MUFFAKHAM JAH COLLEGE OF ENGINEERING AND TECHNOLOGY
MECHANICAL ENGINEERING DEPARTMENT

List of Experiments for A.Y 2021-22

1. **Metallographic Study of Low Carbon Steel**
2. **Metallographic Study of Medium Carbon Steel**
3. **Metallographic Study of Grey Cast Iron**
4. **Metallographic Study of Malleable Cast Iron**
5. **Metallographic Study of Brass**
6. **Metallographic Study of Aluminium-Silicon Alloy**

ETCHING SOLUTIONS

1. **Steel:**

   [4% Nitric Acid + 96% Methyl Alcohol]

2. **High Carbon Steel/Cast Iron:**

   [2% Nitric Acid + 98% Methyl Alcohol]

3. **Stainless Steel:**

   [10% HCl Acid + 10% Nitric Acid + 80% Water]

4. **Brass/Phosphorus Bronze:**

   [5% Hydrogen Peroxide + 5% Ammonium Hydroxide + 90% Water]

5. **Aluminium/Copper:**

   [2% HCl Acid + 98% Water]

INSTRUCTIONS

1. Please take care while handling the specimen. Avoid finger marks on the polished and etched surface of the specimen. Avoid scratches.
2. Carefully Polish the specimen to the sequence of polishing.
3. Use the correct etchant as per ASTM/BS standards.
4. Store the specimen in the desiccated boxes, when not in use.
5. Do not wipe the etched surface.

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M E T A L L O G R A P H Y

INTRODUCTION TO METALLURGY

This course is primarily designed for Mechanical Engineering students to impart the applied knowledge of **Metallurgy**. This course deals with study of metallography and relate the properties of the materials using image analyzer for normal and heat-treated metals and alloys.

Metallurgy is term derived from Greek. It is the combination of metallon and Ourgia. The Greek meaning of metallon is metal and Ourgia mean working. Metallurgy is an art and has been practical since ancient times, Metallurgy is the science and technology of metals, it is the science of obtaining metals from their ores, including mining. extraction, Concentration, and refining of metals and alloys is known as extractive or process metallurgy. The science concerned with physical and mechanical characteristic of metals and alloys is known as physical metallurgy. This field studies properties of metals and alloys as affected by their variables.

Classification of Metallurgy

1. Process or Chemical or Extractive metallurgy
    a). Pyro metallurgy
    b). Hydro metallurgy
    c). Electro metallurgy
2. Physical metallurgy
3. Mechanical metallurgy

1. Process or Chemical or Extractive metallurgy:

It is a science of obtaining metals from their ores including mining, concentration, extraction and refining and formation of alloys. The chemical Constituents of an alloy.

2. Physical metallurgy:

It is a science concerned with the physical and mechanical characteristics of metals and alloys. It includes Metallography, material testing. Property modification process such as heat treatment of metals and alloys.

3. Mechanical metallurgy:

It deals with working and shaping of metals and alloys. Any operation that causes a change in shape such as rolling, drawing, forming or machining etc.

Mineral: A mineral is a naturally occurring material which contains metal either in native state or in combined state.

Ore: A mineral from which a metal can be profitably extracted.

Concentration of Ore: The process of removal gangue from the ore is called concentration.

Gangue: the earthly impurities like sand, rock and clay associated with the ore are collectively known as gangue.

Flux: A substance added to convert the gangue in to fusible mass is called flux. The flux may be basic flux (Cao)and Acidic flux (Silica).

Slag: A non-metallic product resulting from the mutual dissolution of flux and refining operations. Slag = Flux + gangue.

Refractory material: The substance which can withstand very high temperature without melting or becoming soft, they are acidic basic neutral (graphite chromites,)

Refining: The process of removal of impurities to obtain pure metals is called refining. It may be liquation, distillation, poling, cupellation and electrolysis.

Furnaces: A furnace is a device designed for generation and central of heat. The metallurgical furnaces are kiln, hearth, puddling furnace, reverberatory furnace, blast furnace open hearth furnace, Bessemer convector L, D, converter, electric arc furnace rotary furnace, muffle furnace salt bath furnace, pit furnace, oil or gas fired furnace and cupola furnace.

Charge: It is a mixture of the ore, flux and fuel,

Cup and cone arrangement: It is a self-regulating system to introduced the charge in to blast furnace.

Alloy: An alloy is a substance which has metallic properties and is composed of two or more chemical elements out which at least one is a metal.

Phase: A phase is anything which is homogeneous physically distinct and mechanically separable,it may be gaseous, liquid and solid.

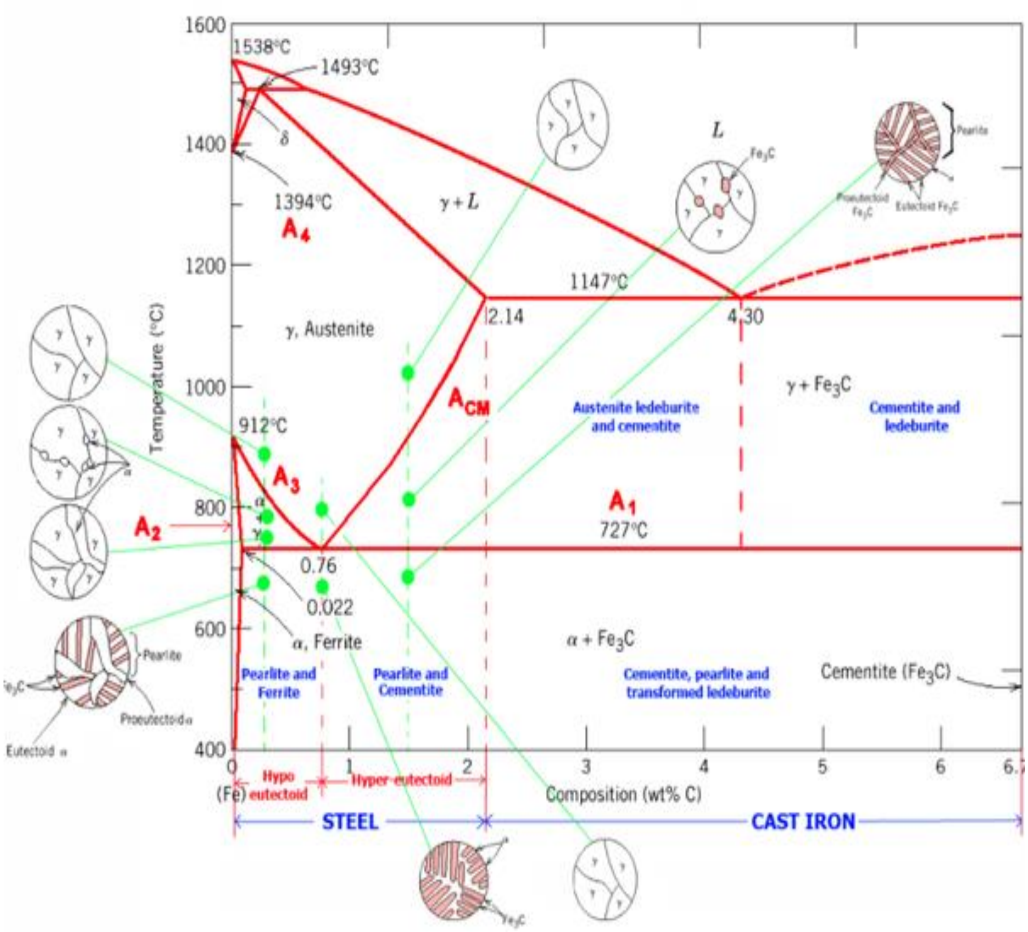
Crystal: "A solid composed of atoms, ions or molecules arranged in pattern which is repetitive in three dimensions".

