ॐ नमः शिवाय

Chapter-1

Introduction

Materials :- Material is a substance that can be used for making or doing something. They can be natural like (wood, stone, metal (iron, aluminium) or synthetic. plastic, polymer.

Materials are classified as.

1. Metals
2. Non-Metals.
3. Polymers.
4. Composites.
5. Alloys.
6. Ceramics.

Engineering materials are classified :-

Materials.

- Metals
  - Ferrous Metals.
    - Metals
    - Alloys
  - Non-Ferrous Metals.
    - Metal
    - Alloys.
- Metalloids.
- Non-Metals.
  - Other.
  - Ceramics
  - Organics
  - Composites
  - Semiconductors.

Difference b/w Metals and Non-Metals :-

Metals	Non-Metals
(1). Metals are good conductor of heat and electricity.	(1) Non-Metals poor conductor of heat and electricity expect Graphite Diamond.
(2) They have high density	(2) They have low density.
(3) They are solid at room temp. expect Mercury	(3) They are solid, liquid as well as gas at Room temp.
(4) They are ductile and Except Bismuth that is brittle in Material.	(4) They have lack of ductility and brittle in nature,
(5) Metals are sonorous.	(5) Non-Metals are non-Sonorous
(6) They have lusture (shine)	(6) Non-Metal don't have Lusture Except Iodine, Diamond.
(7) Metals form Basic oxides.	(7) Non-Metals from Acidic Oxides.
(8) They reacts with acids to form H_2 gas	(8) They do not reacts with acids.

Different Engineering materials and their Application and Ty

(1) Cast iron :- It is obtained by remelting of Pig iron in capula furance.

- It is an alloy of iron + carbon + silicon mainly.
- It is hard and brittle.
- It carbon contents are more than 1.7% to 3%.
- The carbon in cast iron present in two from in the form of cementite and graphite based on following cast iron :-

(1) Grey Cast iron,
(2) White cast iron.
(3) Malleable cast iron.
(4) Motted Cast iron.
(5) Alloy cast iron.

(B) Grey cast iron :- The carbon in it is present as graphite due to which its colour is grey. Grey cast iron widely used for making bodies of lathes, milling machines, shapers etc.

- It is cheap
- It is easy to Machine.
- It has good damping properties.
- It has high compressive strength.
- It absorb vibration.

(C) White cast iron :- Carbon is Present in combine fo Fe_3C (cementite).

- It is hardest constituent of iron.
- It produced by casting method.
-

Applications - (1) It is used in Railway wheel.
(2) Crushing Machine. by annealing
(3) Melleable cast iron which made tougher than cast iron.
(4) It is alloys mellable cast iron or twist without breaking.
(5) It is use for making gear housing.

Alloy cast irons - It is produced by mixing or adding nickel, chromium.
- elements. Chromium increase hardness nickel increase M/C stability.

Molybdenum :- is increase stifness, hardness, Strength, Impact Resistance.
Applications - engine cylinder, piston, piston rings, crank cases, brakes drums etc.

(2) Wrought irons - It is mixture of Pig iron and. It is made by remelting Pig iron in Pudding furance.
- It is purest iron and contains 99.5% to 99.9% Iron.
- It is used for change pipe fitting. It has ductility and Mellability.

Plane carbons - It is divided into four type.
- Dead mild steel. → carbon 0.1% soft and ductile.
- Mild steel. → carbon 0.1% to 0.35% Stronger and less ductile.
- Medium carbon steel → carbon 0.35%. Used for gear axel.
- High carbon steel → contain carbon 0.6% to 1.5%. It is used for making tools like knief, taps, drills kits razer blades.

(5) HSS (High speed steel) :- It contain 18% tugustan (W) 4% Cr and 1% V.
- Molybdenum High speed steel :- 6% W, 4% Cr, 2% V. and 6% Mo.

Super High speed steel :- 20% W 4% Cr 2% V. and 12% Mo.

(6) Stainless steels - The steel which have ability corrosion resistance is called stainless steel 18% ~~Co~~ ~~Cro~~ Chromium. and 8% Nickel.

(7) Brass :- It is alloy of copper and zinc.

(8) Muntz Metal :- 60% Cu, 40% Zn.

(9) Bronze :- It is alloy of copper and zn.

(10) Biomaterials :- these are synthetic material use to device to replace parts of human body or living body and living tissue for Example bone plates, tooth filling.

Uses of Biomaterials :-
- Replacement of damaged parts eg artificial hip Joint M/C kidney dialysis
- For correcting cosmetic problems chin cugmentation
- For correcting functional abnormalities e.g. Cardiac pacemaker.

Semiconductors:- A semiconductor is a semiconductor materials, is a solid crystalline material which electricity conductivity lies b/w a conductor and insulator.

Types of semiconductors:-

- Intrinsic semiconductors:- Semiconductor in absolutely pure state are called intrinsic semiconductor. It acts good insulator and temp. is lower at 0K or -273°K.
- Extrinsic semiconductors:- Extrinsic semiconductor are those which have been doped i.e impurities are added into their crystal structure intentionally. It is two type.

N type :- It has extra electron into valance shell.
P type:- If there is extra e- hole in crystal of semiconductor called P-type semiconductor.
Example · zinc oxide N type, cuprooxide.

Advantages of semiconductors:-

1) They have long life.
2) They hardly show ageing effect
They consume low power.
They are almost shock proof.
They operate low voltage.
They are much smaller in size and light in weight.

Chapter-2

Crystallography.

(1) Definations:-
It is a Branch of science which deals with Structure of crystal.

(2) State of Matters:- Solid, liquid, gas.

Crystalline Solids	Amorphous solid. are arranged in irregular fashion in 3D

Unit cells - The tiny block formed by arrangement groups of atoms is called as unit cell.

The length of the side of unit cell is distance b/w the atoms of same kind. it is of two type. (1) Primitive unit cell. (2) Non-Primitive cell.

1. Primitive:- Atoms are only at the corners of unit cell.

2. Non-Primitive:- Atom are present at the

corners as well as as on the face. and interior parts

Space Lattice :- It is defined. as the arrangment of atom in an orderly three dimensional pattern to form a 'crystal. also define as the 3 dimensional array of atoms' in which atom has identical surrounding.

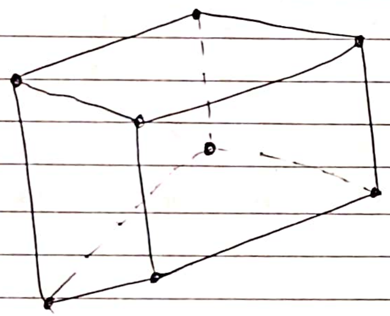
Bravais Lattices - gave an idea of space lattice in year 1880 according to him there are 14. possible type of space lattices.

Crystal structures of Metal :-

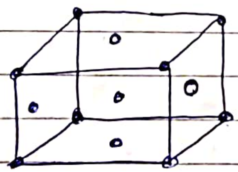
There are 3 types of space lattices with which metallic element crystallize.

1. BCC (Body center cubic structure)
2. FCC (Face center cubic structure)
3. HCP (Hexagonal close packed structure).

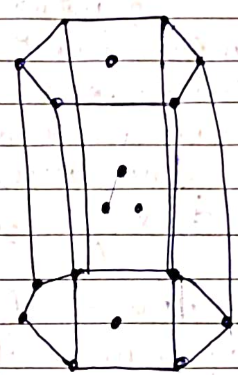
(1.) BCC :- In BCC atoms are at the corner of cube and one atom at the center.
Metal have BCC structure are sodium, Potassium, Molybdenum, lithum, Barium.



(2.) FCC :-
In FCC atom are located at corner of the cube as well as one atom at center of each face. Example copper silver, gold.



(3) HCP :- In this atom are at the each of the twelve corner of hexagonal prism, one atom at each of the two diagonal face and three atom in the body of the cell.



