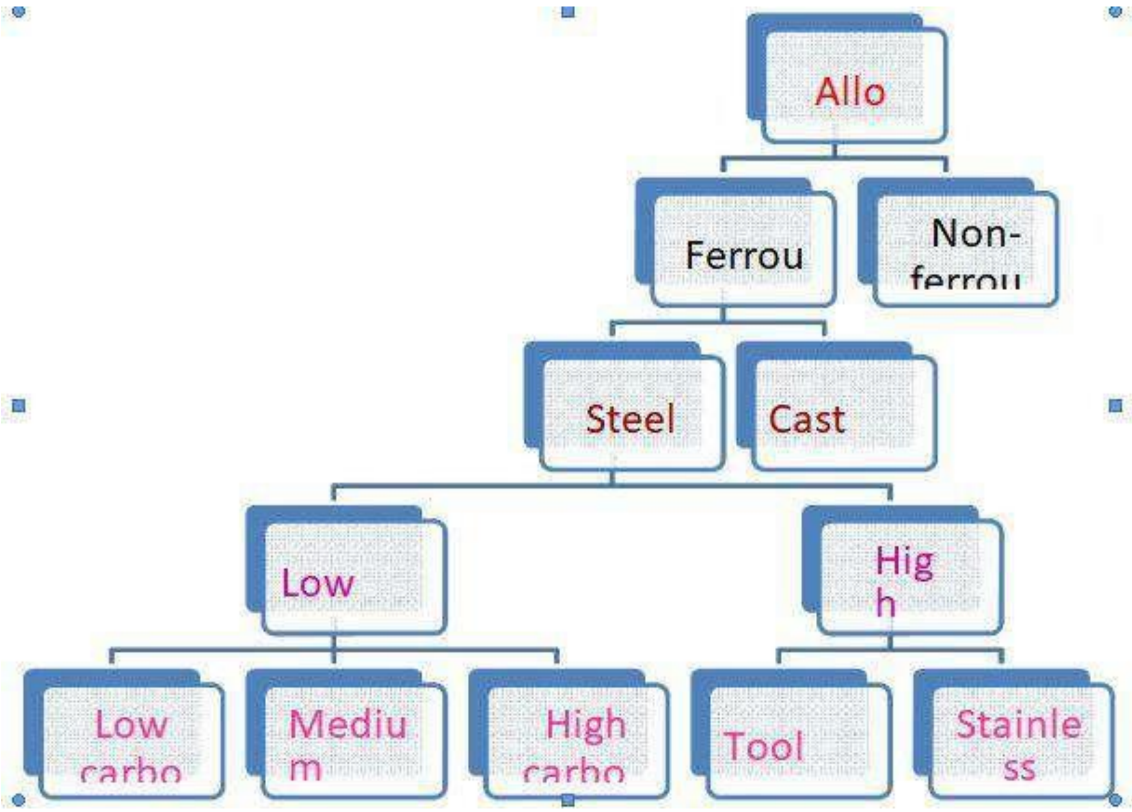
Application:

- Duetothestrengthandresilienceofmetals theyare frequentlyusedin high-rise building and bridge construction, most vehicles, many appliances, tools, pipes, non-illuminated signs and railroad tracks.
- Corrosionresistancepropertymakesthemusefulinfoodprocessing 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 analloyofironandcarboninwhichcarboncontent is upto2%. It may contain other alloying elements.



Castiron-

- Incastironcarboncontentis2%to6.67%
- Lowermeltingpoint(about300°C lowerthanpureiron)dueto presence of eutectic point at 1153°C and more carbon content.

Typesofcastiron:

- Grey,white,nodular,malleableandcompactedgraphite.

- Lowcarbonsteel-Carboncontentintherangeof0–0.3%.
- Most abundant grade of steel is low carbon steel (greatest quantity produced;andleastexpensive).Notresponsivetoheattreatment;cold working needed to improve the strength.
- Ithas goodweldabilityandmachinability

Mediumcarbonsteel-

- Carboncontent intherangeof0.3 –0.8%.Itcanbe heattreated - austenitizing, quenching and then tempering.
- Mostoftenused intemperedcondition–tempered martensiteMedium carbon steels have low hardenability
- AdditionofCr,Ni,MoimprovestheheattreatingcapacityHeat treated alloys are stronger but have lower ductility

Typicalapplications–

- Railwaywheelsandtracks,gears,crankshafts.

Highcarbonsteel

- Highcarbonsteels –Carboncontent0.8 –2%HighCcontent provides high hardness and strength.
- Hardestandleastductile.
- Usedinhardenedandtemperedcondition
- Strongcarbide formerslikeCr,V,Wareaddedasalloyingelements to from carbides of these metals.
- Usedastoolanddiesteelsowingtothe highhardnessandwear resistance property3

Toolsteel

Toolsteelrefers toa varietyofcarbonand alloysteels thatare particularlywell-suited to be made into tools. Their suitability comes fromtheir distinctive hardness, resistance to abrasion, their abilityto hold a cuttingedge, 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 acarbon content between 0.7% and 1.5%, tool steels are manufactured under carefully controlled conditions to produce the required quality.

Stainlesssteel-

Stainlesssteeldoesnotreadilycorrode, rustorstainwithwaterasordinarysteel 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 corrosionresistance are required. Stainless steeldiffers fromcarbonsteelbythe amount of chromium present.

PlainCarbonSteel

Plain Carbon Steel is an alloy of iron and carbon with carbon content up to 1.5%althoughotherelementssuchasSilicon,Manganese maybepresent.The properties of carbon steel are mainly due to its carbon content.

CarbonSteelisclassifiedinto

- LowcarbonsteelorMildsteel
- Mediumcarbonsteel
- Highcarbonsteel

Lowcarbonsteel orMildsteel:

Lowcarbonsteelor mildsteelisfurtherclassified intothreetypesbasingon their composition i-e percentage of carbon.

a) Deadmildsteelor mildsteelcontaining0.05to0.15%ofcarbon.

b) Mildsteelcontaining0.15to0.2%ofcarbon.

c) Mildsteelcontaining0.2to0.3%ofcarbon.

ApplicationofMildSteel:

i) Deadmildsteelisusedformakingsteelwire,sheet,rivets,screws,pipe, nail, chain, etc.

ii) Mildsteelcontaining0.15to0.2%carbonisusedfor makingcamshafts, sheets, strips for blades, welded tubing, forgings, drag lines, etc.

iii) Mildsteelcontaining0.2to0.3%carbonis used formaking valves,gears, crank shafts, connecting rods, railways axles, fish plates and small forgings, etc

MediumCarbonSteel

Steelcontaining0.3to0.7%carbonisknownasMediumcarbonsteel. Medium

carbon steel are of three categories.

- Steel containing 0.35 to 0.45% carbon is used for connecting rod, wires&rod,springclips,gearshaft,keystock,shafts&brakeslever, axle, small & medium forgings, etc.
- Steel containing 0.45 to 0.55% carbon is used for railways coach axles,axles&crankpinsonheavymachines,splinesshafts,crank shafts, etc.
- Steelcontaining0.6to0.7%carbonisused fordrop forgingdie&die blocks, clutchdiscs, plate punches, setscrews, valve springs, cushion ring, thrust washers, etc.

Highcarbonsteel

Steelcontaining0.7to0.1.5%carbonisknownashighcarbonsteel.Uses

i) Steelcontaining 0.7 to 0.8% carbon is used for makingcold chisels, wrenches, jaws for vice, pneumatic drill bits, wheels for railway service,wireforstructuralwork,shearblades,automaticclutchdisc, hacksaws, etc.
ii) Steelcontaining0.8 to 0.9% carbon is used for makingrock drills, railwayrail,circularsaws, machinechisels,punches&dies,clutch discs, leaf springs, music wires, etc.
iii) Steelcontaining0.9to1.0%carbonisused for makingpunches& dies, leaf&coilsprings, keys, speeddiscs,pins, shearblades, etc.
iv) Steelcontaining1.0to1.1%carbonisused for makingrailway springs, machine tools, mandrels, taps, etc.
v) Steelcontaining1.1to1.2%carbonisused formakingtaps,thread metal dies, twist drills, knives, etc.
vi) Steelcontaining1.2to1.3%carbonisused formakingfiles, metal cutting tools, reamers, etc.
vii) Steel containing 1.3 to 1.5% carbon is used for making wire drawingdies, metalcuttingsaws,paperknives,toolsforturning chilled iron, etc.

-Alloy Steel

1) Steelis considered to be alloysteelwhenthe maximumofthe range givenforthecontentofalloyingelementexceedsoneor moreofthe following limits.
2) Mn-1.65%,Si-0.6%,Cu-0.6%orinwhichadefinitemaximum quantity of any of the following elements is specified.
3) Al,B,Crupto3.99%,Cu,Mo,Ni,Ti,W,Voranyotheralloying element added to obtain a desired alloying effect.
4) Lowand mediumalloysteel:Inlowand mediumalloysteelalloying element is not exceeding 10%.
5) 1stsymbol:100timestheaveragepercentageofcarbon.
6) 2nd,4th,6th,etcsymbol:Elements
7) 3rd,5th,7th,etc.symbol:percentageofelementsmultipliedbyfactors as follows.

ElementMultiplyingfactor

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

Highalloy steel:

- Inhighalloysteel,totalalloyingelementismorethan10%.
- Forexample:X10Cr18Ni9S3X-Highalloysteel
- 10%-0.1%CCr18 –18%CrNi9 –9%Ni
- S3–Pickledcondition

-ToolSteel:

Tool steel may be defined as special steel which are used to form, cut or otherwisechangetheshapeofa materialintofinished0rsemi-finishedproduct.