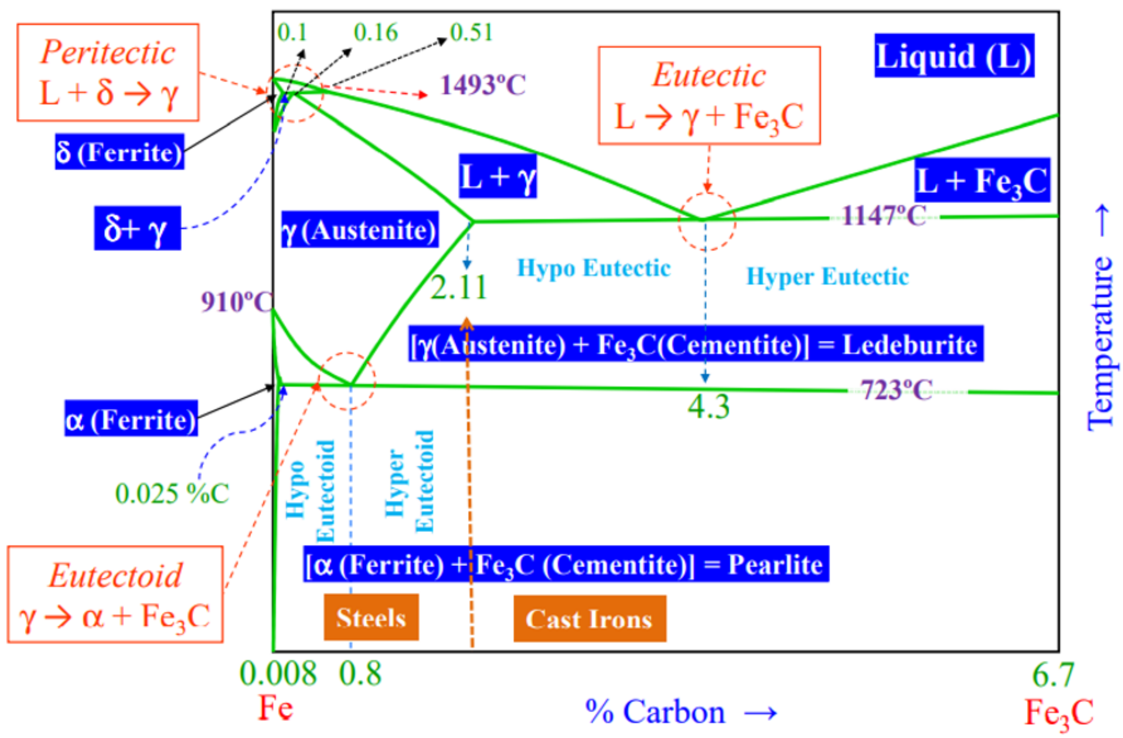
Polymorphism: - It is the property of material to exist in more than one type space lattice in the solid state, it isa non-reversible phenomenon.

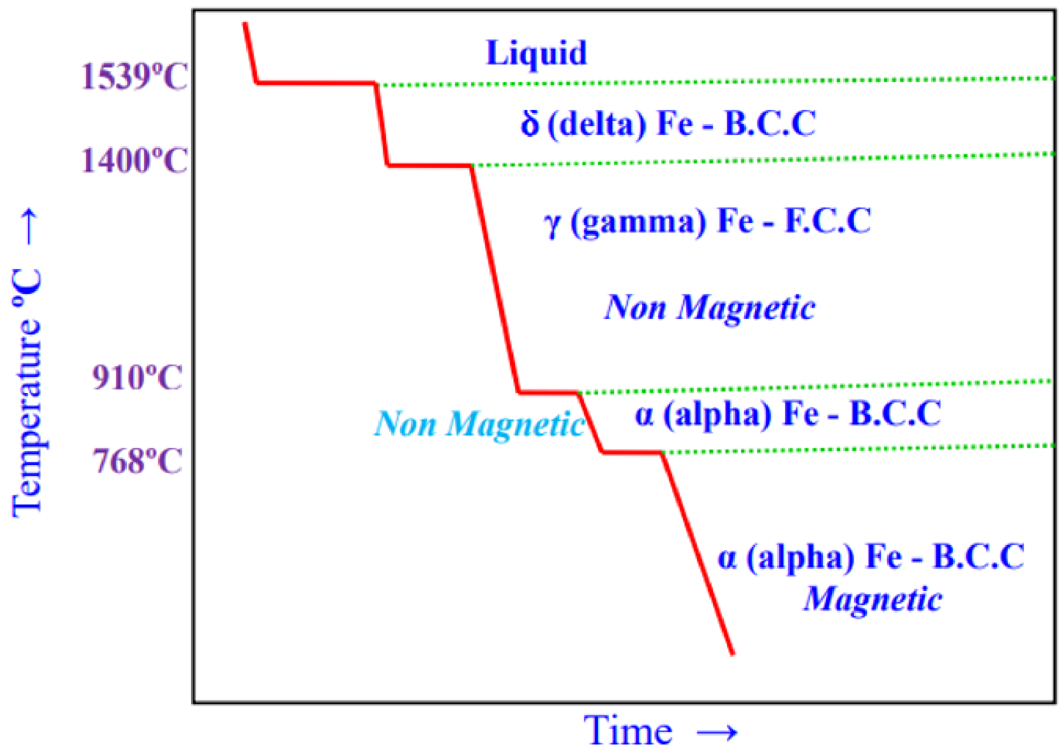
Allotropy: - The reversible phenomenon of existence of certain metals in more than one crystal structure alpha iron, gamma iron.

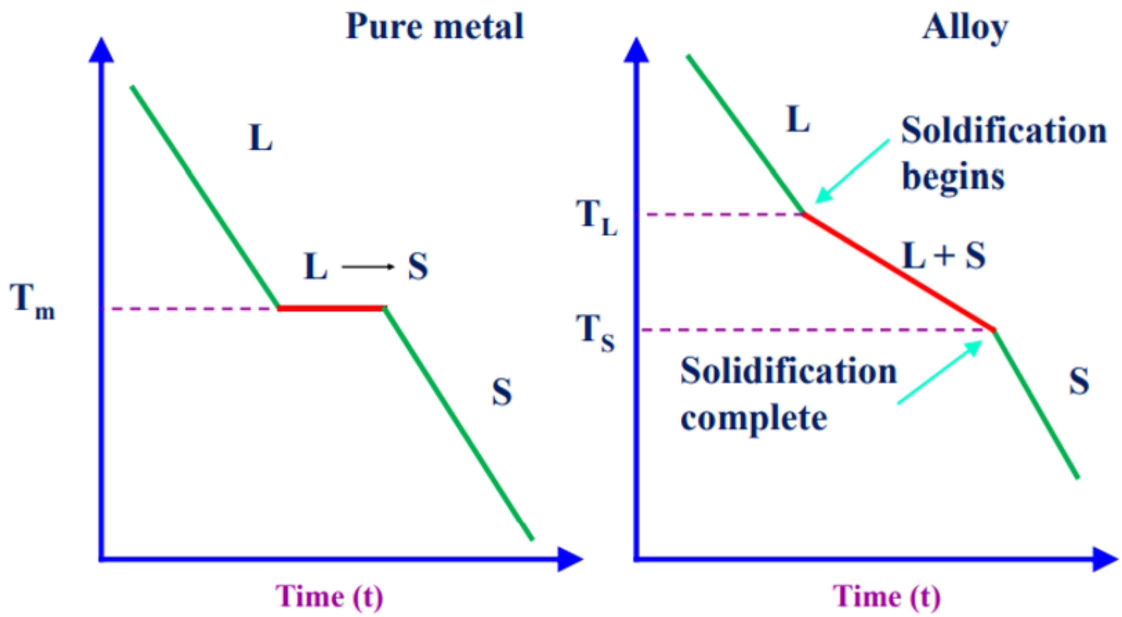
Amorphous: **-** Not having any crystal structure and non-crystalline structure like glass.