SCC :- (Simple cubic structure) In this structure there are 8 corners and each corner has one atom the each corner atom share by 8 adjoint cubes ~~cube~~ therefore in a simple cubic structure the no. of atoms per unit cell

BCC :- No. of atom in BCC $8 \times \frac{1}{8} + 1 = 2$. at each corner atom share by 8 adjoined cube and one single atom present inside unit cell.

FCC :- In FCC corner atoms are shared by 8 adjoining cubes. each corner atom share by only two cube therefore

No. of edge $= 8$ and.
No of face $= 6 \times \frac{1}{2} = 3.$ } Total 4 atoms present fcc.

Hexagonal close Packed structures :-

No. of atoms at the corners are 12 and each atom is shared by 6 Hexagons and 2 atoms at the faces shared by two adjoining hexagons and 3 atoms are present inside the Hexagon, therefore $12 \times \frac{1}{6} + 2 \times \frac{1}{2} + 3 = 6.$

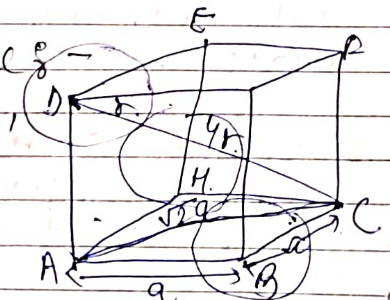
Atomic ~~Package~~ Packing factors :- (APF) is a ratio of volume of atoms per unit cell to total volume of unit cell.

Atomic Packing factor $= \dfrac{\text{volume of atom per unit cell}}{\text{Total volume of unit cell}}$

$$= \frac{\frac{4}{3}\pi \times \left(\frac{a}{3}\right)^3}{a^3} = 0.52.$$

Atomic Packing factor for BCC :-

Atomic Radius of BCC :
side of cube $= a$.
Radius of atom $= r$.



$DG = r + 2r + r = 4r.$
$AG^2 = AB^2 + BG^2$
$AG^2 = a^2 + a^2 \Rightarrow 2a^2$
$AG = \sqrt{2}a.$

$DG^2 = DA^2 + AG^2$
$DG = \sqrt{3}a$ — (2)
from (1) and (2)

$\sqrt{3}a = 4r$
$\boxed{r = \frac{\sqrt{3}}{4}a}$

Atomic Packing factor (BCC.) $= \dfrac{\text{volume of No. of Atom per unit cell}}{\text{Total volume of unit cell.}}$

$$\frac{\frac{4}{3}\pi\left(\frac{\sqrt{3}}{4}a\right)^3 \times 2}{a^3} = 0.68.$$

APF (FCC) :- $\dfrac{\text{volume of atom per unit cell.}}{\text{Total volume}}$

$$= \frac{\frac{4}{3}\pi r^3 \times (4)}{a^3}$$

Atomic radius $= \frac{\sqrt{2}a}{4}$. $= \dfrac{\frac{4}{3}\pi\left(\frac{\sqrt{2}}{4}a\right)^3 \times 4}{a^3}$

$= 0.73$

Coordination no. :- It is defined as no. of nearest atom atom directly surrounding a given atom.

It is 6 for SCC
It is 8 for BCC
It is 12 for FCC.

Crystal defects :- are three type

1. Point defect
2. Line defects
3. Surface defects.

1. Point defects :-
- vacancy defect
- substitutional defects.
- Interstitial defect
- Schottky defect
- frenkel defect)

1. Point defects :- vacancy defects, substitutional defect, intestion defects schottky defects, frental defects.

(a) point defects :- These defect take place due to impact packing of atom during crystallization this is due vibration of an atom at high temp.

(i) vacancy :- when one or no. of atom are missing from the normally occupied position these defect is called vacancy defect.

ii) substitutional defect :- when an foreign atom replace as parent atom the defect are these called as substitutional defect,

iii) Intestion defect :- When an extra atom occupied intersection space in the crystal structure they defect arises is called intsection defect.

iii) Shottky defect :- when a pair of position and negative ions are missing from a crystal structure the defects arised is called as schottkey defects.

(iv) Parental defects :- when An atom missing responsible for vacancy defects occupied interstitious position with in vacancy defects occupied ;

(ii) line defects :- A line defects may be define a defect which Take place due to displacement of atom along a line in a same direction. Having two type.

(i) edge dislocations :- when half plane of atom is inserted b/w Two planes of atom the defects arises is called edge dislocation.

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(b) Screw dislocation of Chapter- When atom are displaces in two seperate place perpendicular, to each other the defects arise is known screw dislocation.

(c) surface defects :- The defects which takes place on the surface of the material are called a surface defects.

(d) Grain boundary :- When the grain of different orientation seperate the general pattern of atom and have Boundary are called as grain boundary defects.

(ii) Twin Boundary :- When the arrangement of an atom of one side of the boundary is the mirror of arrangment of atom on other side, this defects is known Twin Boundary.

(iii) Stacking fault :- When stacking of atom is atom, is not in is called sequence through out out the crystall the defects is called staking fault.

* Deformation :- The changes in Demension

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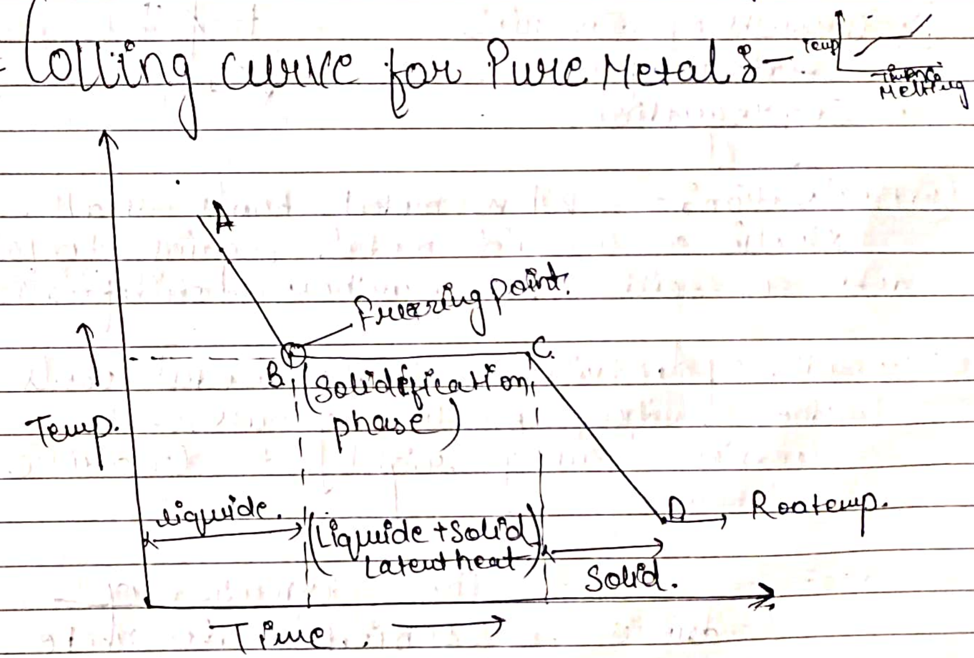
Chapter-3.
Metallurgy.

Metallurgy :- It may be define as the branch of science study of metal and there properties, their extraction processing understanding its physical and chemical properties.

Metal → Refine → Pure → Alloying element.

Iron → Chromium = stainless steel.
↳ carbide (Fe_3C) = cementite.
↳ carbon, tungsten and other alloying element = HSS

Colling curve for Pure Metal :-



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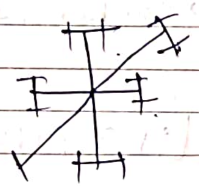
The cooling curve Plot temp. and time on y axis and x axis respectively with some variation in temp. as metal cools from molten state to room temperature the above diagram with ABC source of cooling pure metal.