PropertiesofToolsteel:

i) Slightchangeofformduringhardening.
ii) Littleriskofcrackingduringhardening.
iii) Goodtoughness
iv) Goodwearresistance

v) Verygoodmachinability
vi) Adefinitecoolingrateduringhardening
vii) Adefinitehardeningtemperature
viii) Resistancetode-carburization
ix) Resistancetosofteningonheating

ClassificationofToolsteel:

TheJointIndustryConference,U.S.A.has classifiedtoolsteelasfollows:

Symbol Meaning

T W-Highspeedsteel

M Mo-Highspeedsteel

D HighC,highCrsteelA

Air hardening steel

O Oil hardening steelW

Waterhardeningsteel

H Hot work steel

S ShockresistancesteelCompositionofTool Steel:

1) W-Highspeedsteel

T1: C 0.7Cr4 V1 W18

T4: C 0.75Cr4V1 W18 Co5

T6: C 0.8Cr4.5V1.5 W20 Co12

2) Mo-Highspeedsteel

M1: C 0.8Cr4 V1 W 1.5Mo8

M6: C 0.8Cr4 V1.5 W 4Mo 5 Co 12

3) HighC, highCrsteel

D2: C 1.5Cr12 Mo1

D5: C 1.5Cr12 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:

When11.5% or more chromium is added to iron, a fine filmofchromiumoxide forms spontaneously on the surfaces. The filmacts as a barrier to retard further oxidation, rust or corrosion. As this steel cannot be stained easily, it is called stainlesssteel.Thestainlesssteelbasingontheirmicro-structurecanbegrouped in to three metallurgical classes such as Austenitic stainless steel, Ferritic stainless steel & Martensite stainless steel.

AusteniticStainlessSteel:

Properties:

1) Theypossessausteniticstructureatroomtemperature.
2) Theypossessthehighestcorrosionresistanceofallthestainlesssteels.
3) Theypossessgreateststrengthandscaleresistanceathigh temperature.
4) Theyretainductilityattemperatureapproachingabsolutezero.
5) Theyarenon-magnetic.

Composition:

C 0.03to0.25% Mn 2to10% Si 1to2%

Cr 16to26% Ni 3.5to22%

P&S Normal Mo&Tiinsomecases

Uses:

- Aircraftindustry(Engineparts)
- Chemicalprocessing(heatexchangers)
- Foodprocessing(Kettles,tanks)
- Householditems(cookingutensils)
- Dairyindustries(milkcans)
- Transportationindustry(Trailers&railwayscars)

Ferriticstainlesssteel:

Properties:

1) Theypossesamicrostructurewhichisprimarilyferritic.
2) Theyaremagnetic&havegoodductility
3) Theydonotworkhardentoanyappreciable degree.
4) Theyaremorecorrosionresistantthanmartensiticsteel.
5) Theydeveloptheirmaximumsoftness,ductility&corrosion resistance in the annealed condition.

Composition:

C 0.08to0.20%Si 1% Mn 1to1.5% Cr 11to27%

Uses:

1) Liningforpetroliumindustry.
2) Heatingelementsforfurnaces.
3) Interiordecorativework.
4) Screws&fittings.
5) Oilburnerparts

Martensiticstainlesssteel:

Properties:

1) Theypossesmartensiticmicrostructure.
2) Theyare magnetic inallcondition&possessthebestthermal conductivity of the stainless types.
3) Hardness,ductility&abilityto holdanedgearecharacteristicsof martensitic steels.
4) Theycanbecoldworkedwithoutdifficulty,especiallywithlow carbon content, can be machined satisfactorily.
5) Theyhavegoodtoughness.
6) Theyhavegoodcorrosionresistancetoweatherandtosome chemicals.
7) Theyareeasilyhotworked.

Composition:

C 0.15to 1.2%Si 1% Mn 1% Cr 11.5to18%

Uses:

1) Pumps&valveparts
2) Rules&tapes
3) Turbinebuckets
4) Surgicalinstruments,etc.

EffectofAlloyingElements:

Chromium:Itjoinswithcarbonto formchromiumcarbide, thusaddstodepth hardenability with improved resistance to abrasion & wear.

Manganese:

1) Itcontributesmarkedlytostrengthandhardness.

2) Itcounteractsbrittlenessfromsulphur.
3) Lowersbothductility&weldabilityifit ispresent inhighpercentage with high carbon content in steel.

Nickel:It

1) increasestoughness&resistancetoimpact.
2) lessensdistortioninquenching.
3) Lowersthecriticaltemperaturesofsteel&widenstherangeof successful heat treatment.
4) strengthenssteels.
5) Rendershigh-chromiumironalloysaustenitic.
6) doesnotunitewithcarbon.

Vanadium:It

1) promotesfinegrainsinsteel.
2) increaseshardenability.
3) impartsstrength&toughnesstoheat-treatedsteel
4) causesmarkedsecondaryhardening.

Molybdenum:It

1) promoteshardenabilityofsteel.
2) makessteelfinegrained.
3) makessteelunusuallytoughat varioushardnesslevels.
4) counteractstendencytowardstemperbrittleness.
5) raisestensile&creepstrengthathightemperatures.
6) enhancescorrosionresistanceinstainlesssteels.
7) formsabrasionresistingparticles.

Tungsten:It

1) increaseshardness.
2) promotesfinegrains.
3) resistsheat.
4) promotesstrengthatelevatedtemperature.

SHORTQUESTIONSWITHANSWERS

1- Writedowntheapplicationoflowcarbonsteel.[2020 W]

Ans-Lowcarbonsteelaresuitable forautomobilebody,refrigeratorbody,cams etc.These are also used for nut,bolts ,boiler plates ,ship plates etc .

2- Writedowntheusesofstainlesssteel.[2019W]

Ans–stainlesssteelareusedforfollowingpurpose

- A-Aircraftindustry
- B-Chemicalprocessing
- C-Heatingelements
- D-Diaryindustry
- Screwand fittings

3- whatarethedifferentkindofironore ?[2018S] Ans-

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

4- Defineferrousandnonferrousmetal?[2019S]

Ans–The metalwhichcontain ironiscalledferrous metalandthe metalwhich does not contain iron is called non ferrous metal .

Ferrousmetal–castiron,steel

Nonferrous metal–aliminium,copper.

LONGQUESTIONS

1. writedowntheeffectofalloyingelementaddedtosteel.[2018S]
2. writeshortnoteon[2018S]

   A-stainlesssteel,B-Highspeed

3- Howcastironis obtained?classifyandexplaindifferenttypes ofcastiron.[2018 S]

Chapter-03

IRON-CARBONSYSTEM

LearningObjectives:

Iron–Carbonsystem

Conceptofphasediagramandcoolingcurves

FeaturesofIron-Carbondiagramwithsalientmicro-constituents of

Ironand Steel

3.1Conceptofphasediagram

Aphase in a material is defined as a region ofspatiallyuniform macroscopic physical properties like density, atomic arrangement, crystal structure, chemical composition etc.

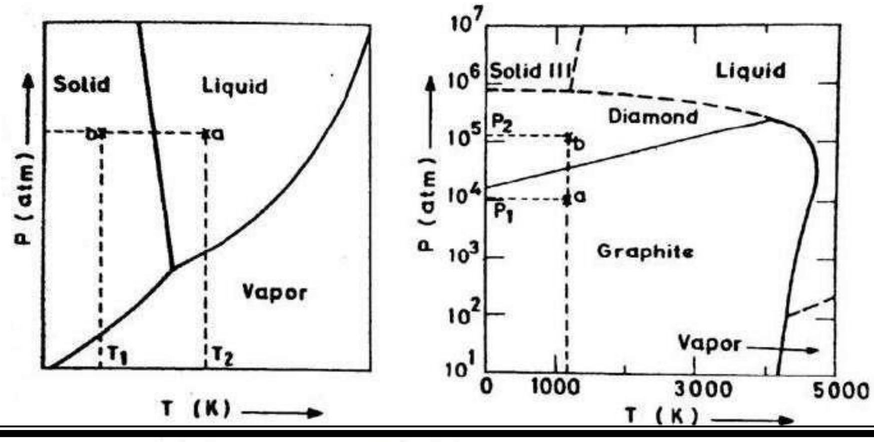
Example : Iron in bcc structure, f cc structure, in liquid form and in gaseous state aredifferent phases of iron. In one component materials a phase is stable over a range of temperature and pressure. A homogeneous solution of two or more components that may exists over a range ofcomposition, temperature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

Equilibriumphase diagram are normallyused to show the stabilityofdifferent phases in a material as function of temperature, pressure and composition.

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

Where,Cisnumberofcomponents inthesystem;Pisnumberofphases inequilibrium,

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.



(a) Fig-3.1 (b)

Thefig. 3.1showsphasediagramsoftwoonecomponentsystem,H2Oandcarbonasa

functionoftemperatureandpressure.InasinglephaseregionsbothPandTmaybe independently varies.