Study of Fe-Fe3c Phase Diagram & Identify and label the Phases, lines and points






Liquid
1539°C
δ (delta) Fe - B.C.C
1400°C
γ (gamma) Fe - F.C.C
Non Magnetic
Temperature °C →
910°C
Non Magnetic
α (alpha) Fe - B.C.C
768°C
α (alpha) Fe - B.C.C
Magnetic
Time →


Pure metal
L
L ⟶ S
T m
S
Time (t)
Alloy
L
Soldification begins
T L
L + S
T S
Solidification complete
S
Time (t)

IRON –IRON CARBIDE - EQUILIBRIUM DIAGRAM

Iron carbon equilibrium diagram is used to know the different phases, at different temperature levels. This diagram gives the detail reaction about temperature Vs carbon percentage. It indicates the structural changes due to variation of temperature and composition. This diagram used to find out the number of phases and amount of phases in a given alloy with their composition at any temperature. The phase diagram essentially a graphical representation of phases which are present in alloy system at various temperature, pressure and composition. It represents the state of a given system under equilibrium conditions in which there will be no change with time. It provides 1). Various phases present at different composition and temperature, and their change during heating or cooling. 2). Solid solubility of an element in another. 3). Temperature range over which solidification of an alloy occurs. 4). Temperature at which different phases start to melt. Iron carbon diagram help to decide the Heat treatment temperatures etc.

PHASES OF IRON CARBIDE DIAGRAM:

Ferrite: It is interstitial solid solution of carbon in the iron at low temperature. It is almost pure iron. The solubility of carbon in α–iron at room temperature is 0.008% and increases with increase in temperature to 0.025% at 727^0C. The low temperature ferrite with maximum carbon solubility 0.025% and minimum carbon content at room temperature is 0.008%. High temperature ferrite, has 0.1% carbon only under microscope, it is seen as homogenous polyhedral grain. It is a relatively very soft and ductile phase, so it can be extremely cold worked without cracking (it is softest structure of the iron carbon diagram). It has body centered cubic (BCC) structure and it is strongly ferromagnetic upto 768^0C and becomes paramagnetic (non-magnetic) at 768^0C during heating and hence this temperature is known as curie temperature.

Mechanical Properties:

- Tensile Strength (σ_t) = 25 Kgs/mm^2
- Yield Strength (σ_y) = 12 Kgs/mm^2
- % Elongation (δ) = 50%
- % Reduction in area = 80%
- Hardness = 90-100 BHN

Austenite: It is known as gamma-iron. It is the interstitial solid solution of carbon in iron with maximum carbon content of 2% at temperature of 1130^OC, decreases and reaches minimum of 0.83% at 727^0C. It has face centered cubic (FCC) structure. It is non-magnetic, soft and ductile but harder than ferrite. It has good formability. It can exist between 727^0C to 1493^0C. It is unstable below 727^0C and upto room temperature. Under certain conditions it is possible to obtain the austenite at room temperatures also.

Mechanical Properties:

- Tensile Strength (σ_t) = 1050 MPa
- % Elongation (δ) = 10%
- Hardness = 40 RC
- Toughness = High

δ-ferrite/δ-Iron:

it is an interstitial solid solution of carbon in iron at high temperature (i.e., 1400^0C to 1493^0C). It has BCC structure and similar to α-ferrite but its presence at high temperature. The maximum solubility of carbon at 1493^0C is 0.08 to 0.1%.

Cementite (Fe_3C): It is an intermetallic compound of iron and carbon with a fixed carbon content of 6.67%. which also known as iron carbide or simply carbide. It is a meta stable phase. It has a complex orthorhombic crystal structure. It is extremely hard and brittle phase. It imparts strength and hardness to steels. It is ferromagnetic upto 210^0C and paramagnetic above this temperature. It forms graphite with high carbon content. The melting point of cementite is not determined precisely because of decomposition but it is equal to 1550^0C. It is a typical hard and brittle phase of iron carbon diagram. It is an interstitial compound of low tensile strength got high compressive strength.

Mechanical properties:

- Tensile strength σ_t = 35 MPa
- Hardness=1000DPH

Ledeburite (γ + Fe_3C): It is a eutectic mixture of austenite and cementite formed at 4.33% carbon at a temperature of 1130^OC. The ledeburite is developed by German metallurgist A. Ledebur therefore ledeburite name has come. Graphite: It forms hexagonal crystal structure. The graphite flakes give high strength in cast iron. It has hexagonal crystal structure. It's inter atomic distances are equal to 1.4 A^O and the distance between layers is 3.40 A^O. Graphite is soft and low strength and electrical conductivity.

Pearlite (α + Fe_3C):

1. It is the Eutectoid mixture containing 0.8%C and is formed at 723^0C, on very slow cooling.
2. It is a lamellar mixture of Ferrite and Cementite.
3. The fine finger print type mixture contains the white ferrite black ground or matrix with thin plates of black cementite.
4. It forms at 727^0C upon slow cooling. The mechanical properties of pearlite are intermediate of ferrite (i.e., soft and ductile) and cementite (i.e., hard and brittle).
5. The average properties are: Tensile strength 90 Kg/mm², elongation 20% in gauge length of 50mm.Hardness Rockwell “C20 (approx).

Martensite:

Martensite is a metastable phase of steel, formed by transforming B.C.C Crystal to B.C.T. Because of not having enough time the austenite transformed to needle liken structure which is known as martensite, this is only obtained during the heat-treatment process.

Table1: Different phases in Iron-Carbon diagram

S. No	Phase	Crystal Structure	Relative Hardness
1	α-Ferrite	BCC	Very soft
2	γ-Austenite	FCC	Soft
3	Cementite (Fe_3C)	Orthorhombic	Very hard
4	Pearlite (α + Fe_3C)	-	Medium Hard
5	Ledeburite (γ + Fe_3C)	-	Hard

Table: Critical temperature and transformation in iron-carbon diagram

S. No	Critical Points	Temperature (^{0}C)	Significance During Heating
1	A_0 (Curie Temperature of Cementite)	210^0C	Ferromagnetic Cementite becomes paramagnetic
2	A_1 (Lower Critical Temperature)	727^0C	Pearlite starts transforming to austenite
3	A_2 (Curie Temperature of Ferrite)	768^0C	Ferromagnetic ferrite becomes paramagnetic
4	A_3 (Upper critical temperature for hypoeutectoid steels)	768^0C - 910^0C	Completion of ferrite to austenite transformation
5	A_{cm} (Upper critical temperature for hypereutectoid steels)	727^0C - 1150^0C	Completion of cementite to austenite
6	A_4	1400^0C - 1493^0C	Completion of austenite to δ-Ferrite transformation

INVARIANT TRANSFORMATION or REACCTIONS:

1. **Peritectic Reaction:**

   $L + \delta \leftrightarrow \gamma$

2. **Monotectic Reaction:**

   $L_1 \leftrightarrow L_2 + \gamma$

3. **Eutectoid Reaction:**

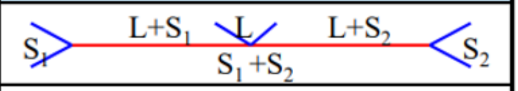
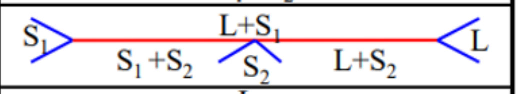
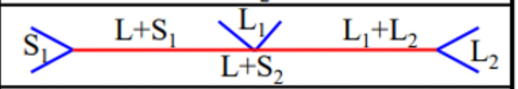
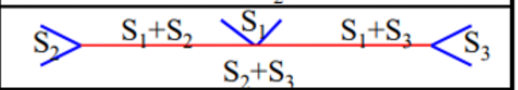
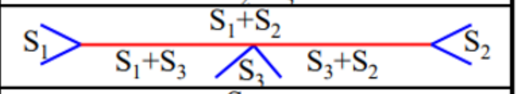
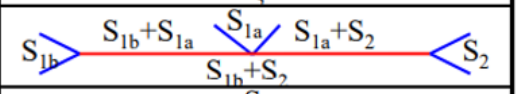
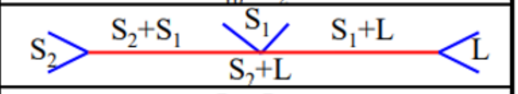
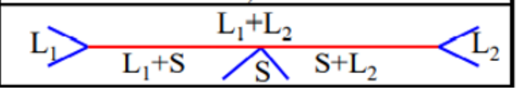
   $\gamma \leftrightarrow (\alpha + Fe_3C)$

4. **Peritectoid Reaction:**

   $\alpha + \gamma \leftrightarrow (\alpha + Fe_3C)$

5. **Eutectic Reaction:**

   $L \leftrightarrow (\gamma + Fe_3C)$

Name of reaction	Phase equilibrium	Schematic representation
Eutectic	$L \leftrightarrow S_1 + S_2$	
Peritectic	$S_1 + L \leftrightarrow S_2$	
Monotectic	$L_1 \leftrightarrow S_1 + L_2$	
Eutectoid	$S_1 \leftrightarrow S_2 + S_3$	
Peritectoid	$S_1 + S_2 \leftrightarrow S_3$	
Monotectoid	$S_{1a} \leftrightarrow S_{1b} + S_2$	
Metatectic	$S_1 \leftrightarrow S_2 + L$	
Syntectic	$L_1 + L_2 \leftrightarrow S$	

PLAIN CARBON STEEL:

Carbon steel can be classified, according to various deoxidation practices, as rimmed, capped, semi-killed, or killed steel. Deoxidation practice and the steelmaking process will have an effect on the properties of the steel. However, variations in carbon have the greatest effect on mechanical properties, with increasing carbon content leading to increased hardness and strength. As such, carbon steels are generally categorized according to their carbon content. Generally speaking, carbon steels contain up to 2% is known as plain carbon steel and can be divided as below.

- Low carbon steels: 0.05% to 0.30%
- Medium carbon steels: 0.3% to 0.6%
- High carbon steels: 0.6% to 0.9%

Plain carbon steel also classified as

- Eutectoid Steel (C_o = 0.8% C)
- Hypo-Eutectoid Steel (C_o < 0.8% C)
- Hyper-Eutectoid Steel (C_o > 0.8% C)

CAST IRON:

- Cast Iron containing 2 to 6.67% carbon. As its name suggests, cast iron has excellent casting properties. It can be strong, but brittle compared to most steels.
- Cast iron that contains more than 4.3 wt% carbon equivalent. This results in the formation of graphite flakes in the resultant microstructure. The combination of these with the lighter-coloured remainder of the casting results in an observed grey colour. Grey cast irons are generally brittle due to the presence of thegraphite flakes which act as cracks.
- Based on the carbon content cast iron divided as
  - Eutectic cast iron (C_o = 4.3% C)
  - Hypo-Eutectic cast iron (C_o < 4.3% C)
  - Hyper-Eutectic cast iron (C_o > 4.3% C)
- Classification of cast iron:
  - White cast iron
  - Grey cast iron
  - Malleable cast iron
  - Nodular or spheroidal cast iron

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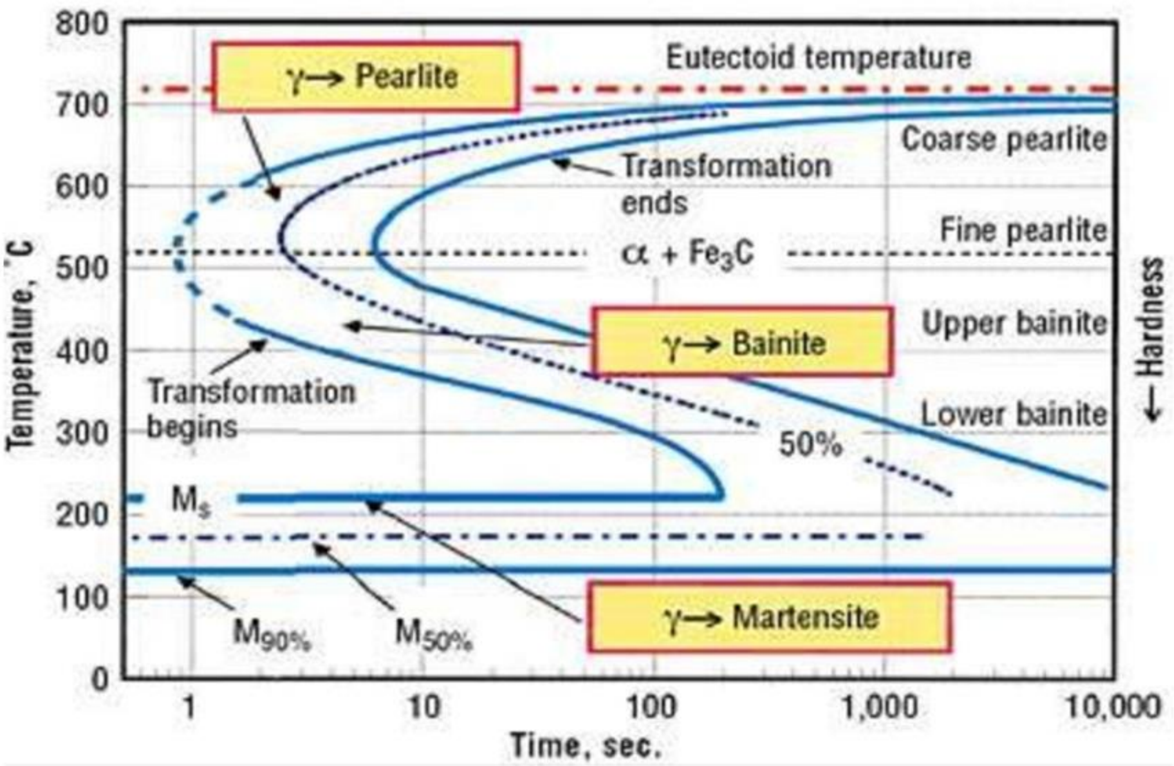
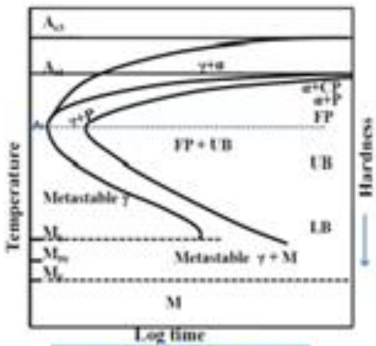
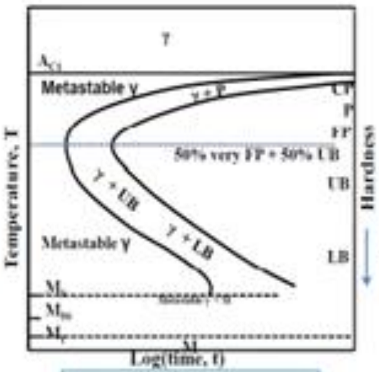
Study of TTT Diagram for Hypo-Eutectoid, Eutectoid, Hyper-eutectoid Steels