* Dendritic Solidification of Pure metals:-

The process when the metal solidifies into structure with tree like branches is known as Dendritic solidification this occurs when metal cools and solidifies from molten state it occurs in four step.

1. Nucleation.
2. Growth of Dendritic.
3. Heat transfer.
4. Segregation.



1. Nucleation:- When metal cools small nuclie of a solid metal begains to fall acts as seeds for further solidification.

2. Growth of dendrities:- As the metal cools further these nuclie grows into dentries giving right to dendritic structure.

3. Heat transfer:- The formation of dendrities is subjected to rate of heat transfer if cooling rate is slow large dentries will ~~flood~~ form if cooling rate is fast smaller dentries will form.

4. segregation:- During solidification the components of metal may not solidifies at a same time which causes segragtaties therefore center of dendritic may be richer in certain element compared to surrounding solidifies material.

Effect of grain size:- The property of material is effected by its grain size and grain size smaller ~~in~~ metal and grain no. of grain boundaries if the grain size smaller in metal it is called as fine grain structure where as if grain size is bigger it is called cross grain structure.

Grain size have following effects:-

1. temperature at which it is heat.
2. Heating and holding temp. of metal in the furnance.
3. Rate of cooling.

The effect of grain size on Mechanical properties are as follow:-

(1) ~~Temp.~~ Fine grain metal are difficult to deform i.e. they have high yield strength, high tensile strength and more hardness.

(2) Fine grains metals have high toughness.

(3) Fine grains metals have high ductility and malleability.

(4) Coarse grain metal show better creep strength at elevated temperature.

(5) Coarse grain metal have better machinability.

(6) Fine grain metal possess better resistance.

(7) Coarse grain causes surface roughness. Coarse grain metal are difficult to polish.

Solid Solution :-
When two metals are completely soluble in liquid phase and retain the homogenity in solid phase also, the alloy was formed is called solid solution. Alloy

The solid solution is easy to form when solute and solvent size are similar and have same electron structure.

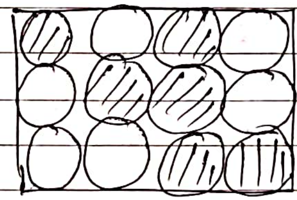
Example → Gold + silver, Au + Pt
Al + Ag. Gold + Platinum.
Cu + Ni
Copper + Nickel

Type of solid solution Alloy :- There are are two type of solution.

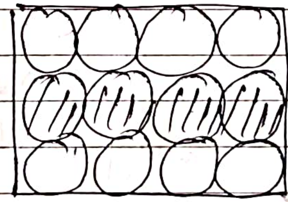
(1) Substitutional solid solution → Disordered, ordered.
(2) Interstitial solid solution.

Substitutional solid solution :- This type solution the atom of solute substitute atoms of in lattice structure of solvent it is of two types.

(a) Disordered substitutional solid solution :- In this type of solution the solute occupies random position in the solvent.



(b) Ordered substitution solid solution :-



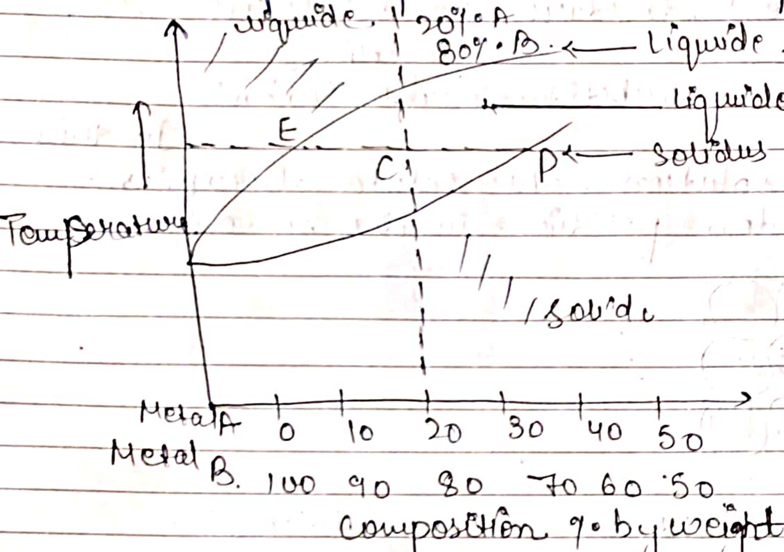
In this type of solid solution the solute occupied definite position in the solvent and form super lattice.

(C) Interstitial solid solution :- In this type of solution the solute atom occupies interstitial space of the solvent.

this type of solution is obtained generally when the size of solvent Example carbon in Iron. (C+Fe).

Interstitial Diagram.

Lever Rule :- is use to calculate % of each phase present in two phase region.



% of liquide phase present = $\frac{\text{Length of CD}}{\text{Length of ED}} \times 100$.

At point E there is 100% liquid and 0% solid.

A Thermal equilibrium :- (Diagram).

A thermal equilibrium diagram is a plot also known as phase diagram. It is a temperature composition diagram which indicate structure changes that takes place during heating and cooling of an alloy.

Important Term :-

1. System :- A body which is insulated with surrounding on which we analysis change in composition temp and Pressure and volume. component : the basic chemical substance is required to create a system is called system.

2. Phase :- The physically distinct ~~prop~~ portion of the system is called Phase.

3. Constituent :- The sepratable part of multiphase mixer is called constituent.

4. Liquidous :- It is the point at which crystallization starts. Locus of such points is called liquidus line. above this line the ~~liquide~~ Alloy is in liquide phase.

5. solidus :- It is a point at which crystallization ends and locus of point such as points is called solidus line.

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Below Solidus line the alloy is completly in Solidphase.

(6)

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Chapter-IV Metals and Alloys.
unit-III

Ferrous Metals:- Consist mainly of Iron with small amount of impurities as alloying element.
Example steel, carbon steel, Cast Iron, Pig Iron.

Non-Ferrous Metals:- The metal or alloys which doesn't contain significant amount ferrous in it are called Non-ferrous metal or alloys.
Example Al, Cu, Zinc, Gold, Platinum, Tungst

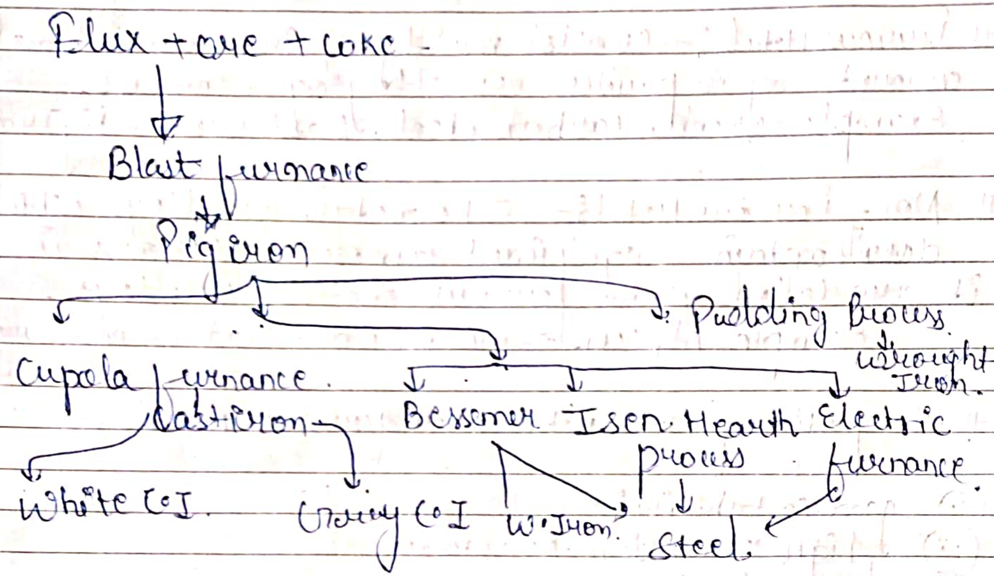
Properties of Non-Metal over ferrous Metals:-

1. good castability:-
2. high corrosion Resistance.
3. Low density.
4. Non-Magnetic properties
5. good Alloying properties. Example Al, Cu, Zin, Gold, Platinum, etc.