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

CollingCurves

CollingCurvesofpureIron:-

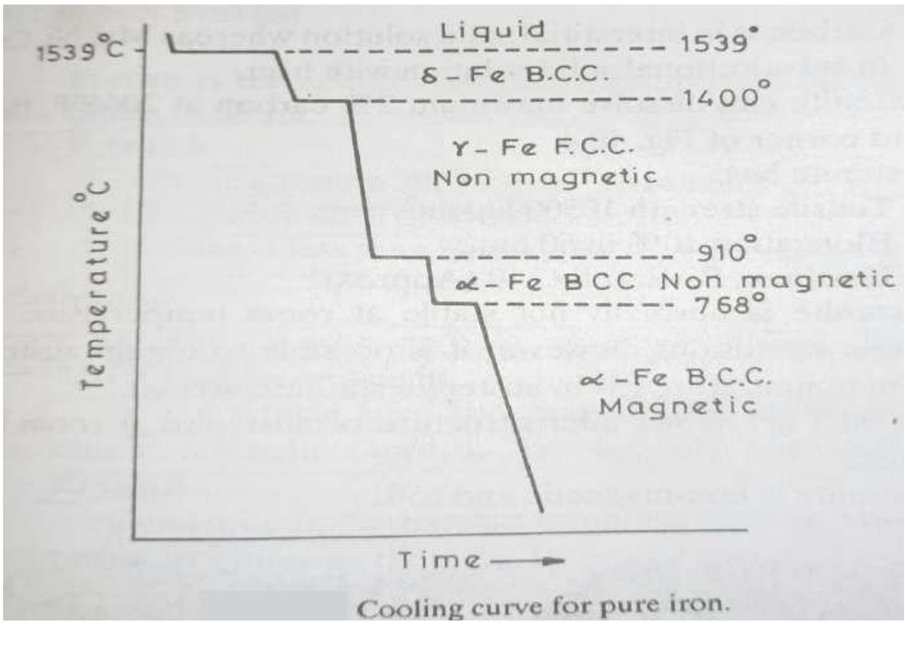
- Ironisarelativelysoftandductilemetal.
- Ironhasametaling point of1539" C
- Ironisallotropicmetal,whichmeansthatisexistsinmorethanonetypeoflattice structure (e.g., B.C.C./F.C.C.) depending upon temperature.

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.



Cooling curve for pure iron.

On further coolingat 1400’C, a phase change occurs and the atoms rearrange themselvesinto (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 at768’C , thealpha – iron (B.C.C.) becomes magnetic without achange in lattice structure.

MICRO–CONSTITUENTSOFIRONANDSTEEL

- 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.
- Variousmicroconstituentsare:

a–Austeniteb-Ferritec-Cementited-Ledeburitee-Pearlitef-Bainiteg-Martensite h-Troositei-Sorbite

a.AUSTENITE

Austenitecandissolvemaximum2% carbonat2066’F,theleft-handcorner.

- Austenitehas:
  * Tensilestrength10500kg/cm2
  * Elongation10% in50mm.
  * HardnessRockwellC40(Approx)

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

(b)FERRITE

-FerriteisB.C.C.ironphasewithverylimitedsolubilityfor carbon.

The maximumsolubilityis 0.025%carbonat1333’F atextremelefthandcornerof and dissolvesonly0.008%carbonatroomtemperature.

-Ferritehas:

*Tensilestrength2800kg/cm2

*Elongation40%in50mm

*Hardness lessthanRockwellC0 orRockwellB90.

(c)Cementite

Cementiteorironcarbide,chemicalformulaFe3C5Contain6.67% carbonbyweight.

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

(d) Ledeburite.

- Ledeburite istheeutecticmixtureofausteniteandcementite.Itcontains4.3% carbon.It is formed at about 1130’C (2065’F).

(e) Pearlite

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

Pearliteistheproductofaustenitedecompositionbyaneutectoidreaction. Thus, pearliteisaneutectoidmixturecontainingabout0.8%carbonandisformedat1333’F (723’C)pointC.

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

Bainite-it istheconstituent product inasteelwhenaustenitetransformat atempraturebelow that at which pearlite is produced and above that at which martensite is produced .

Itistheadecompositionproductofaustenite,consistingofanaggregateofferriteand carbide.

If bainite is formed in the upper part of the temperature range ,its appearance is feathery anditiscalledfeatherybainiteandifitisbelowthetemperature rangeitiscalledacicularbainite .

MARTENSITE-

Martensite is a metalstable phase of steel ,formed by transformationof austenite below the temperature .

Martensiteisconsideredtobehighlystressedalphaironwhichissupersaturatedwithcarbon .

Itisaproductofquenchinganditpossesses needlelikestructure.

Troosite-Troosite isa mixtureofradiallamellae offerrite and cementite and therefore differs from pearlite only in degree of fitness and carbon content which is same as that in austenite from which it is formed .

In steel heat treatment ,the troosite that is the microstructure consisting of ferrite and finely divided cementite is producedontempering martensite below approximatelytemperature450 c.

Sorbite:sorbiteisthemicrostructureconsistingofferrite andfinely dividedcementite 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.

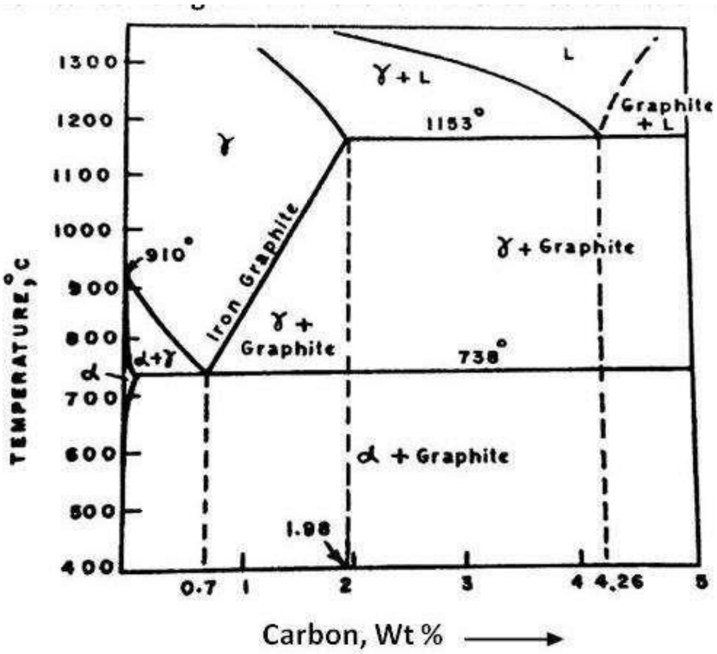


Fig-3.3 –Iron – Carbon phase diagram

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

An equilibrium diagram is a graphical representation of the effects of temperatureand composition upon the phasespresent in an alloy .

An equilibriumdiagram is constructed by plotting temperature along y –axisand percentage ofcarbonalong x- axis .and compositionwith inwhichthe various phase changes are stable .

Iron carbon diagram indicatesthe phase changes occure during heating and cooling andthe natureand amount ofthestructuralcomponent that exist at anytemperaturebesides it establisha correlation betweenmicrostructure and properties of steel and cast ironand provide a basis for the understanding ofprinciple of heat treatment .

Ironwhichcontainupto 2% ofcarbon is called steeland the ironwhichcontain more than 2% of carbon is called cast iron .

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

Theraremainlythree reactionsoccureinironcarbondiagram thatisperitectic ,eutecticandeutectoidreaction.

Peritecticreaction

Thisreactionoccure approximatelyat1500candcarbonpercentageisapproximately 0.25%.it may written

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

Eutecticreaction

Thisreactionoccureapproximatelyat 1149candcarbonpercentageis4.1% It may

written

Liquid->heating/coolingAustenite+cementite/leadeburite

Eutectoidreaction–

Thisreactionoccureapproxmatelyat 727candcarbonpercentage is0.8% Solid -

>Cooling /heatingferrite +cementite /pearlite .

SHORTQUESTION

1- Whatarethelimitationofiron carbondiagram?[2020W]

Ans–thenonequilibriummatrensitedoesnotappearondiagram.T he diagram

provides no indication to the time temperature relationship .

2- WhatIsPhase Diagram?[2019 w,2020w]

Ans–Phasediagramrepresentsthelimitsofstability ofthevariousphasesinchemical system at equilibrium with respect to variable such as composition and temperature .

3- Whatisanequilibriumdiagram?[2018S]

Ans –Anequilibriumdiagramis consist ofironcontaining percentage ofcarbononwhich the properties of iron depends and vary according to it .

4- Nametwo ironoresanditssymbol.[2018S]

Ans–Hematite-Fe_2O_3, Magnetite –Fe_3O_4

5- Whatisdifferencebetween cast ironandpigiron?[2016w]

Ans–Castiron-Pigironpartlyrefinedincupolaproducesvariousgradesofcastiron.

Pig iron–It isproduced inblast furnace ,it isthe first productofinprocessofconverting iron into useful metal .

LONG QUESTIONS

1- Withneat sketchexplain ironcarbonequilibriumdiagram? [2011w,2009w,2006w, 2007 w,2014 w,2017 w, 2018 w,2008 w,2010w,2015 w, 2016 w,2019 w,2020w]

2- Explain theconceptofphase diagramcooling curve?[2018w,2019 w]

3- Explainvariousreaction in ironcarbondiagram?[2017 w]

CHAPTER - 04

CRYSTALIMPERFECTIONS

Crystalimperfections

Crystaldefines,classificationofcrystals,idealcrystaland

crystalimperfections

Classificationofimperfection:Pointdefects,linedefects,

surfacedefects and volume defects

Typesandcausesofpointdefects:Vacancies,

Interstitials andimpurities

Typesandcausesoflinedefects:Edgedislocationand

screwdislocation

Effectofimperfectiononmaterialproperties

Deformationbyslipandtwinning

Effectofdeformationonmaterialproperties

Introduction

Whenever atoms arrange themselves in an orderly repetitive three dimensional pattern a crystalis formed. It isasolidwhichconsistsofatomsarranged ina patternin3-D. Aperfect crystalisconstructed bytheinfiniteregular repetitioninspaceofidenticalstructuralunitsor building blocks. The symmetry is an important characteristic of most of the crystals.