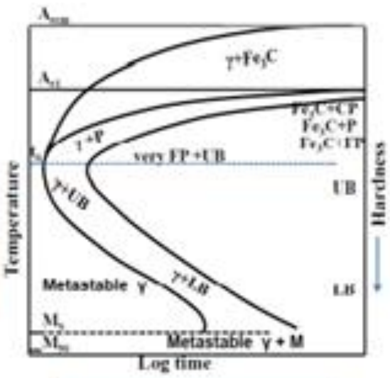




TTT diagram for hypo-eutectoid steel

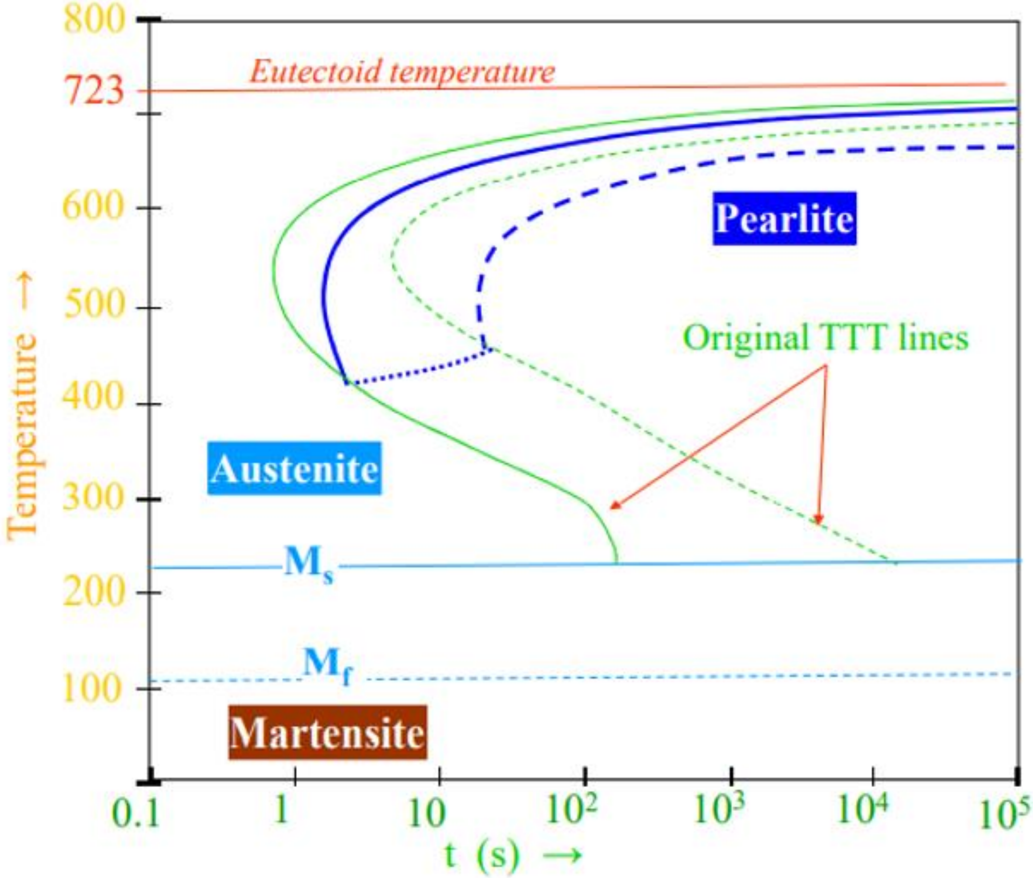


TTT diagram for eutectoid steel



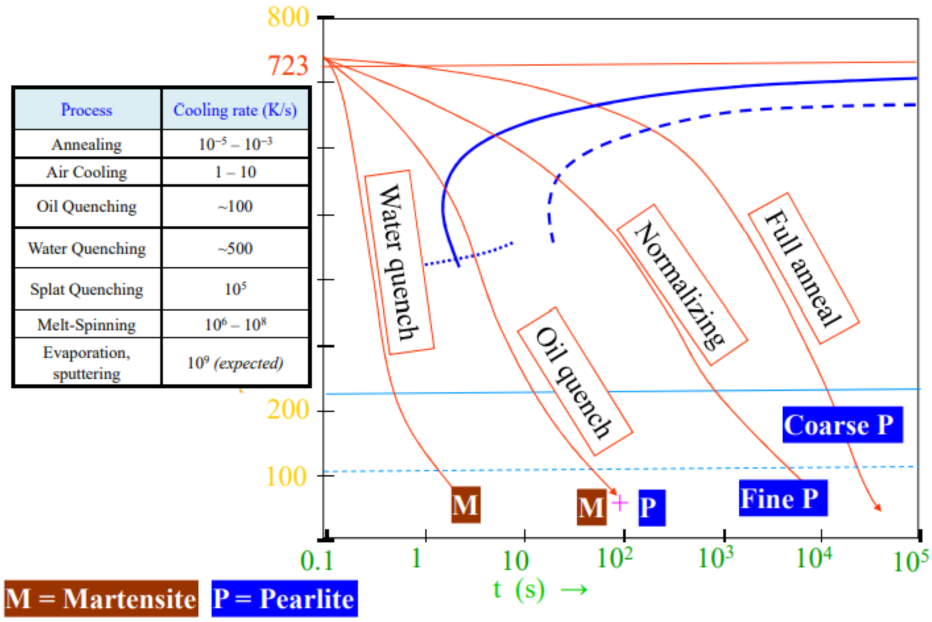
TTT diagram for hyper-eutectoid steel

Study of Continuous Cooling Curve (CCT) for Eutectoid Steels



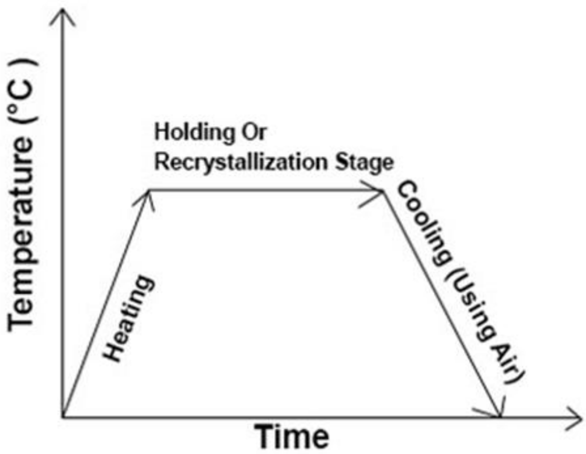
Different cooling treatments for eutectoid steel