Iron Ores:-

Ore.	Form	Percentage (%)
Haematite	oxide (Fe_2O_3)	60-70
Magnetite	oxide (Fe_3O_4)	60-75
Lamonite.	oxide ($Fe_2O_3H_2O$)	40-60
Iron Pyrites.	Sulphide	30-40
Siderite.	Carbonates.	35-58

Flow Diagram for production of Iron and steel :-



Raw material for Iron (Fe) and Steel.

(1.) In iron and steel production Iron ore, coke, lime stone, (flux). is used.

(2.) The lime stone floats on the molten metal thus protects metal from oxidising.

(3.) To produced one ton of iron. 2 tons of ore, one ton coke, half ton of Lime stone are used.

(4.) To produced low carbon steel. carbon % is 0.25%.

(5.) For producing H.S.C.S. 0.5% to 1.25% carbon used.

(6.) Steel can be obtain by adding upto 2% of carbon in the Iron if carbon % increase from 2% it will give you cast iron.

(7.) Manganese. A small quantity of Maganese is added to this to remove un-wanted oxygen and also control sulphur.

(8.) Sulphur induced brittleness in the steel.

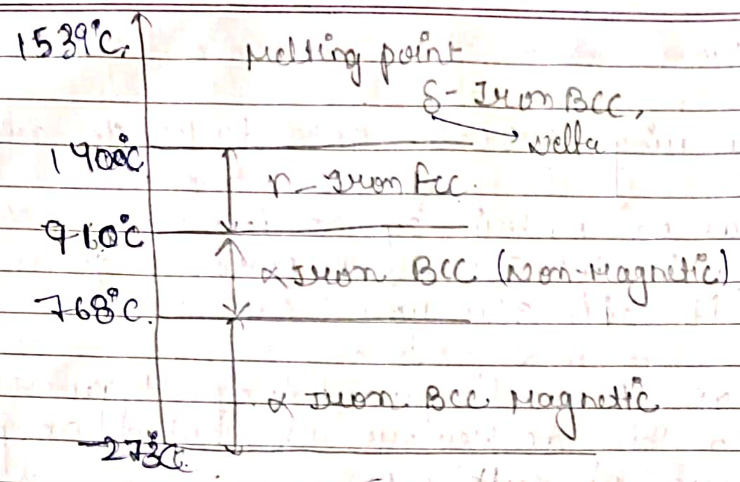
(9.) phosphorous. reduced ductility and limits cold working.

(10.) Sillicon. increase strength and toughness without reducing ductility.

(11.) To produced Medium carbon steel. 0.25%-0.5%.

Allotropic forms of Iron :-

δ - Iron → delta Iron.
α - Iron → Alpha Iron.
γ - Iron → Gamma Iron.



→ The phenomena of metal existing in more than one type lattice structures. (BCC, FCC) at different temp are called as Allotropes. Iron is an Allotropic metal having allotropic forms α-BCC Iron, γ Iron FCC, (δ) delta Iron BCC. Iron has a ~~metal~~ melting point of 1539°C.

→ Delta Iron (δFe) is soft and ductile ~~and~~ at 1539°C On cooling it at 1400°C its BCC structure is retain. but on cooling it further below 1400°C ~~an~~ its atom rearrange themselves in gama form which is having FCC arrangement and Non-Magnetic.

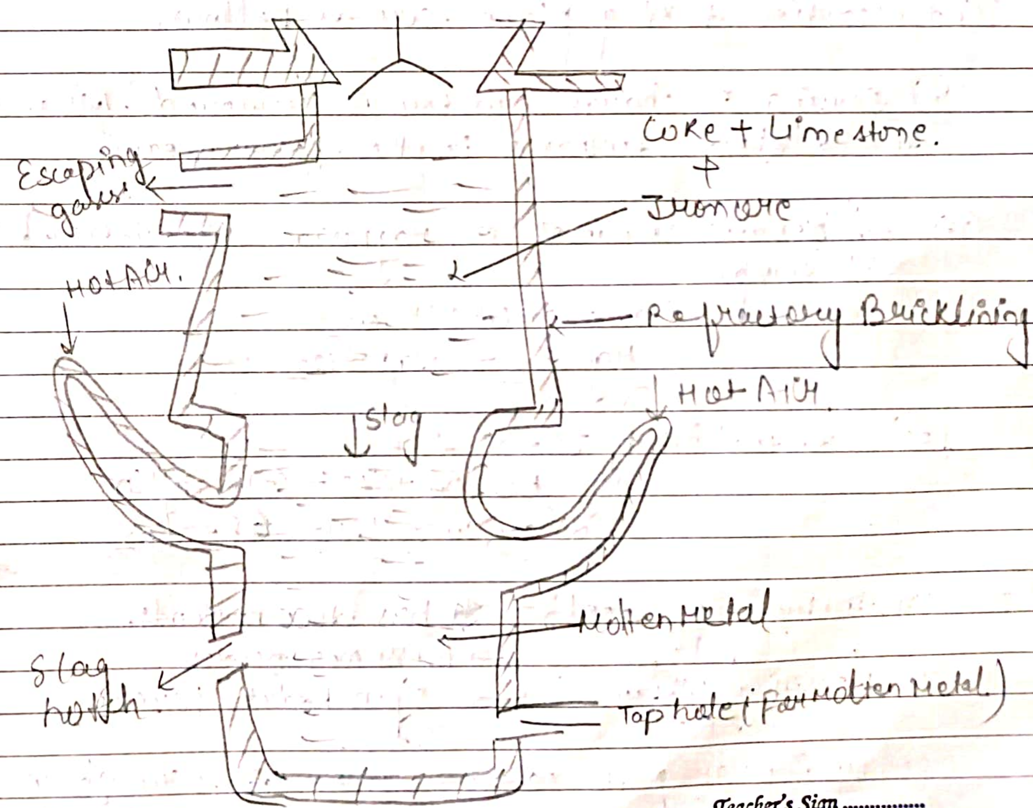
→ On its cooling further below 910°C Once again Iron converts into Alpha iron rearrange its stretcure back to BCC And Non magnetic on cooling it further below 768°C it becomes magnetic and retain its BCC Struc-

which is called as Alpha Iron.

Manufacturing of Pig Iron :-
Iron is produced in blast furnance, Molten state or cast iron. Pigs its called Pig Iron.

→ The Raw Material for Pig Iron are core, coke, Lime stone ($CaCO_3$).

→ Coke is use as fuel and lime stone.



→ A Blast furnance tall cylindrical. stack of steel plates. with Refractory line inside having height 15 to 30m. and diameter 4 to 6 meter the bottom of the stack holds the molten metal and slag.

Working of Blast furnance:-
A hot Air Blast of about 500 to 600°C is supply to the furnance at high pressure. this heats up the charge inside the furnance a proper quantity of Iron. Ore. flux and coke are supplied. ignites. the charge Blast.
The reaction taking place. are as follow.

1. Drying of charge, water is removed from the Blast furnance in the form steam.

2. carbonates, limes of Magnesia dissociates at high temp.

$$CaCO_3 \rightarrow CaO + CO_2$$
$$MgCO_3 \rightarrow MgO + CO_2$$

3. Reduction of Iron.

$$Fe_3O_4 + 4C \rightarrow 3Fe + 4CO.$$
$$2Fe_3O_4 + 4CO \rightarrow 6Fe + 4CO_2$$

Manufacturing of steel:- It has two methods.