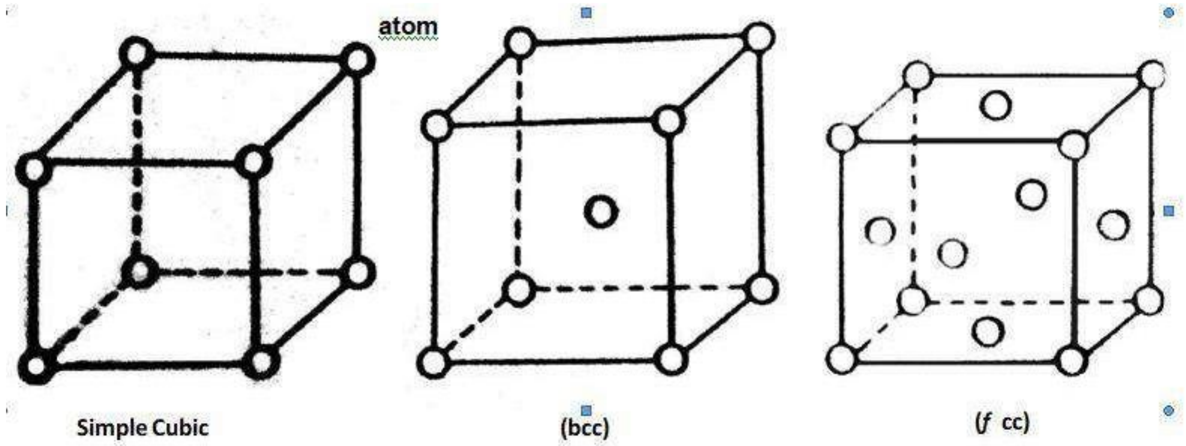
E.g cubeand octahedronsaresimpleformofthe crystal.

Allmetalsarecrystalline,whereatomsarearrangedinadefiniteperiodic order.

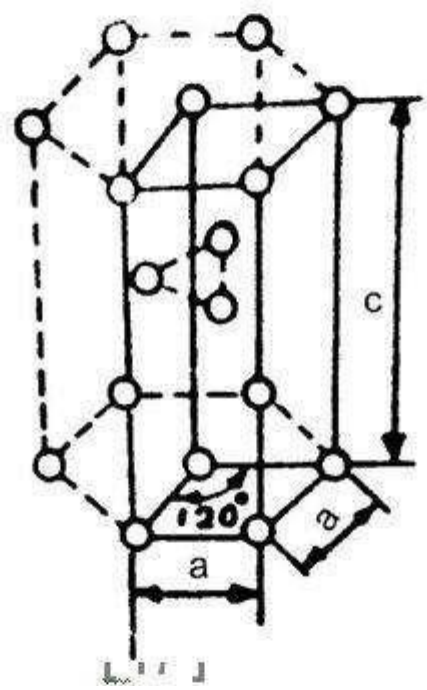
ClassificationofCrystals

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. Inthepresent context,onlycubicand hexagonalcrystalstructuresareconsideredas most ofthe metals and alloys belong to these two systems. In crystalstructure, the smallest unit is one unit cell which characterizes the specific arrangement and location of atoms.

Therearethreetypesofunitcellswithcubiccrystalstructure suchasSC,BCC,FCC.



HexagenalCrystalStructure



Inidealcrystals,theanglesbetweenthe facesrequiredto determinethecrystalformare same.

CrystalImperfections

Crystals are not perfect. An important characteristic which determines some important propertiesofcrystalline materialsisthepresenceofimperfections.Except some idealcrystals most of the crystals have some type of defects or imperfections. All crystals are notcomposed of identical atoms on identical sites throughout a regularly repeating 3D lattice. Theseimperfectionor defectsareusedto describeanydeviation fromanorderlyperiodic arrayofatomsand influencethecharacteristics like mechanicalstrength, electricalproperties and chemical reactions.

Classificationofimperfections

Defectsoneclassifiedinto

1- poindefect
2- linedefect
3- Boundarydefect
4- volumedefect

TypesandcausesofpointdefectsPointDefects

Incrystallattice,point defect iscompletelylocalinitseffect.Whenpoint defect gets introduced in crystal lattice, internal energy of the crystal increases.

Types

Vacancies,interstitialciesandimpuritiesareexampleofpointdefctes.

Causes

Avacantlatticesiteisapointdefect.

Vacancies

Avacancysite impliesanunoccupiedatompositionwithinacrystallatticeiscalled vacancies.it mayoccurduringoriginalcrystalisationortheymayarise fromthermal vibrationof atoms at elevated temperature .

Vacancies are atomic sites fromwhich the atoms are missing and exist in metalat all temperaturesaboveabsolutezero.It playagreat role indiffusionofatoms inthecrystal lattice. It arises from thermal vibrations and introduced during solidification.

Schottkydefect iscloselyrelatedto it and is formedwhenanatomorion isremoved fromits lattice site and replaced in average position on the surface of the crystal .

Interstitialcies

Whenanforeignatomoccupiesaadefinite positioninlatticethat is notnormallyoccupied in perfect crystalis called interstitialcies.

When an atom is displaced from a regular site and occupies an interstitial site, an interstitialcyisformed iscalled frankeldefect .Italso givesriseto latticedistortionbecause interstitialatomtendstopushthesurroundingatomsapart.Thesmaller thesizeofinterstitial atoms smaller the defect.

Impurities

Impurities are foreign atoms which are present in the crystal lattice. Impurityatoms may occupyeither interstitialor substitutionalposition. Itisasmallatomoccupiesaninterstitial void space between atoms at lattice points of the crystal.

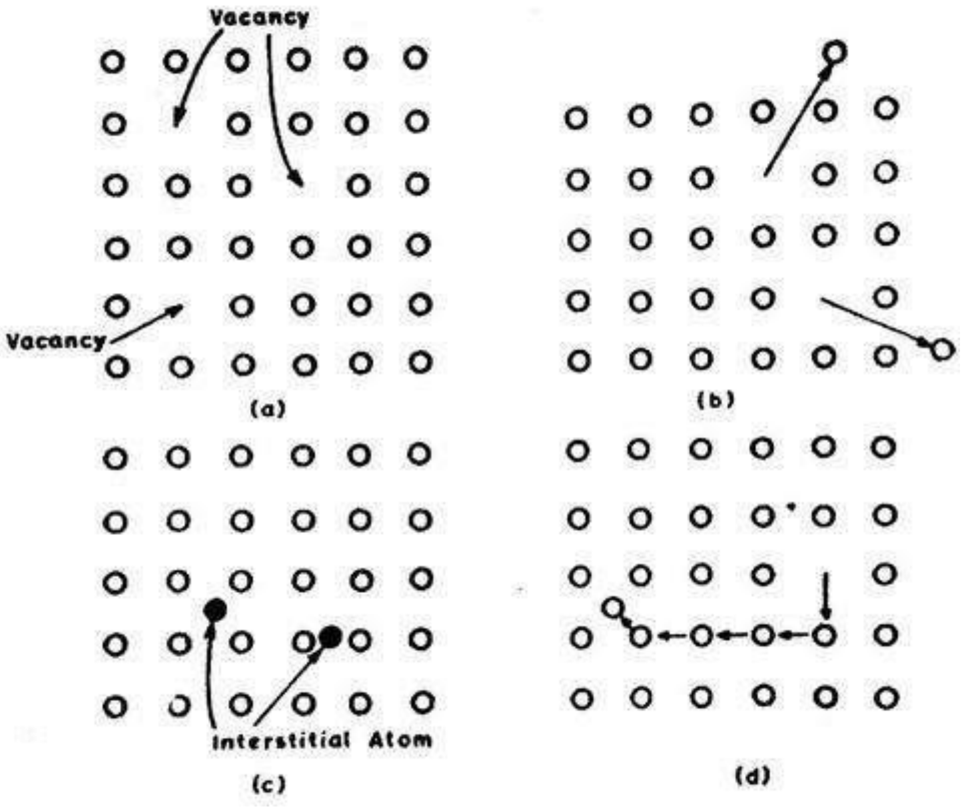


Fig3.5Varioustypesofpoint defects.(a)Vacancy,(b)Schottkydefect,(c)Interstitialcy,(d) Frankel defect.

Typesandcausesoflinedefects,Edgedislocationandscrew dislocation.

LineDeffects

Line defects are also known as dislocations. Dislocation is the region of localized lattice disturbance betweenslippedandunslippedregionsofa crystal.Dueto latticedisturbances, elastic strain fields and stresses are associated with dislocations.

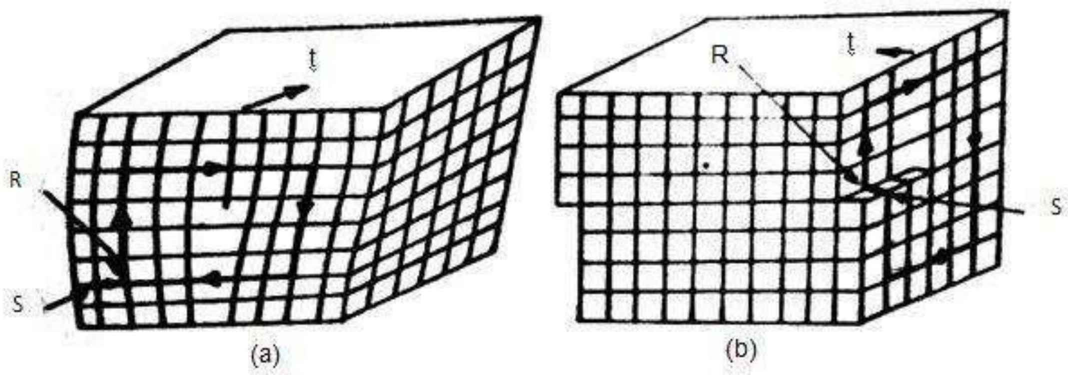


Fig-3.6

Types

Dislocationsareoftwo types: (1)Edgedislocation(2)Screwdislocation

Edgedislocation

In the figure of edge dislocation in which a burger's vector lies perpendicular to the dislocationline.Aburgercircuit isdrawnaroundthedislocationlineandthevectorrequired to close the circuit RS is knownas the burger vectorofthe dislocation. Anedge dislocation moves in the direction of the burger vector. It has an extra rowof atoms either above or below the slip plane in crystal.