Process	Cooling rate (K/s)
Annealing	10^{-5} – 10^{-3}
Air Cooling	1 – 10
Oil Quenching	~100
Water Quenching	~500
Splat Quenching	10^5
Melt-Spinning	10^6 – 10^8
Evaporation, sputtering	10^9 *(expected)*

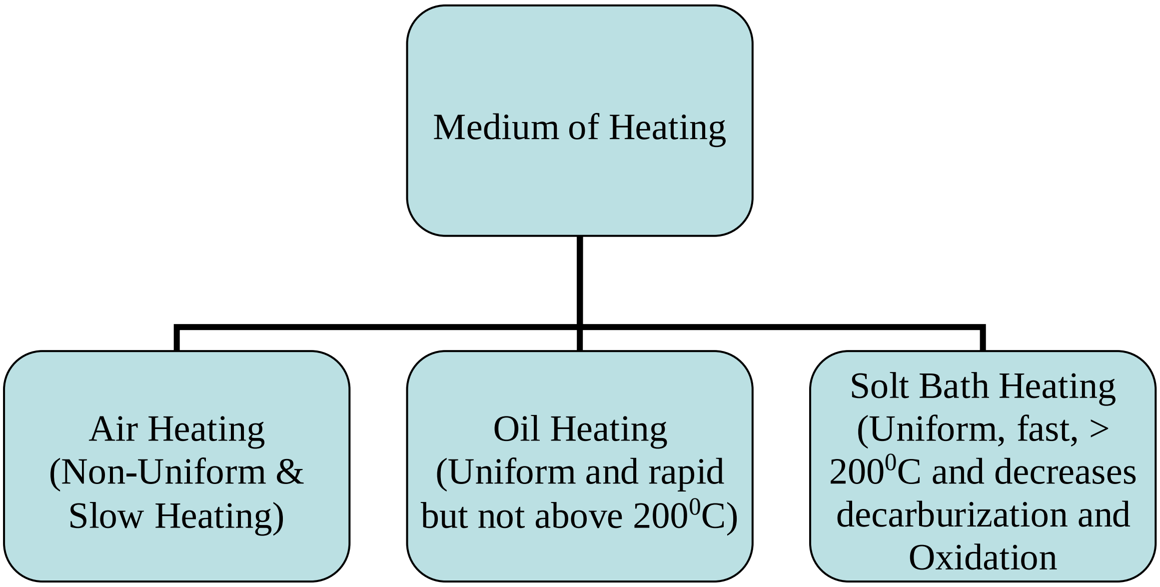


HEAT TREATMENT OF STEEL

Heat Treatment: Process of controlled heating, holding and cooling a steel in order to modify or alter the microstructure to obtain desired properties. Stages of heat treatment:



1. **Heating:** steel is heated to austenitising temperatures, at this temperature previous structure of steel is converted into austenite. Steel is heated to austenitizing temperature at specified rate so as to achieve uniform and quick heating to avoid distortions and cracking of the steel components due to thermal shock. Fast heating reduces the time of heat treatment and also help in obtaining a fine grain size.



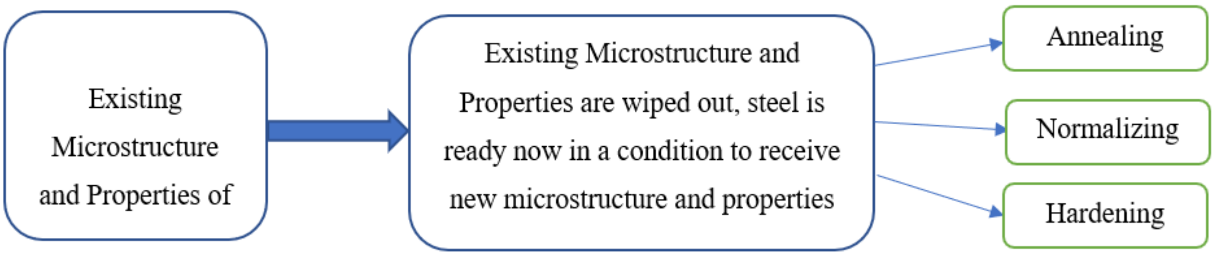
2. **Soaking/Holding:** Steel is held at austenitising temperature to obtain homogeneous austenite throughout the cross section of the component.

3. **Cooling:** Steel from austenite structure is cooled to room temperature at different cooling rates. The coolingrate depends upon the properties required. Steel after cooling may or may not be reheated to a temperature below lower critical point and cooled again.

   Medium of Cooling:

   - Brine (Cold water + Solt)
   - Cold Water
   - Water + Soluble Oil
   - Oil
   - Air
   - Furnace Cooling

Principle of Heat Treatment:



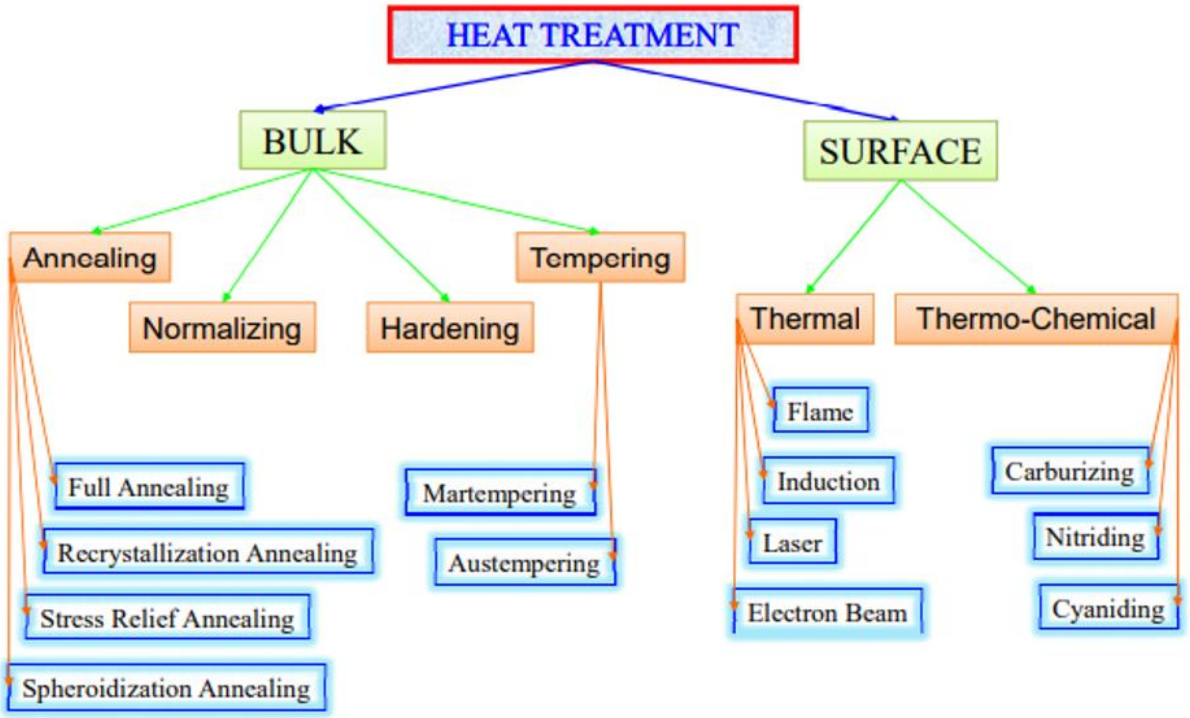
Purpose of Heat Treatment:

Heat treatment in a major technique to obtain desired properties.