1. Remaing carbon (from C.I) → Bessemer process, → Open hearth Process.
2. by increasing the carbon from . Wrought Iron.

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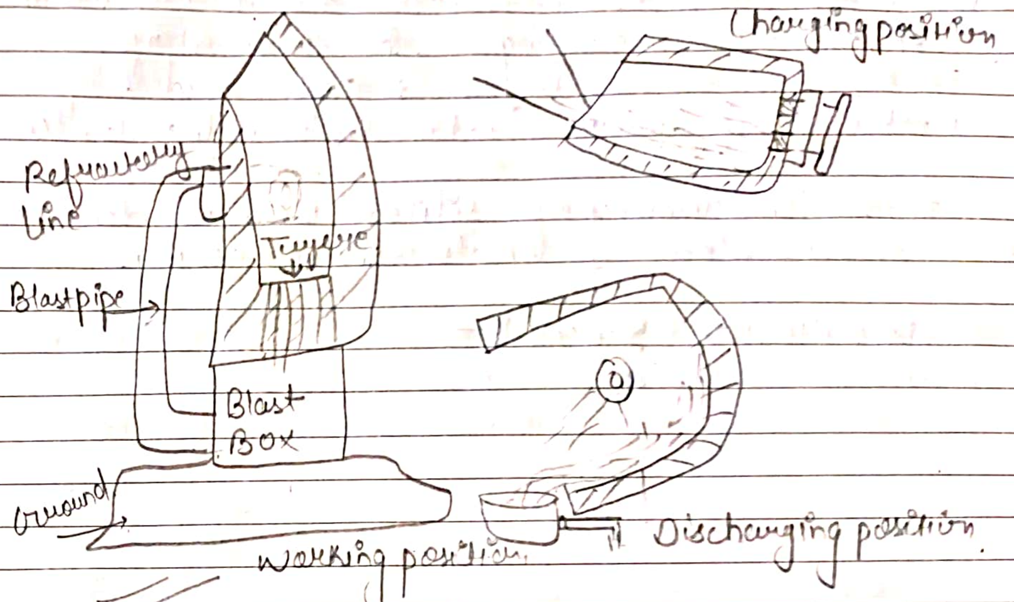
MS 0.15 - 0.25 WSH
MCS 0.25 to 0.5
HSS 0.5 to 1.5
2% Cast Iron
Max 6.67%



Bessemal process and steel Manufacturing:-

1. It is process of Manufacturing of steel in which a large pear shape vessel with refractory Brick lined is used.
2. It is charged/filled with Molten cast iron in h/z position.

→ Sillicon is oxidised. to sillica which form Slag.

→ The ferric oxide form due to oxidation of Iron. removes. carbon monoxide. which burns. with yellow flame at the.

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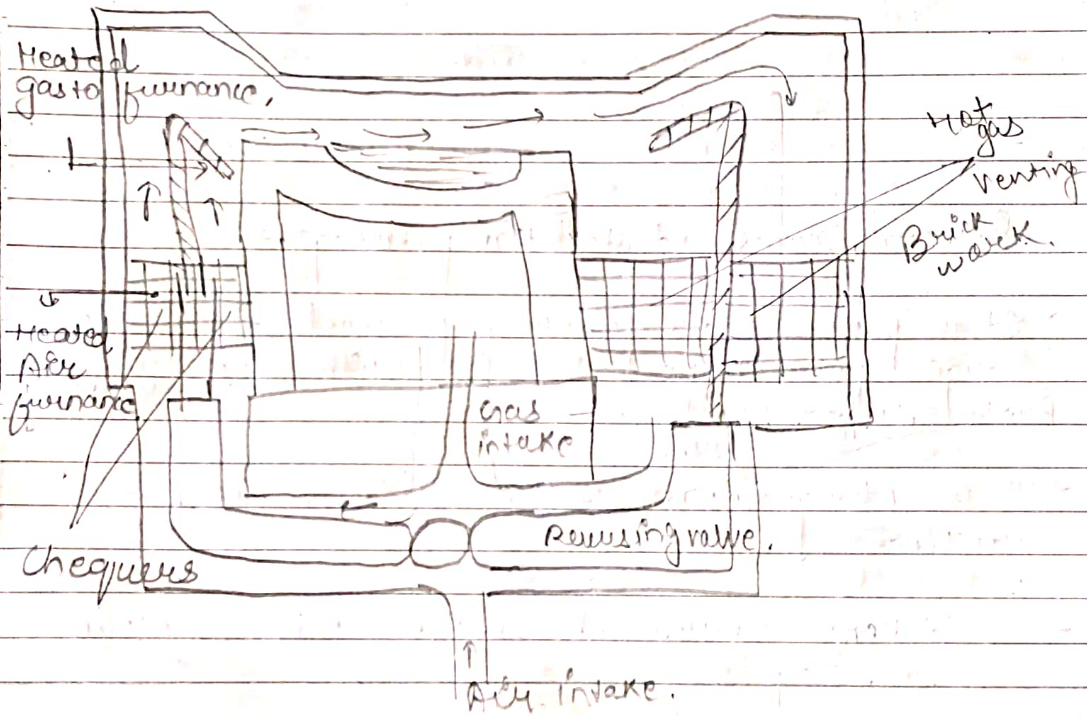
mouth of vessel. after 6 to 8 min the flame extinguishes Indicating the removal of carbon. Now vessel is tilted and molten metal poured into ladles.

A small quantity of silicon is added to remove blow holes during casting.

Open Hearth process :-



The steel manufacturing can also be done in open Hearth furnance it a large flat crucible enclosed in a furnance. It is heated by producer gas $(N_2 + CO)$. the air and gas are supplied through seprate Hearth having sillica lined lining in it. the required amount of cast iron is added to the crucible. And the portion of carbon is burn resulting in molten steel. and molten steel poured into ladle by tilting the furnance. this process of manufacturing of steel is widely used.

Cast Iron :- Cast iron is obtained by copula furnance. in which Pig iron along with coke and lime stone is use to produced cast iron. the percentage of carbon in cast iron is very strong 2% to 4.3%.

The carbon in cast iron may be present in two forms.

(a) Free carbon or graphite.
(b) Combined carbon or cementite.

Properties :-

1. good machineability.
2. good damping properties
3. High compressive strength.
4. Low cost.
5. Good wear Resistance.

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Types of cast Iron :-

1. Grey cast iron.
2. White cast iron.
3. meallable cast iron.
4. Alloy cast iron.
5. Nodular cast iron. / Spheroidal.

1. Grey cast iron :- The carbon is present in free form of graphite. It is grey in colour, the carbon in combined form is about 0.3 to 1%.
Total carbon present in grey cast iron is about 2.5% to 3.8%.

- It has higher of wear resistance.
- good vibrations damping properties.
- high compressive strength
- good thermal conductivity.
- Low ductility.
- have corrosion resistance.

Uses :- Machine tools, beds, cam shaft Atuomobile, clutch plates and breaks drums, cylinder blocks and heads. Gas, water pipe lines or underground purpose

2. White cast iron :- 1. All most all carbon is in the form of cementite (Fe_3C)
2. It is very hard and brittle.
3. Carbon percentage in white cast iron varies from 1.8% to 3.6%.

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Properties :-
1. It is very hard therefore expect hard to Machine.
2. It is brittle. high wear resistance.
3. It is made up of white cast iron casting made using sand moulding.

Uses :-
1. It is use for making meallable cast iron.
2. For making grind mills parts.
3. It is use for shot blasting equipments
4. It is use for making cement brick plant equipments.
5

#3 Meallable cast iron :- is obtained by suitable Annealing of white cast iron in which the combined carbon precipitate graudually into free carbon or graphite and then carbon content is reduce to 2%. it can be done by two process

1. White heart process
2. Black heart process.

1. White heart :- It has carbon 2 to 3%.
properties
- High yield strength
- Low (Alpha) coefficient of thermal expansion.
- Good wear Resistance.
- vibration damping.
- Moderate cast.