Whentheextrarowofatomsisabovetheslipplane it iscalledpositiveand is denoTtoeredmobveythis notice, visit:

sign When the extra rowof atoms is below the slip plane, it is called negative edge dislocationand isrepresentedbysignT . Heretheatomsabovetheedgesare incompression and those below are in tension.

Screwdislocation

Heretheburger vectorisparalleltothedislocationlineand distortionisofsheartype. It follows a helicalpath and it may follow right hand or left hand screw rule. Positive and negativedislocationsareshownbyclockwiseandanticlockwisesigns,respectively.It shows cross slip, where it moves from one slip plane to another.

Eitheredgeorscrewofoppositesigns ifpresent inthesame line, attract eachotherandcan annihilate each other.

Effectofimperfectionsonmaterialproperties.

Itaffectsorinfluencethecharacteristicslikemechanicalstrength,electricalpropertiesand chemical reactions. The role of imperfections in heat treatment is very important.

Imperfections account for crystalgrowth, 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,carbonisaddedto steelasinterstitialimpuritytoimprovethe mechanicalproperties and this properties are further improved by heat treatment.

4.6Deformationbyslipandtwinning

Slip- Metalsdeformplasticallybyslip.Slippingis facilitatedinthepresenceofdislocation.

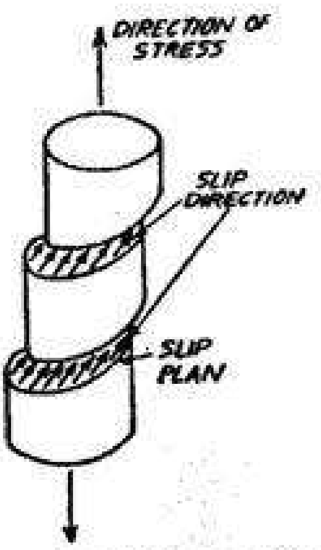


Fig. 3·2 Mechanism of slip

Slip isdefinedastheprocessor mechanismbywhicha largedisplacementofonepartofthe 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 beginswhentheshearingstressactingalongtheslipplanes inthedirectionofslipexceedsa 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.

TwinsandTwinning

Otherthanslip,twinningalso givesrisetoplasticdeformationincrystals.It maybecalledas a special case of slip movement. Intwinning, instead of whole blocks of atoms moving different distancesalongtheslippingplanes,eachplaneofatomsconcerned movesadefinite distanceandthetotalmovement at anypoint relativetothetwinningplane isproportionalto the distance from this plane. In bcc and hcp it occurs frequently.

4.7. Effectofdeformationonmaterialproperties

The mechanical properties are greatly affected by deformation i.e plastic deformation. The deformationprocesslikerolling, forging,extrusion,drawing.Strainhardeningtakesplace,so hardness changes. Elasticity changes, cracking takes place, grain growth takes place. Residualstressareproduceincold working.

SHORTQUESTIONSWITHANSWERS

1. Whatisschottkydefect?[2008w,2017w]

Ans–whenanvacanciesarecreatedbymovement ofatoms frompositioninsidethecrystal to position on the surface o f the crystala schottkydefect is said to be formed

2. Classifycrystalimperfection(2016w,2017 w)

Ans-Crystalclassifiedinto

1- poindefect
2- linedefect
3- Boundarydefect
4- volumedefect.

3. Whatispointdefect?[2009 w,2011]

Whenadefect occureat anypoint ofacrystallatticethatiscalledpointdefect .it istotally local in crystal lattice and its presence increases the internal energyof the crystal .

4. Whatislinedefect?

Ans–Whentheregionoflocalised latticedisturbancewhichseparatetheslipregionofthe crystal from its unslipped region the line defect occure.The plastic deformation of metals due to slipphenomenon is mainly on account of dislocation only .

LONG QUESTIONS

1-Explainedgedislocationandscrewdislocation?[2017w,2018s]

2-Definepropertieschangesbydeformation ?[2010 w,2011w 2018w]

3-Explainvarioustypesofpointdefect?[2006w,2009w,2018s]

CHAPTER-5.0.

HEAT TREATMENT

LearningObjectives:

HeatTreatment

PurposeofHeattreatment

Processofheattreatment:Annealing,normalizing,

hardening,tampering, stress relieving measures

Surfacehardening:CarburizingandNitriding

Effectofheattreatmentonpropertiesofsteel

Hardenabilityofsteel

Definition-

Itmaybedefinedasheatingandcoolingoperationsappliedto metalsandalloysinsolidstate so as to obtain the desired properties.

5.1-Purposeofheattreatment

Theobjectofthisprocessistomakethemetalbetter suited,structurallyandphysically,for some specific applications.Heat treatment may beundertaken forthe following purposes.

i) Improvementinductility
ii) Relievinginternalstresses
iii) Refinementofgrainsize
iv) Increasinghardnessortensilestrengthandachievingchangesinchemical composition of metal surface as in the case of case-hardening.

Also compress machinability, alteration in magnetic properties, modification of electrical conductivity,improvementintoughnessanddevelopmentofre-crystallizedstructureincold-worked metal.

ProcessofheattreatmentAnnealing

Annealinginvolvesheatingtopredeterminedtemperature,holdingatthistemperatureand finally cooling ata very slowrate. The temperatureto which the steel is heated and the holdingtimearedeterminedbyvariousfactorssuchaschemicalcompositionofsteel, size and shape and final propertiesrequired. The various purposes for thistreatment areto

i) Relieveintervalstressesdevelopedduringsolidification,machining,forging,rolling or welding.
ii) Improveorrestoreductilityandtoughness.
iii) Enhancemachinability.
iv) Eliminatechemicalnon-uniformity.
v) Refinegrainsize.
vi) Reducethegaseouscontentsinsteel.

Normalizing

- Normalizing isa process of heating steel to about 40-500C aboveupper critical temperature,holdingforpropertimeandthencoolinginstillairor slightlyagitated air to room temperature. After normalizing theresultant microstructure should be pearlite.
- This isimportant for somealloy steels whichareair hardening by nature. Better dispersion of ferriteand cementite in the final structureresults in enhanced mechanicalproperties.Thegrainsizeis finerandrefinementofgrainsize.Rolledand forgedsteelspossessingcoarsegrainsduetohightemperaturesinvolvedaresubjected to normalizing. Normalized steelsare generally stronger and harder than fully annealed steels.

Hardening

- Hardeningconsistsofheatingtohardeningtemperature, holdingat thattemperature, followedbyrapidcoolingsuchasquenchinginwateroilorsaltbaths.Highhardness developed by this process is due to phase transformation with rapid cooling.
- Forplaincarbonsteels,itdependsoncarboncontent.Hypoeutectoidsteelsareheated toabout 30 – 500C above the critical temperature whereas eutectoidand hyper eutectoid steelsare heated to about 30 – 500C 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 knownas tempering. This treatment lowers hardness strength and wear resistance of the hardenedsteelmarginally.Thehigherthetemperingtemp,themoreistherestored ductility and toughen the steel. Proper tempering treatment results is optimum combination of mechanical properties. Elastic properties is affected by this. Hardening followed by tempering will improve elasticit

5.3-Surface Hardening

- Inordertoprocessconsiderablestrengthtowithstandforcesactingonthemandto withstand wear on their surface, the parts must be made of tough materialsand provided witha hard surfaceby introducing carbon or nitrogen on itssurfacewith coreremainingsoft.Surfacehardeningorcase-hardeningprovidesusahandandwear resistant surfaces, closetolerancein machining partsand tough-corecombined witha higher fatigue limit and high mechanical properties in core.

Itiscarriedoutbyfollowingoperations

(a) Carburising (d)Cyaniding

(b) Nitriding (e)Inductionhardening

(c) Carbonitridin(f)Flamehardening.

Carburising

- Itistheprocessofproducinga hard surfaceonlowcarbonsteelparts.Therearethree methods of carburising suchas(a) pack or solid carburising(b) Gas carburising(c) Liquid carburing.
- Liquid carburising is performedinactivated bath of calcium cyanamide, sodium or potassiumcyanideandother controllingchemicalswhichgovernthedecomposition ofthe cylinders. The baths are operated at 815.50C to 898.850C producea case of depthof0.5mmin90minutes.Theprocessextremelyflexibleandeasilycontrolled. Thereaction inthe bath is2Na2CO3 + SiC – Na2SiO3 + Na2O + 2CO + C.

Nitriding

Theintroductionofnitrogenintotheoutersurfaceofsteelpartsinordertogiveanextremely hard, wear resisting surface is called nitriding. It is provided by placingthearticle in ammonia vapoura temperaturebetween4500Cand5500Cfor10 hours. Thecore shouldbe brought to its

original toughness before nitriding by quenchingin oil fromabout 9000C andtempering fromabout6000Cto6500C.Itisusedforvariousautomotives,airplaneanddieselengine parts like cylinders, sleeves, liners etc.