The major considerations are to produce a satisfactory combination of microstructure and mechanical propertiesso that the metal can fulfil its intended purpose.

1. Relieving residual/internal stresses, and softening for further deformation.
2. Refining the grain size to improve mechanical properties (i.e., to improve strength, ductility, toughness etc.).
3. Improve the machinability.
4. Altering the surface conditions.
5. Increasing the corrosion and wear resistance.

Classification of Heat Treatment:

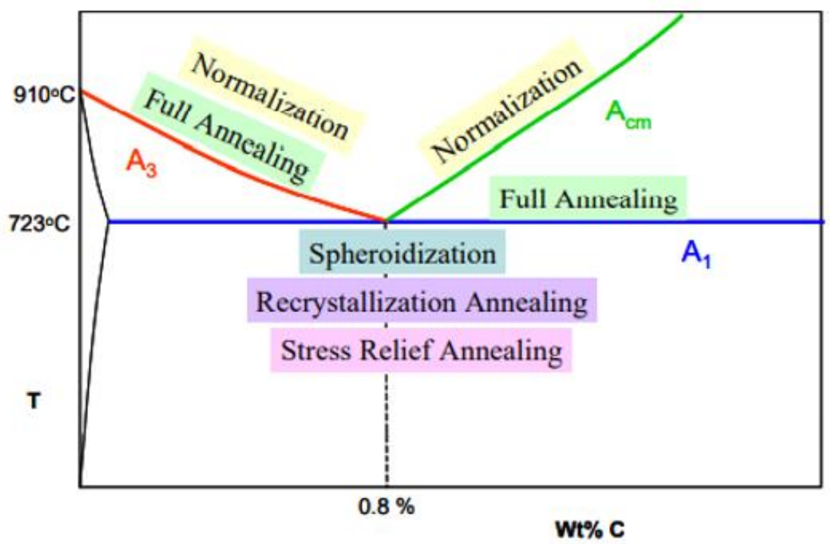


Annealing: - Heating and holding at certain temperature and then slow cooling (furnace cooling) rate for getting suitable properties.

Heating temperature: about 50^0C above A_3 for hypo-eutectoid steel and above A_1 for Hyper-eutectoid steel.

Cooling: Furnace Cooling

Expected Microstructure and properties: Coarse microstructure, lower strength, higher ductility.



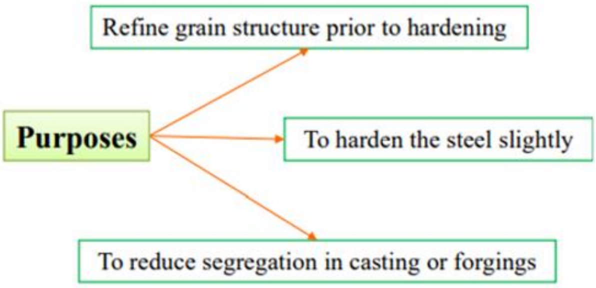
Normalizing: Heating and holding at certain temperature and then medium cooling (air cooling) rate for getting suitable properties.

Heating temperature: above A_3 for hypo-eutectoid steel and above A_{cm} for Hyper-eutectoid steel.

Cooling: Air Cooling

Expected microstructure and Properties:

Fine microstructure compared to annealing. More strength and lower ductility than annealed steel.



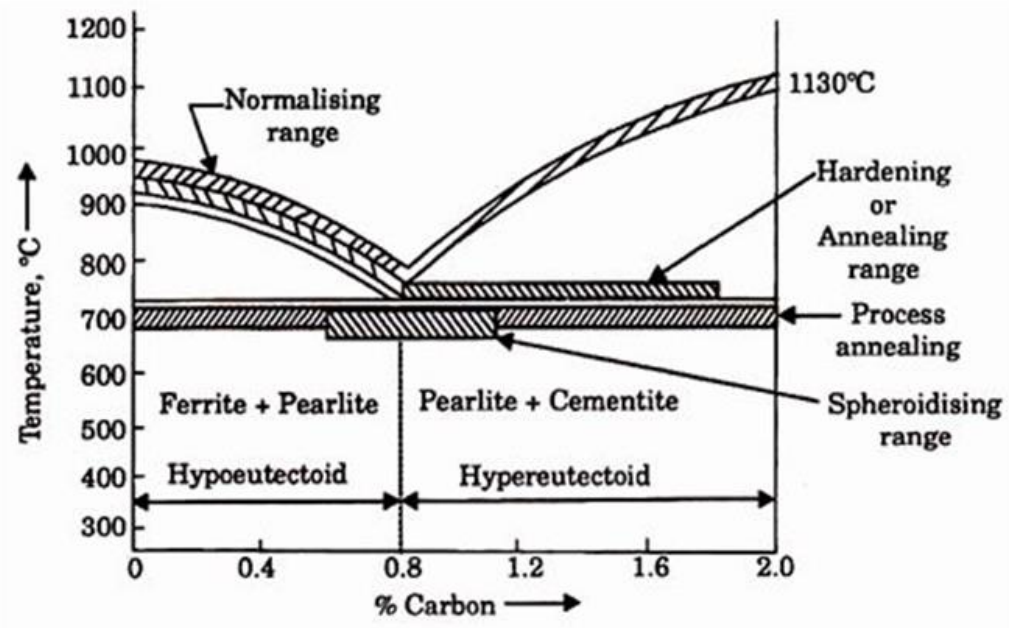
Hardening:

Heating and holding at certain temperature and then fast cooling (water quenching) rate for getting suitable properties. It imparts high hardness to steel by producing martensite in steel.

Heating Temperature: About 50^0C above A_3 for hypo-eutectoid steel and 50^0C above A_1 for Hyper-eutectoid steel.

Cooling: Water Quenching (cooling rate high enough to miss nose of the CCT curve.

Expected microstructure and Properties: Complex microstructure. Martensite may also contain quench cracks. Very high hardness but poor ductility.



Tempering: It is always followed by hardening. Reheating and holding at certain temperature and then medium cooling (air cooling) rate for getting suitable properties.

Heating Temperature: below A_1 for all steels.

Cooling: air cooling

Expected microstructure and Properties: modified microstructure. It recovers the ductility.

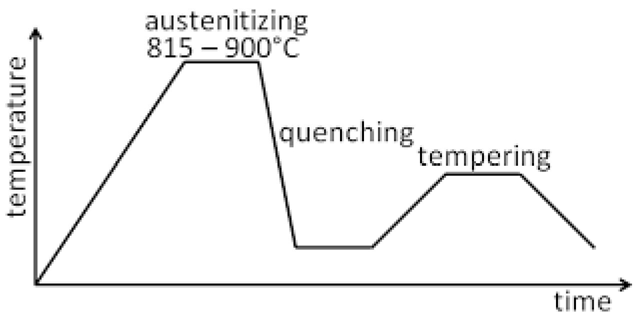


Table3: Different heat treatment process, nature of cooling and microconstituent

S. No	Process	Nature of Cooling	Microconstituent
1	Annealing	Very slow cooling (Furnace cooling)	Coarse pearlite
2	Normalizing	Faster cooling (Air cooling)	Fine pearlite
3	Austempering	Interrupted Quench	Bainite
4	Tempering	Heating after Quench	Tempered martensite
5	Hardening/Quenching	Very fast cooling (Quenching in water)	Martensite

STUDY OF METALLURGICAL MICROSCOPE

Study of Metallurgical Microscope:

Metallography consists of the microscope study of the structural characteristics of a metal or an alloy. The microscope is the most important tool of a metallurgist from both scientific and technical point view, it is possibleto determine the grain size, shape and distribution of various phases and inclusions which have a great effect on the mechanical properties of the metal or alloy. It used for obtaining the more magnification and resolution so that finer details of the structure cab be revealed properly. A large range of metallurgical microscopes are available for the below mentioned purposes and all the metallurgical microscopes works on the same principle for microscopic observation by light reflected from specimen surface. For microscopic observation the specimen surface must be prepared properly.