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Uses :-
1. Fitting of gas, water, Air, steam pipelines.
2. Agriculture Equipments.
3. Conveyor Belt.
4. Automobile gear, Axle casting.
5. Wheel hubs.
6. Railway coupling.

1. Nodular cast iron :- It is also called ductile cast iron. It is obtained by adding magnesium into molten grey cast iron which convert free graphite into nodular form spheroidal from the carbon in spheroidal cast iron varies from 3.2% to 4.2%.

* Properties :- 1. It has good strength and toughness.
2. good ductility.
3. good damping properties in compare to grey cast iron.
4. high castability.
5. good Machineability wear resistance.

* Uses :- It is use Naryan casting, locomotive and Railway truck parts Hydraulic cylinder and pump ~~vases~~ valves, parts and body of electric motors.

Steel :- is an alloy of iron and carbon with carbon content up 1.5% in combined form cementite carbide. carbon
The other element such as silicon sulphur phosphorous are also present.

Plain carbon steel :- The carbon present in plain carbon steel varies from 0.05% to ~~...~~ 1.5% carbon. It is divided into three categories.

- Low carbon steel (Mild steel)
  - Dead Mild steel (0.05 to 0.15 carbon)
  - Mild steel (0.15 to 0.3% carbon)

- Dead steel :- • It is soft and ductile.
  • It can not be mlc well due to its softness.
  • It has tensile strength of 390 (MPa or N/mm²

- Mild steel :- • It is harder than dead steel.
  • It can be easily welded and Machin.

Uses :- 1. It is use for structural section.
2. Plates.
3. steel casting.
4. cam shaft.
5. Fan Blades.
6. Railway Axles.
7. Fish Plates.

Medium carbon steels - when carbon content in the steel is b/w 0.3%. to 0.7%. this type of steel is b/w 0.3% to 0.7 %. this type of steel is called Medium carbon steel.

- It is harder and stronger than mild steel but less ductile
- As the carbon % increases hardness increases and ductility increases.

Uses -

1. It is use for its load Bearing capacity and Resistance abrassion
2. It uses for connecting rods.
3. gears shaft
4. Clutch disc
5. Screws.

High carbon steels - when % of carbon is b/w 0.7%. to 1.5% steel is known as high carbon steel,

- It is harder than medium carbon steel.
- It is less ductile then medium carbon steel,
- As the carbon content increases in the steel its toughness decreases and hardness increases.

Key point - Brittleness $\propto \frac{1}{\text{toughness}}$

- It is difficult to weld and Machining (operation),

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Uses - • Press tools
- Remmers.
- Saw (Metal cutting)
- Twisted Drills

EFFECT OF VARIOUS ALLOYING ELEMENT :-

1.) Aluminiums - It produces fines grains. It helps in providing surface toughness and hardness in nitriding for heat treatment

Key points - Nitriding is process of surface harding by heat treatment.

2.) Carbon - Imparts hardness and Brittleness
- Reduce ductility and toughness
- Impart corrosion Resistance.
- Increase tensile strength.

3.) Chromium - • corrosion Resistance.
- It increases strength of steel

4.) Phosporous - It reduce ductility.

5.) Maganese - • It increase unwanted oxygen
- It help in reducing brittleness due to sulphur

6.) Nickel - • It increase toughness and impact Resistance.
- Strength the steel

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Imp Silicon :- It increase machinability also toughness increase.

Special Steel :- high speed steel.
this type of steel have high hardness and suitable for high speed machine.
It category in three types.

* 18-4-1 HSS.
* Molybedenum HSS
* Super high speed steel.

* 18-4-1 HSS :- It contain 18% toughness 4% chromium, 1% vanedium, carbon 0.75%

uses :-
- used for single point cutting tool,
- tool for lathe, shaper and plainer.
- Drills Reamers.
- Broches
- Threading dies and punches,

* Molybedenum :- • Molybedum 6% tungusten 6%. 4% of chromium and 1% vanedium.
- It has excellent toughness and relatively cheaper than other type of steel.

- uses :- • It is use for high speed cutting.
  - It is use for drills and tapping tools.

* Super high speed Steel :- It is also known as cobalt high speed steel, It has tugsten 20%, 4% of chromium and vanedium is 2% cobalt is 2 to 15%.

uses :-
It heavy cutting operation.
It is use for cutting sand casting cast iron and heat treated steel.

Properties of high speed steels :-

1.) They have excellent hardness
2.) They have good wear resistance.
3.) They have fair machinability properly
4.) They have good non-~~deformatio~~ deforming property
5.) They have good resistance to decarburation is poor,
6.) They have good shock resistance.

Stainless steels :- It ~~is also~~ the name subject Steel is a special steel that has high corrosion resistance this is due to high amount of ~~corrosi~~ chrominum the chrominum in the steel react's with oxygen form a layer of chrominum oxide on the surface. this ~~restrictio~~ restricting rusting and staining.

Dt. Page

Types

(1) Stainless steels - It is classified into three types.

(i) **Austenetic S.S.** -
In this steel chromium added along with nickel. The nickel helps in stabilizing the austenitic structure at room temp. It is denoted by 18-8 stainless steel. 18% chromium and 8% nickel.

Uses - It is use in pump shaft ~~utensils~~ food cans cooking utensils.

(ii) ~~Feraadic stainless steel.~~

(2) **Feritic S.S** - This steel has good heat resistance due to silicon in it. as alloying element percentage of silica about 3%.

Uses - It is use for lining of petroleum industry.

- heating element for furnances.
- Heat exchanger in power plant.
- Surgical instrument.

(3) **Martensitic S.S.** - It has chromium content as well as carbon. The % of carbon is about 0.2% to 1.2%. The carbon dissolves in Austenitic and on quenching gives Martensitic structure. thus have martensitic structure.

\# Uses - It is use for spring pump and values parts turbins Buckets Rules and tapes.

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1H M,MD Unit - 3, 3

Dt. Page

Thursday.

Que1. Importants of S.S Critecality
(A) life cycle cost
(B) corrosion impact
(C) Why it is different from other steel.
(d) per capita consumption.
(e) growth rate.

Que2. Various grades of stainless steel and its nomen-clature.

201
301
321
304.
316

Que3. Effect of alloying element in stainless stee[l] Nickel, Cr, Mn, Carbon, Nitrogen.

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Assignment

Ques. Effect of various Alloying element?

Ans. 1.) Aluminimum :- It produce fines grains. It providing surface toughness and hardness.

2.) Carbon :- Imparts hardness and Brittleness
Reduce ductility and toughness.
Impart corrosion resistance.
Increase tensile strength.

3) Chromium :- corrosion resistance.
Increase in strength in steel.

4.) Phosphorous :- It reduce ductility.

5.) Maganese :- It reduce unwanted oxygen, It help in reducing brittleness due to sulphur.

6) Nickel :- It increase toughness and impact Resistance and strength of steel,

7.) Silicon :- It increase Machinability and toughness.

Ques 2. Importants of S.S criticality.

1. Life cycle costs :- Stainless steel may have higher initial cost compared to other steel. but its corrosion resistance life cycle is often lower due to its corrosion resistance and durability.
Stainless steel requires less maintenance compared to other steel. Stainless steel has a longer lifespan compared to other steel.

Differences from other steel.
1. Corrosion resistance due to its chromium content (forms protective layer)
2. good strength and durability.

Growth Rate.
1. Global demand for S.S is expected to grow at a rate of 3-4%
2. Industry demand for S.S also varies by Industry with the largest consumers being automotive, construction and consumer good sector.

Corrosion impacts :-
Corrosion costs
Safety risk,
Environmental impact

Q.2. Various grades of Stainless steel and its Nomenclature. 201, 301, 321, 304, 316

Stainless steel is classified into various grades based on its composition and properties. The most common grades are identified by a three digit numbering system, such as 304, 316, 201, 321 and 301.