Hardenability

Itisdefinedaspropertyofa steeltobehardenedbyquenchinganddeterminedthedepthand distribution of hardnessthroughout a section obtained by quenching.

Factorsareasfollows

Themainfactorsaffectinghardenabilityare:

- Alloyingelements

- Carboncontent
- Grainsizeofsteel
- Thehomogeneityofstartingsteel
- Homogeneityobtainedintheaustenitebeforequenchingbyincreasingcarbon content, hardness can be

SHORTQUESTIONSANDWITHANSWERS

1. Whatisheattreatment?2018W,2019W .

Ans–Heat treatment is a processin whicha metal is heated to certain temperatureand cooledinaparticularmannertoalteritsinternal structureforobtaining desiredegreeof physical and mechanical properties such brittleness,hardness and softness .

2. Defineannealing?2019w,2019S.

Ans–Annealingisdefinedasheatingofmetalor steeltoatempratureatornearcritical temperature ,holdingthere for a proper timeand thenallowing it to cool slowly .the temperature for annealing varies with different steel .

3. Definehardening?2007w

Ans–hardening is definedas heating the steel to temperature wit or abive its critical temperatureand held at this temperature for a considerabletime to ensure proper penetrationoftemperatureinsidethecomponentandthenallowedcoolbyquenchingin water ,oil etc .

4. Whatisnormalising?2009w,2008w2019w.

Ans–normalising or air quenching consist of heating steel toabout40 -50 c abive its uppercriticaltemp.Andifnecessary holdingitatthattemperatureforashorttimeand cooling in still air at room temp.

5. Whatistempering?2019w,2007w,2020w.

Ans-itisaprocessofreheatinga quenchhardened steeltoreduceitsinternalstressand to increase itstoughness.Reheating is done to a tempraturevarying from250 cto650 c depending upon the reheating temp.this process is called tempering .

LONGQUESTIONS

1. Explainthepurposeofheattreatment? 2009 w,2007w,2006w,2017w,2020w,2010 w .

2. Listtheeffectsofheattreatmentonthepropertiesofsteel?2010new,2008w,2018w

3. Describevarioustypeofheattreatmentprocess?2010new,2017 w.

4. Describeannealing?2009w.

5. Describehardenabilityofsteel?2007w,2018w.

CHAPTER- 6

NON-FERROUS ALLOYS

LearningObjectives:

Non-ferrousalloys

Aluminumalloys:Composition,propertyandusageof

Duralmin, y-alloy.

Copperalloys:Composition,propertyandusageofCopper-

Aluminum, Copper-Tin, Babbit , Phosperous bronze,

brass, Copper- Nickel

Predominatingelementsofleadalloys,ZincalloysandNickelallo

Low alloy materials like P-91, P-22 for power plants and other high temperatureservices.Highalloymaterialslikestainlesssteelgradesofduplex, super duplex materials etc.

6.1Composition,PropertiesandUsesofAluminiumAlloyes, Duralumin, Y- Alloy

It is one of the oldest and best known alloys of aluminiumwidely used for aircraft parts.Itscompositionis3.5-4.5%copper,0.4-0.7%manganese,0.4%siliconandsometimes contain 0.4- 0.7%, magnesium and below 0.5% iron. It developed maximumproperties as a result of heat treatment and age hardening which can be worked readily about 5000C and after quenching ages over a period of 4 to 5 days. Its tensile strength increase from 1.55-1.86ton/cm2 yield point from 1.04-2.325 t/cm2 and hardness from 65 brinell to 95 brinell. Used forhighlystressedstructuralcomponents,aircraftsandautomobilepartslike front axle, levers,bonnets,connectingrods,chassisfrom,girdersforships,aeroplaneairscrews,spares, clips, fitting, levers etc. Also used for surgicaland orthopaedics works for non magnetic and other instrument parts.

Y-alloys

Y-alloysareofthebest alloysofthisgroupsisa highstrengthcosting alloywhich retains its strength and hardness at high temperature.

Itspercentagecompositionis4%copper,1.5%magnesiumand2%nickel, eachof silicon, manganese is 0.6%. Inthe cost and heat treated from its ultimate strength is 2.12

tons/cm2 but chill costing after heat treatment show a strength of 3.1 tonnes/cm2. Heat treatedforged alloysgiveanultimatestrengthof3.565 – 4.185ton/cm2 anelongationof17 – 22% and brinell hardness of 100-105.

Itisextensivelyused forpistons,cylinderheadsandcrankcaseofinternal combustion engine.

6.2-Copperalloys

(a) Copper-Aluminiumalloys

Aluminium gets hardened and strengthened by the addition of copper. The most extensivelyusedalloys for castingsarethosecontaining4,5,7,10and12%ofcopper andwith ultimatestrengthranging from1.12 –4.185t/cm2. It isemployed inindustryfor light casting requiring greater strength and hardness than ordinary aluminium.

Itisused forautomobilepiston,crankcases,cylinderheads,connectingrods.

(b) Copper-Tin

These bearingalloyscontaininggreaterproportionoftinwithcopperandantimonyand known as white metals.

Anotheralloysofthistype havingcompositionof86%tin, 10.5%antimony, 3.5%copperhas a tensile strength of 0.996 t/cm2, elongation 7.1% with brinell hardness of 33.3 and compressive yield point of 4.3.

Itisusedin mainbearingsofmotorsand aero-engines.

(c) Babbot

Itisageneralwhite metalalloywithsoft leadandtinbase metalscoveringarangeof alloyhavingsimilar characteristics varyingcomposition. Itsactualcompositionis82.3%tin, 3.9% copper, 7.1% antimony.

A cheaper babbit metal used for bearings subjected to moderate pressure has compositionas59.54%tin,2.25to3.75%copper,9.5to11.5%antimony,26%lead,0.08% iron,0.08% bismuth.

Theyareuseaslinersinbronzeorsteelbackingandarepreparedforhigherspeed, exTcoerelmleovnetthis notice, visit: embedability, conformability, ability to deform plastically used in IC engine bearing, general machinery purpose bearings.

(d) Phosphorousbronze

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 generalpropertiesofthe metal. Intheformofcasting phosphorousbronzegivesand ultimate strengthofabout 18tonnes/cm2 withelongationof4% brinellhardness number 80-100.It is used for heavycompressive loads and is used for gear wheels and slide values. Phosphorous bronze in wrought alloy form containing 10% tin, 0.1 – 0.35% phosphorous has a tensile strength 3.72 t/cm2, Bhn 100

–130.Ithasgoodcorrosionresistancetoseawaterandisusedforspringandturbine blades.

(e) Brass

These are the alloys of copper and zinc with varying percentage of two metals. If small amountofoneormore metalsareaddedtheyprovide morespecificproperties likecolour, strength, ductility, machinability.

- brasses- 36%zincand64% cu.
- brasses– 40 to 44%znand 64to55%cu.
- brassespossessgoodtensilestrength,goodductility,suitable forproducingsheet, strips, tubes, wires etc.
- brassesareusedforhotpressings,stampings.

Copper-Nickel

Nickelformswithcopperinvaryingpropertiesa largenumberofalloys.Theaddition 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 propertieswithtensilestrengthof6.2t/cm2used forsheathsor envelopesofriflebullet.

A70/30cupronickelused forcondensertubesproducedbyextrusionprocess. 8t/cm2 elastic limit, 5.9 t/cm2 ultimate strength, Bhn 140.

6.3-Predominatingelementsofleadalloys,zincalloysandnickel 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 possessthe leadcarryingcapacitystrengthdecreaseswithincreasing intemperature.Analloy containing 80% lead, 15% antimony and 5% tin or 20% antimony generallyused for long bearings with medium loads.

Binarycopper leadalloys-lead10 –20%,20–30%andabove30%.

Zincalloys

Thesealloysusedintheformoftoolingplateandeasyandspeedoffabrication.Brasses–AlloysofCu andZn.

Nickelalloys

Nickelisoneofthe most important metalswhichisusedasapuremetalandalloyed with other elements. Nickel copper, nickel copper silicon alloys. Nickel copper tin, sometimes with lead.

Nickelchromium- withironorcobalt. Nickelmolybdenum-alsowithchromium. Nickelsilicon.Nickelmanganese,nickelaluminium.

6.4- Low alloy materials like P-91, P-22 for power plants andotherhightemperatureservices,highalloymaterialslikestainlesssteel grades of duplex, stiper duplex materials.

Lowalloymaterials

Which possess slowly cooled micro structures, similar to those of plain carbon steel in the sameconditionnamelypearlite,pearliteplusferrite.These lowalloyalso knownaspearlite alloy steel.

Highalloysteel

Whichpossessslowlycooled micro structure,consistingeitherofmartensite,austeniteor ferrite plus carbide particle. It is more than 8% in the case of steels.

SHORTQUESTIONSWITHANSWERS

1- Givetwoexampleofnonferrousalloys.2017w2018w. Ans –

Aluminium alloy , Copper alloy

2- Whatisalloy?

Ans. Whentwoormoremetalcombinewitheachotherand formanew materialthat is called alloy .steel is the alloy iron and steel .

3- Givetwoexampleofferrousandnonferrousmaterials.2017w.

Name two ferrous materials – Cast iron ,Steel .

Nonferrousmaterials–Copper,Bronze. 4 –

What is brass ?2019 w?

Ans:Brass isanalloyofcopperandzinc

Copper -64, Zinc -36.

LONG QUESTIONS

1. Describecompositionand propertiesand applicationofzinc?[2010w]

2. Describecomposition,propertiesanduseofaluminiumalloys.[2008w,2014w,2015w ,2019w]

3. What aretheeffectofvariousalloyingelementssuchasc, Ni, Mn, Mo, vandw. [2019w 2020 w]

4. Writedownthecompositionofduralumin.[2020 w]

5. Give some example ofnickelalloyandwrite downpreparationofinconel.[2019w]

CHAPTER-

07.BEARING MATERIAL

LearningObjectives:

BearingMaterial

Classification,composition,propertiesandusesofCopper

base, TinBase, 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 apartwithrelativemotionandmetalispulledfromoneorbothsurfacesdecreasingthelifeof thebearing.Thisfrictionandweldingismostcommonwhenlikemetals,suchassteelorcast 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,andembedability.Theyeasilyadapttheirshapestoconformto 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 duetobabbitt’shard/soft composition.High-tinbabbitts,forexample,consistofarelatively soft, solid matrix of tin in which are distributed hard copper-tin needles and tin-antimony cuboids.Thisprovidesfor“goodrun-in”whichmeansthebearingwillabsorbalubricanton 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 ClassificationofBearingMaterial

1. TinBased Babbitt
2. LeadbasedBabbitt
3. CadmiumBased Bearing Material
4. Copperbased BearingMaterial(CinteredMetal)

Compositionandusesofdifferenttypeofbearing material.

Name	Composition(Wt%)	Uses
TinBased Babbitt	85Sn-10Sb-5Cu	High speed bearing bushes in steamand gasturbine, electric motor,blower,pumps etc.
LeadBasedBabbitt	80Pb-12Sb-8Sn	RailwayWagonbearing.
CadmiumBased	95cd-5ag&small amount of iridium	Medium loaded bearing subjectedtohightemperature
CopperBased	80Cu-10Pb-10Si	Heavyduty bearing.

PropertiesofBearingMaterial

Abearingmetalshould possess thefollowingimportant properties.

I. Itshouldhaveenoughcompressiveandfatiguestrengthtopossessadequateload carrying capacity.
II. Itshouldhavegoodplasticityforsmallvariationsinalignment& fittings.
III. ItshouldhavegoodwearResistancetomaintainaspecifiedfit.
IV. Itshouldhavelowco-efficientoffrictimtoavoidexcessiveheating.
V. Thematerialshouldresist vibration.
VI. ItshouldhavehighThermalconductivitysoasto takeawaytheheatproduceddueto friction between two moving parts.
VII. Itshouldhavethepropertiestofromacontinuousthinfilmoflubricantbetweenthe shaft & bearing to avoid direct contact between two rotating surface.

SHORTQUESTIONSWITHANSWERS

1. Classifybearingmaterial.[2010w]
Ans–Bearingmaterialareclassifiedasfollows

- a-tinbase
- b-leadbase
- c–cadmiumbase
- d–copperbase.

2. Writedownthecompositionofleadbasebearingmaterial.[2009W .2019W]
Composition

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

3. WRITEANYFOURDESIRABLEPROPERTIESofbearingmaterial.[2009w, 2014 w]
Ans–

- Posseslowcoefficientof friction.
- Havehighcompressivestrength.
- Havehighfatihuestrength .
- Shouldbearshockandvibration.

LONGQUESTIONS.

1. Describethecomposition,propertiesandusesofcopperbaseandtinbasebearing material .[2010 w ,2008 w,2014 w ,1018 w]
2. Classifybearingmaterial with example[.2007w]
3. Statethe propertiesofcadmium basebearingmaterial .[2006 w]
4. Explainleadalloys withcomposition,properties anduses[2007w]

CHAPTER NO- 08

SPRING MATERIAL

LearningObjectives:

Springmaterials

8.1Classification,composition,propertiesandusesofIron-baseandCopper base spring material

Introduction

Springs are fundamental mechanical components found in many mechanical systems. Developments in material, designprocedures and manufacturing processes permit springs to be made with longer fatigue life, reduced complexity, and higher production rate. Most springsare linearwhichmeanstheresisting forceis linearlyproportionaltoitsdisplacement. Linear springs obey the Hooke's Law, F =k× Dx

Where Fistheresisting force,kisthespringconstant,andDxisthedisplacement. Depending on load characteristics spring may be classified as:

Classificationpropertiesandusesofspringmaterial

Mostspringsare madewithiron- basedalloy(high-carbonspringsteels,alloyspringsteels, stainless spring steels), copper base spring alloys and nickel base spring alloys.

Iron-basedSpringmaterial

i) High Carbon Spring Steel –(C 0.7-1.0,Mn 0.3-0.6& remaining Fe) These spring steelsarethe mostcommonlyusedofallspring materialsbecausetheyarethe least expense, are easily worked, and are readilyavailable. They are not suitable for springs operating at high or low temperature or for shock or impact loading.

ii) Alloy Spring Steel –EN-45(C 0.5,Mn 1.0,Cr 0.2-0.9,V0.12 &remaining Fe),EN-60(C0.5-0.75,Mn0.6-1.2&remaningFe).Thesespringsteelsareusedforconditionsofhigh stress,andshockorimpact loadings.Theycanwithstandawidertemperaturevariationthan highcarbonspringsteeland areavailableineithertheannealed or pre-tempered conditions.

iii) StainlessSpringSteel–(Cr18,Ni8,C0.1-0.2&remainingFe)Theuseofstainless 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. Theyare suitable for valve springs.

CopperBaseSpringMaterial

Copper base alloys are more expensive than high carbon and alloy steels spring material. Howevertheyare frequentlyused inelectricalcomponentsbecauseoftheirgood electrical properties and resistance to corrosion. They are suitable to use in sub-zero temperatures. i)Brasses(Cu67,Zn33):Switch control, electrical application.

ii) NickleSilver(Cu56,Ni18,Zn18):Electricalrelays.iii)PbBronze(Cu92,Sn8,Pb 0.1):Bushes.

Iv)BerylliumCopper(Cu98,Be2.0):Relaysand Bushes

SHORTQUESTIONSWITHANSWERS

1. Writedowntypesofspring materials.[2019new]

Ans.

- Ironbase
- Nickel base
- Copperbase.

2. Whatisironbasespringmaterial. [2019w2020w]

Ans.Thespring materialinwhichironisusedasmainconstituent iscalled ironbase spring material . Example . Hard drawn spring wire .

3. Writedown4propertiesofspringmaterial.

Ans :

- Posseshighmodulusofelasticity .
- Highelasticlimit
- Goodresistancetocorrosion
- Highelectricalconductivity.

LONG QUESTIONS

1. Writedownthecomposition,propertiesandusesofironbasematerials. [2016w ,2017w.2018w.2019w.]

2. Listthepropertiesofcopperbasespringmaterials.[2018w,2019s]

3. Writedownthecomposition,propertiesandusesofcopper andtinbasespring materials . [2019 s]

ChapterNo-09

POLYMERS

LearningObjectives:

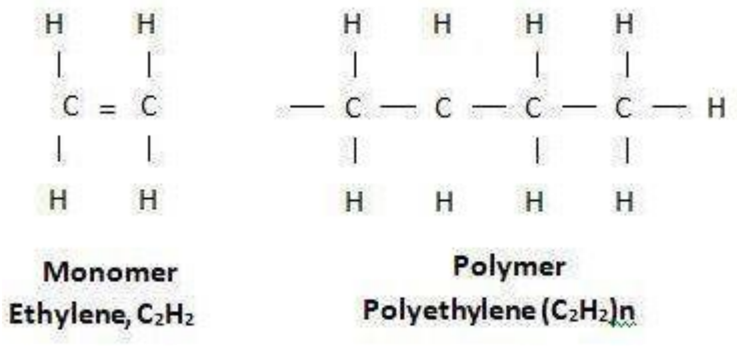
Polymers

Propertiesandapplicationofthermosettingandthermoplasticpolymers

Propertiesofelastomers

INTRODUCTION

The plastic is an organic substance and it consists of natural or synthetic binders or resins withorwithoutmouldingcompounds.Theplasticismanufacturedbythepolymerization.A polymer consists of thousands of monomers joined together.



Monomer:

Thesimplest substanceconsistingof oneprimarychemical areknown as the monomer.

Polymerization:

- Monomersaretobecombinedtoformpolymersbytheprocessknownas polymerization.
- Thepolymermoleculeisalsocalleda macromolecule.
- Apolymericmaterial consistsof alargenumber oftheselongchain molecules.
- Thepropertiessuchasstrength,rigidityandelasticityareconsiderablyimprovedby thepolymerizationandit furtherleadstothemanufactureofplasticsinaneconomy way.

CLASSIFICATIONOFPLASTICS

Theclassificationofplasticscanbemadebyconsideringvarious aspectsandforthepurpose of discussion, they can be classified according to their

1. Behaviourwithrespecttoheating.
2. Structureand
3. Physicalandchemical properties.

Ascase-1is thetopicof ourdiscussion wewill concentrateon that.

PropertiesandApplicationofthermosettingand thermoplastic polymer

Accordingtothisclassification theplasticsaredividedintotwo 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 basedontherawmaterialsfromwhichplasticsareprepared.Itisinterestingtonotethateach of above group contains several hundred different products and with the advance of plastic industry, the number of sub-divisions under each category is constantly increasing.

(i) Thermoplasticpolymer

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 hardeningmayberepeatedforanindefinitetime.Providedthetemperatureduringheatisnot so high as to cause chemical decomposition. It is thus possible to shape and reshape these plastics bymeans of heat and pressure. One important advantage of this varietyof plastics is that the scrap obtained from old and warn-out articles can be effectively used again.