1. Grades 304 (Austenitic) composition 18-20% Chromium (Cr) 8-10.5% Nickel (Ni)

Properties : Excellent corrosion resistance, good weldability and formability.

2.) Grade 316 (Austenitic)

Composition 16-18% Chromium (Cr) 10-14% Nickel (Ni) 2-3% Molybdenum (Mo)
Properties High corrosion resistance.

3.) Grades 201 (Austenitic) low nickel.
Composition 16-18% Chromium (Cr). 3.5-5.5% Nickel (Ni) 5.5-7.5% Manganese (Mn).

Properties low cost alternative to 304 less corrosion resistance Manganese (Mn), Stronger than 304.

4.) Grade 321 (Austenite Stabilized).

Composition 17-19% Chromium (Cr) 9-12% Nickel (Ni), Titanium (Ti) Stabilized
Properties : Improved resistance to corrosion.

5.) Grades 301 (Austenitic - High Strength).

Composition 16-18% Chromium (Cr) 6-8% Nickel (Ni)

Properties Higher strength and hardness, good corrosion resistance but lower than 304

Unit IV – Heat treatment

It may be define as heating of metal or alloy on its solid state towards specify temp. and then holding at that temp. then cooling it at suitable temp.

Objectives of Heat treatment:-

1.> To improve strength and hardness.
2.> To improve ductility and toughness.
3.> To improve machinability.
4.> To soften the material for further working as in working and wire drawing.
5.> To improve resistance to heat and corrosion and shock.
6.> To effect a change in grain size.

Micro structures:-

1.> Ferrite:- is a solid solution of iron and carbon (BCC α iron).

- It contain's 0.025% of carbon
- It is soft and ductile.
- Wrough iron has major constituent of ferrite.

1.> Cementite:- It is Hard compound (Fe_3C)

- It contain carbon about 6.6% by weight
- It is having low tensile strength.

3.) Pearlite :- It contain 0.8% carbon and is strongest constituent of steel.

4.) Austenite :- It is solid solution of Iron and carbon having FCC structure (γ Iron). It contain maximum 2% of carbon. It is non-magnetic. It is unstable at room temp - 1400°C.

5.) Martensite :- It is hardest constituent of steel. It is niddle like structure. It is form due to quenching (rapid cooling).

6.) Troostite :- It is obtained by tempering of martensite below 450°C

Annealing :- It is define as softening of place is which the metal is ~~heated~~ heated to Austenite phase. hold at that temp. for some time so that internal recovers and then cooled slowly when internal chages stabilize.

* Purpose for Annealing :-

- To soften the material and improve machining.
- To refine grains and provide Homogeneous structure.
- To release internal stresses.
- To improve cold working and further process.

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Delta type Annealing :-

1.) full annealing.
2.) Speroidise Annealing.
3.) Homogenesy or diffusion Annealing.
4.) Isothermal Annealing.
5.) process Annealing.

2.) Normalising :- is done refine the structure of steel and improve its machinability, tensile strength structure. and to remove cold working strain.

The objective of normalising.

1. To obtain uniform structure.
2. To refine internal structure.
3. Improve structure of weld.
4. To improve desired strength and ductility for machine.
5. To improve harder and stronger.

Process :- T 40 to 50°T upper critical point

Holding time → 15 minute.
final → Sorbite + ferrite.

In this steel is heated at above at 40° to 50°T critical point it is hold at this point temp for 15 min It is ~~hold at~~ then cooled

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to room temp. In the still air there for the final structure of the steel will be sorbite + ferrite

(Quenching).

3.) Hardening :- It is a heat treatment process to increase the hardness by Rapid cooling of Austenite phase.

→ For Rapid cooling three types of cooling medium are used.

(a) water.
(b) Brine. (H_2O + salt)
(c) oil

Purposes :- 1. To increase hardness of the part.
2. To enable the steel to cut of other metal (tool steel)
3. To make parts resistance to wear.
4. To improve toughness

Process :- In Quenching the steel is heated to a temp. 30 to 50 above critical temp.
holding it at that temp. for about 15 min. Coolined get rapid in suitable medium.

4.) Tempering :- It is a heat treated process in which externally hard and brittle steel is soften and it toughness is increased.

Dt.
Page

Purpose - The steel hardent by quinching process is very hard and Brittle therefore it also contain's internal stress therefore to remove there internal stress the tempering is done.

1) To rescle internal stress.
2) To improve ductility.
3) To reduce Hardness and Brittleness.
4) To improve toughness.

Process - The process of tempering involve reheating the hardent steel to be temp - at for about 3 to 5 min - for each mm of thickness and the cooling it at room temp as desired rate.

5) Surface hardnings - It is necessary for mlc part to possess hard, wear resistance surface also should have high toughness to with stand shock to achieved this only surface layer of particle such as gear, ball bearing railway wheel, are hardend.

following are surface hardning process :-

1) Carburizing.
2) Nitriding
3) Cyaniding.

1) Carburizings - In carburizing low carbon steel is heated above critical range in.

Spiral

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a carbon rich material in ordore to reproduce carbon in the surface of alloy either by diffusion or obsorbtion.

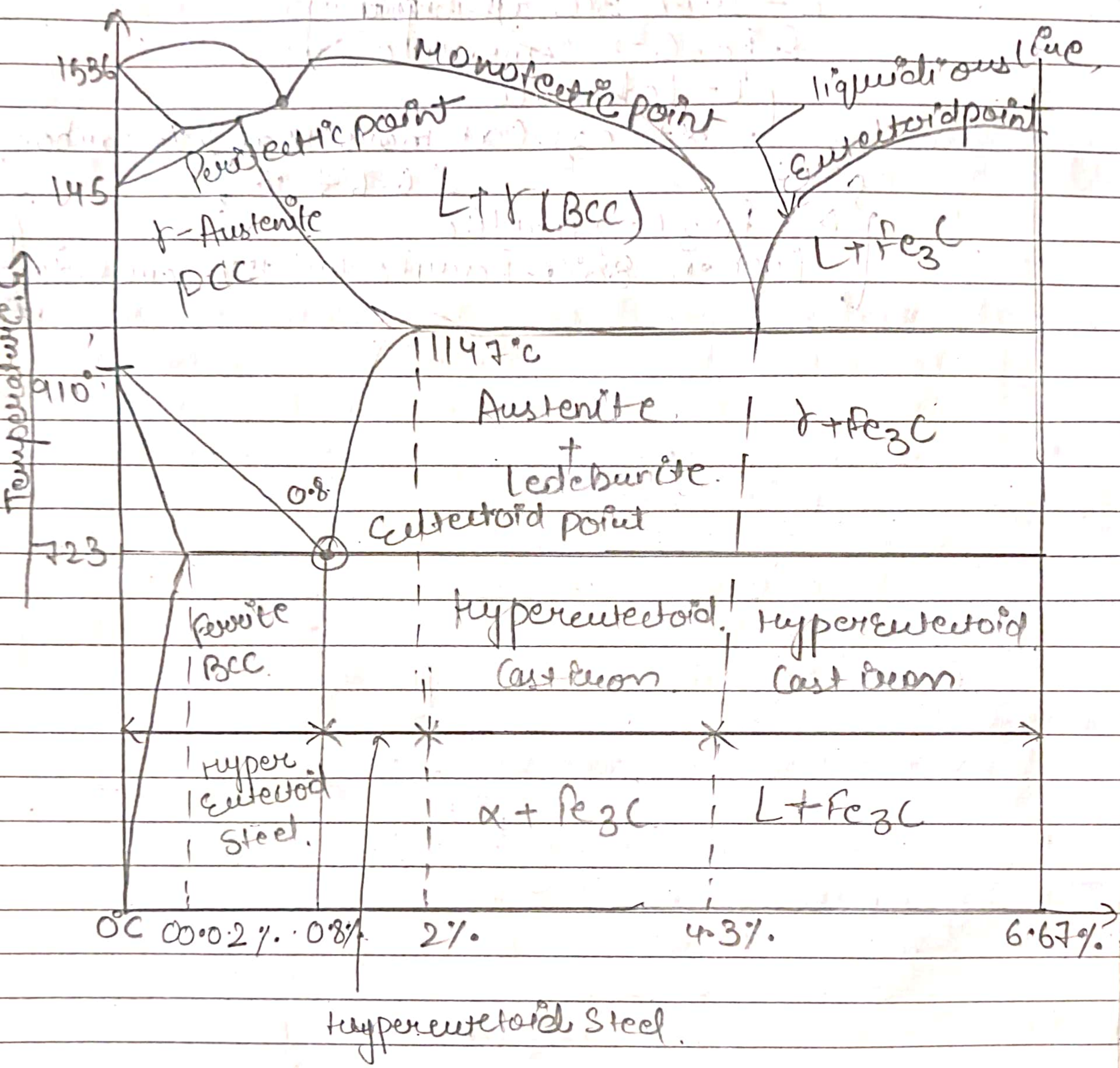
It can be done by there types:
- pach carbonining
- liquid "
- Gas "