(ii) Thermosettingpolymer

Thethermosettingorheatconvertiblegroupisthegeneraltermappliedtotheplasticswhich become rigid when moulded at suitable pressure and temperature. When they are heated in temperature range of 1270C to 1770C, theyset permanently and further application of heat does

notalteredtheirformorsoftenthem.Butattemperatureofabout3430C,thecharringoccurs. This charring is a peculiar characteristic of the organic substances.

Properties

Thethermosettingplasticsaresolubleinalcoholandcertainorganicsolventswhentheyare in thermo-plastic stage. This propertyis utilised for making paints and varnishes from these plastics.

Theseplasticsaredurable,strongandhard.Theyareavailableinavarietyofbeautiful colours. They are mainly used in engineering application of plastics.

Propertiesofplastics

1. Appearance: Transparent
2. Chemicalresistance:Theplasticsoffergreatresistancetomoisture,chemicalsand solvents, excellent corrosion resistance.
3. Dimensional stability.
4. Ductility: Theplasticlacksductility. Henceits membersmayfailwithout warning.
5. Durability: Theplastics arequitedurable, iftheypossess sufficient surfacehardness.
6. Electricinsulation : Theyarefar superiorto ordinaryelectricinsulators.
7. Finishing: Anysurfacetreatment maybegiven to theplastics.
8. Fireresistance: Allplasticsare combustible.
9. Fixing: Can be easilyfixed inposition.
10. Humidity: PVCplasticsoffer great resistanceto themoisture.
11. Maintenance: Itiseasytomaintainplasticsurfaces.Theydonotrequireany protective coat of paints.
12. Meltingpoint:MostoftheplasticshavelowmeltingpointandMPofsomeplastics is only about 500C.
13. Opticalproperty: Severaltypes ofplasticsaretransparentand 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,syrupbottles,coffeecups,plasticutensilsetccanbeconvenientlyrecyclesinto carpets, detergent bottles, drainage pipes, fencings, handrails, grocery bags, car battery cases pencil holders, benches, picnic tables, roadside posts etc.
15. Soundabsorption:Theacousticalboardsarepreparedbyimpregnatingfibre-gTlao rsemsoevesthis notice, visit:
16. withphenolicresins.Thismaterialhasabsorptionco-efficientof about0.67.
17. Strength:Thetensilemembersaregenerallymadeofplasticsastheirstrengthto weight ratio in tension very nearly approaches to that of metals.
18. Thermalproperty:Thethermalconductivityofplasticsislowanditcanbecompared with that of wood.
19. Weatherresistance:Certainplasticsareseriouslyaffectedbysunlight,butother plastic can resist weather which as prepared from phenolic resins.
20. Weight:Theplastics,whetherthermo-plasticorthermo-settinghavelowspecific gravity being 1.30 to 1.40.

Applications:

Thetypical useofplastics inbuildingareas follows :

1. Bathandsinkunits.
2. Cisternballfloats.
3. Corrugatedandplainsheets.

4. Decorativelaminatesandmouldings.
5. Electricalconduits.
6. Electricalinsulators.
7. Floor tiles.
8. Foamsforthermalinsulation.
9. Jointless flooring.
10. Lightingfixtures.
11. Overheadwater tanks.
12. Paintsandvarnishes.
13. Pipes to carrycold water.
14. Roof lights.
15. Safetyglass.
16. Wall tiles.

PropertiesofElastomers:

These plastics are soft and elastic materials with a low modulus of elasticity. They deform considerablyunderloadatroomtemperatureandreturntotheiroriginalshape,whentheload is released. The extensions can range up to ten times their original dimensions.

SHORTQUESTIONSWITHANSWERS

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

Ans : An elastomer is a polymeric material that may be experience large and reversible elasticdeformation.elastomersaregenerallyrefersto asrubbers.theyareessentiallynon crystalline in structure .

2- Writedowntwopropertiesofofelastomer.[2020w] Ans

–

- Highchemicalresistance.
- Goodfuel,oilandozoneresistance.

3.What isthermo settingpolymer?[2014 w]

Ans.Thepolymerwhichoncehardenandsoftandthendonotsoftenwithapplicationof heat is called thermosetting polymer .

Example–RadioandTVcabinet.

LONGQUESTIONS

1- Explaintheapplication andproperties ofthermoplasticpolymers ?[2008 w,2019w]

2- Differencebetweenthermoplasticandthermosettingpolymers.[2015w,2016w,2019 w]

3. Writethe propertiesofelastomers .[2009 w,2015 w]

4. Writedownpropertiesthermosettingpolymers .[2018 w]

Chapter - 10

COMPOSITE AND CERAMICS

LearningObjectives:

CompositesandCeramics

Classification,composition,propertiesandusesofparticulatebasedand fiber reinforced composites

Classificationandusesofceramics

Classification,composition,propertiesandusesofparticulatebased composite

Classification

Thecomposite materialsareshortenedascomposites.Theyare formedbycombiningtwoor more different materials to make better use oftheir virtues and by minimizing their deficiencies. Each material retains its physical or chemical properties separate and distinct within the finished product.

Composition

Thecompositesaremadefromtwomainconstituentmaterials.

1. Strongloadcarryingmaterialknownasreinforcementorreinforcingfibres.
2. Weakermaterialknownasmatrix.
1. Reinforcingfibres

Fiberreinforcedcompositematerial

Followingarethefunctionsofreinforcingfibres:

(i) Itprovidesstrengthandrigidity.
(ii) Ithelpstosupport structuralload.

Therearethreemostcommontypesofreinforcingfibres.

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

Glassfibersaretheheaviest havinggreatest flexibilityandthelowest cost.Aramidhas moderate stiffness and cost.

Carbonismoderatetohighincost,slightlyheavierthanaramidbut lighterthanglassfibres. Carbon is the strongest.

2. Matrix

Followingarethefunctionsofmatrix.

(i) Itworks as abinder
(ii) Itmaintainsthepositionand orientationofthe reinforcement.
(iii) Itbalancestheloadsbetweenthe reinforcement.
(iv) Itprotectsthereinforcementdegradation.
(v) Itprovidesshapeand formtothestructure.

The most common type of matrix is thermosetting resins.

Epoxyresinsarethemostwidelyusedthermosettingresinsinadvancedcomposites. Othersresinsusedasmatrixarepolyester,vinylester,phenolic,bismaleimade,epoxyno volar.

Examples:

Compositesnatural

Wood- Cellulosefibrespluspolysaccharide.

Bones,teethandmolluscshells=Hardceramic+organicpolymer Man

made composites

1. Mud+ straw
2. Bricksmadeupstraw+mud
3. Plywood
4. Concrete,plastic,MMC,CMC

ClassificationandUsesofCeramics

Thetermceramics isusedto indicatethepotter'sartorarticles made bythepotter. The ceramics are divided into the following three categories.

1. Clayproducts
2. Refractories
3. Glass

Clayproducts

Theclayproductswhichareusedaretiles, terra-cotta, porcelain,bricks, stoneware's&earth wares.

Tilesare oftwotypes

(1) Commontile
(2) Encaustictiles

Types of common tiles

(i) Draintiles
(ii) Floororpavingtiles
(iii) Rooftiles

Typesofrooftiles

Allahabadtiles,Corrugatedtiles,Flattiles,Flemishtiles,Gunatiles,Mangaloretiles,pan tiles.

Refractories

Thetermrefractoriesisusedto indicatesubstancesthat areabletoresist hightemperatures.

Classification

(i) Accordingto chemicalproperties.
(ii) Accordingtoresistancetotemperature.

Accordingto chemicalproperties

(a) Acidic

(b) neutraland

(c) Basic

(a) Acidic

Fireclay:It isused forthe manufacturedoffirebricks,crucibles,hollowtiles.Quarizite-For making the silica bricks.

Silica-Cokeoverandlining forglassfurnaces.

(b) Neutralrefractorymaterials

Bauxite-Fortirebricks

Carbon-Liningmaterialforfurnaces

Chromite-Powerfulneutralrefractorymaterial.Forsterite-Usedinfurnacesformelting copper.

(c) BasicRefractorymaterials

Dolomite-Formakingrefractorybricks.Magnesia-Magnesiabricks.

Accordingtoresistancetotemperature

(a) Low quality

(b) Highquality

High quality–

Usedinmodernaeroplanes,rockets,jetsetc.Molyblendum,tungsten,zirconiumandtheir alloys are used as the refractory materials.

Cermet–

Refractorymaterialcontainingacombinationofclayand metal. Surface

Preparation and Industrial Painting

SHORTQUESTIONWITHANSWERS

1- Whatiscompositematerial?[2012w,2011w,2008w,2019w,2018w]

Ans– Compositematerialcan bedefined asthematerialmadeup oftwoormore dissimilar .compositematerialdoes notoccurenaturallyasanalloybut areseparatelymanufactured before they are combined together mechanically or metallurgical .

2- Writeapplicationoifceramics.[2011w,2010w,2008 w,2019s,2018w,2020w.]

Ans:Ceramicsmaterialcanbeusedassand,glass,brick,cement etc.ceramic materialare corrosion resistance and can be used as concrete , refractories and plaster .

3- Definecompositeandalloys. [2017w]

Composite materialsare madebytwoormoremetallicandnonmetallic elementsbut the alloys are made by two or more different types of metals .

Example–

Compositematerial–tyre

Alloys –zinc alloy

Aluminium alloy .

4. Classifycompositematerial.[2010w] 1-

particle reinforced

- A-largeparticle

- 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]