(2). Nitriding :- It is a surface harding process in which wear resistance surface can be produced by absorbtion of Nitrogen in certain type of steel. and quenching is not required.
Alloying element like chromium and alluminium hard. nitrides are which improve surface hardness. the plain carbon steel is not suitable for nitriding as Iron Nitrides are Brittle.

Process :- The specific heat preheated
1. The sequence.
2. oil harding
3. tempering
3. Rough Maching.
4. stabalizing.
5. Anealing. to remove internal stress.
6. Finishing machining followed by nitriding.
7. the finish product is placed in Air tigh heat resistance fill with.

NM Important

Iron carbon diagram



Composition (% (by weight)

α - Iron - BCC (Ferrite)

γ - Iron - FCC (Austenite)

δ - Iron BCC at hightemp

$Fe_3C \rightarrow$ Cementite.

L - Ledeburite.

$\alpha + Fe_3C$ (at more than 2% carbon.

< 6.67 %)

$\alpha - Fe_3C \rightarrow$ Pearlite

(when 88% Ferrite and 12% cementite)

Properties:-

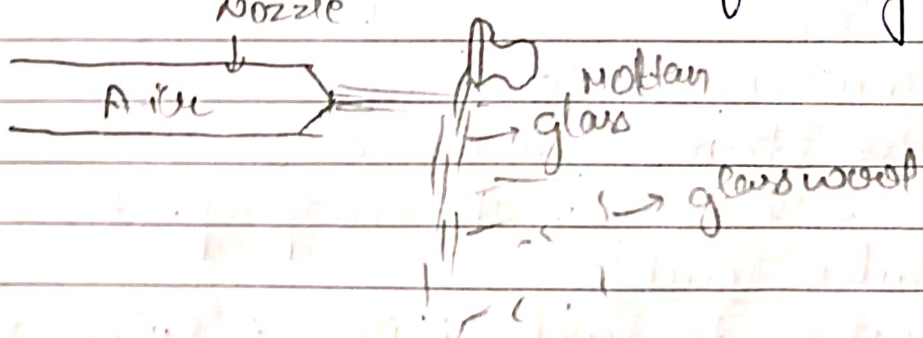
1. Resistance to heat and fire.
2. It has high coefficient of friction.
3. It has high mechanical strength.
4. Insulator of Heat, sound and electricity.

Uses:-

1. It is use break lining due to its coefficient of friction.
2. For making fire proof suit and curtains and suits.
3. For insulating furnance and Boilers.
4. For making electrical insulation.

*. Glass wool:-

It is made by Blowing high temp. stream of air on molten glass. the molten glass scatters in all direction forming glass wool.



Properties:- 1. It is a insulator of heat fire.
2. fire resistance
3. Resistance to moisture.
4. Good insulator of heat and electricity.
5. has high strength to weight Ratio.

Dt. Page

Uses :- (1.) It is use a Electrical Insulation Material.
(2.) It is use: as Heat Insulation Material. Glass wool blanket are used for sound
(3.) Insulation.
(4) Glass wool mats are used as plate seperator in Batteries.

Thermocole :- • The Chemical name is polystrene.

- Thermocole is its trade name.
- It is developed during II world war by USA
- It is manufactured in India since 1956.

properties :-
- It has snow white colour.
- It is oderless.
- It has Good heat insulation up to 20°C
- It is light in weight.
- High Resistance to moisture.
- Imp Good shock absorbtion properties
- Chemically stable.
- Resistant to salt, Acids Alkalies etc.

Uses :- It is use in making Models.
It is use in Packages.
It is use in helmets.
It is use in Refrigrators.
It is use to protect glass.

Teacher's Sign ....

Spiral

Dt. Page

* Refractory Materials :- → Dolomite. → Procelain.

The materials having high heat resistance or which can withstand high temp. are called as refractory Materials.

(a) Dolomite :- • It consist of carbonate of calcium and magnesium.
- It Bricks made up of Dolomite have low conductivity.
- It is used in open hearth furnace.
It is formula $CaMg(CO_3)_2$

Properties :- 1. It's fusion temp. is about 2300°C.
2. High resistance to thermal shocks
3. They are cheaper then Magnisium Bricks.
4. They have good strength.

Uses :- 1. use in preparing of open hearth furnace.
2. It is use in Inner lining of furnace having Basic slag.

* glass :- A glass is a transparent material made up of silica.
- It is an amorphous solid.
- It is an inorganic high polymere
- glass in addition to silica may contain Oxides of sodium potasium calcium magnesium ~~etc~~ etc.

Teacher's Sign ....

Spiral

Dt. Page

* Types of glass:-
1. Soda lime glass
2. Potash lime glass.
3. Lead glass
4. Boro silicate glass
5. Safety glass
6. Toughened glass.

1.) Soda lime glass:- Soda glass is also known as glass it contain silica, lime stone and soda ash. (Na_2O) It is cheaper and It has low melting point. It has poor resistance to acids. It is use in window glasses, Bottles etc.

2.) Potash lime glass:- Silica (SiO_2), lime stone (CaO), potassium oxide (K_2O). It is resistant to Acid, Bases. It is costly than soda glass.

- Used for testing Apparatus generally for heating chemical labs.

3. Lead glass:- (PbO) lead oxide, Silica (SiO_2), Potassium oxide (K_2O)

- It is also called as flint glass.
- It is bright, lustrous.
- It has high refractive index.

Use:- for table wares, optical lense, Cathode Ray Tubes, Prisms, Artificial Gems.

Spiral Teacher's Sign ....

Dt. Page

(4.) Borosilicate glass:- It is also called as pyrex glass or Jena glass.

- Contains silica (SiO_2), Borax B_2O_3, Alumina, potassium oxide K_2O, sodium oxide Na_2O.
- Have low ~~therm~~ thermal coefficient of Expansion denote (α)
- High Chemical resistance.
- Used for Labotory, Apparatus, kitchen wares, Electrical Insulators.

(5.) Safety glass:- It is combination of vinyl plastic and glass layers sandwiched together. The layer of glass and vinaly plastic to are subjected of high pressure and Temp. giving rise to a strong glass with enhanced safety. This glass will not scattered on breaking thus reducing the risk of injury.

(6.) Toughen glass:- (1.) It is also called as tempered glass (2.) It is a glass produced by controled thermal and chemical treatment so to increase strength as compared to ~~oral glass~~ normal glass

(3.) It has high shock resistance.

(4.) when It breaks it does not fly but Scatters in small pieces.

(5.) It is used in cars, trucks, Aeroplane, window of small furances

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