This was used for the first time by “Sorby” in the year 1863, for the structural examination of the metal. Metals are opaque to light and hence are to be examined by reflected light. Unlike the other Microscopes, the metallurgical microscope is not provided with a sub stage condenser and mirror, which controls the beams of lightwhich illuminates a transparent object.

Therefore, the optical system of a metallurgical microscope consists of two compound lenses. The lens near the object under examination is known as the objective and the other lens which further magnifies the image produced by the objective is known as the eye-pieces are detachable and are available in different variety of power such a s 10X, 15X etc. The quality of an objective is important in determining the final results in microscopy.

The magnification of the objective depends on its focal length, the shorter the focal length; the greater will be the magnification. The focal length is usually marked on the size of the objective. The different varietyof powers used as objective is its magnifying and resolving power. the resolving of the objective are 10x 45x. the other important properties of the objective are its magnifying and resolving power. The resolving power of an objective is the property by which it shows distinctly separated two small adjacent bands in the structure of an object. Th is is usuallyexpressed as the number of times per inch that can be separated. The resolving power of the objective is important when dealing with micro-constituents of the metals consisting fine laminations. The total magnification in a microscope is the product of the individual magnifications of the objective, the eye-piece and any intermediate lenses used.

The Objective Lens:

The objective lens forms the primary image of the microstructure and is the most important component of the optical microscope. The objective lens collects as much light as possible from the specimen and combines this light to produce the image.

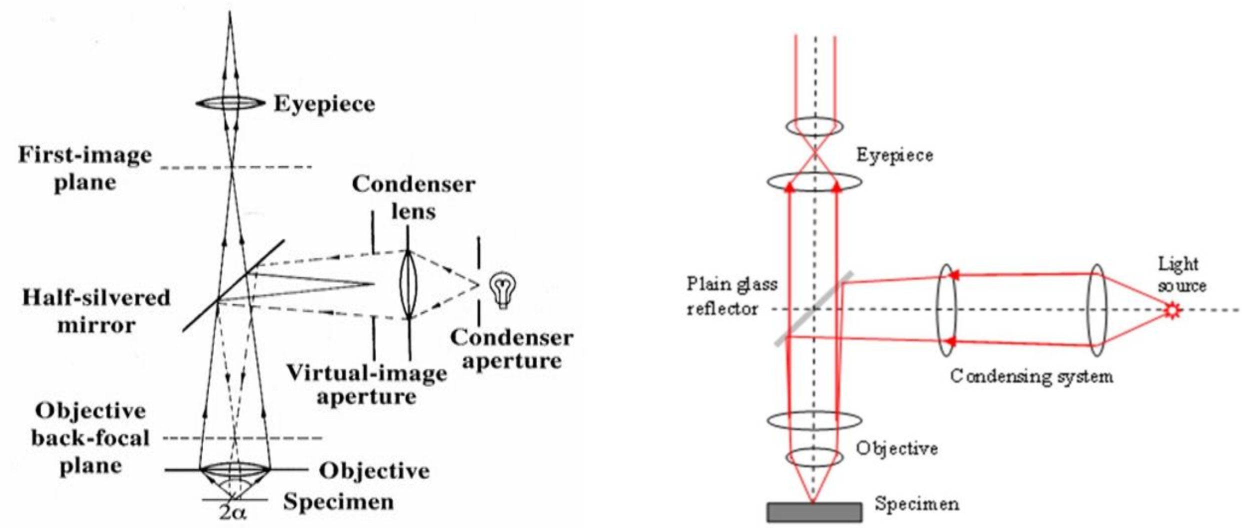


Figure: Ray diagram for optical microscope.

SPECIFICATIONS:

Magnification: 25x to 1500x

Observation: Binocular inclined at 45^0 and rotatable at 360^0

Stage: Horizontal mechanical stand 120x140mm

Illumination: Incident bright light through epi-illuminator, 12 V halogen lamp with iris diaphragmand filter slot

Objective: Achromatic M 5x, M10x, M 45x and M100x

Figure: Optical Microscope

A metallurgical microscope helps determining:

- Grain size and shape.
- Shape, size and distribution of various phases and inclusions which have a great effect on the mechanical properties of metals and alloys.
- Mechanical and thermal treatments given to alloys

Constructional details of metallurgical microscope:

It consists of a stand, to which is attached a movable tube consisting the optical parts viz., eye piece, objective and illuminating system. Metals and alloys are opaque to light hence they are to be viewed by reflected light.

Working of metallurgical microscope:

Light from an electrical bulb and through aperture falls on a silvered portion of a semi-silvered glass plate kept at 45^0 to the vertical axis in the movable tube. These light rays get reflected vertically downwards, travel through the objective, and fall on the specimen surface and reflects. The specimen is kept on the mechanical stage of the microscope. The reflected rays of light again pass through the objective, silvered glass plate and eye piece and reaches the eye and enlarged image can be seen. The total magnification of the lens system can be given as the product of the magnification of the eye piece and objective.

Total magnification of the lens system = (Magnification of eye piece) X (Magnification of objective)

The objectives are available in magnifications such as 10X, 15X, 45X, 75X, and 100X. The eye piece magnifications are available such as 5X, 10X and 15X. Focusing of the microscope is done to get clear image by adjusting coarse and fine knobs. These knobs make the draw tube move-up and down with the help of a rack and pinion. A photographic camera can be mounted above the eye piece if a permanent record of the microstructure is to be obtained. The eye pieces are detachable. The magnification of the objective depends upon its focal length. The shorter the focal length, the greater will be the magnification. The focal length is usually marked in the size of objective. The important properties of the objective are its magnification and resolving power. Resolution is very important property for distinct.

PRECAUTIONS:

1. Do not force up or down the coarse focusing knob, when it comes to a stop.
2. The position of the T-block, coarse movement has to be suitably adjusted.
3. The focusing should be first done with 10x, or 45x objective and the can be proceeded for highermagnification.
4. The focusing should not be tried with coarse movement knobs when 100x.
   a) The 45xor 10x objective is brought in position.
   b) The specimen platform is brought to the top most position with the help of coarse knob such thatthe specimen's top surface should first touch the 45x0r10x objective.
   c) Lock the T- block in this position with the help of locking knob and focus.
5. Check that the eye piece and objective are free from any dust. The objectives should be tightly screwedin the nosepiece.
6. The microscope should be kept covered when not in use.
7. Any part or parts of the microscope neither should not be detached.
8. Put off the light source when not in use.

Preparation of Specimen for Examination

The preparation of the specimen for micro–examination has the aim of producing a flat surface free from any scratches and strains. The selection of the representative sample is of permanent importance. The sample should be characteristic of the material to be examined. A representative specimen of size which can be easily handled say 1-2 cm. so, around and 1cm length is obtained by gently cutting with a hacksaw. The material is taken and polished in different stages to be used for micro-examination.

EQUIPMENT & MATERIALS:

Specimen Cut off Machine, Specimen Mounting Press, Belt Grinder, Polishing Stand, Disc Polishing Machine, Drier, Metallurgical Microscope, Bakelite Powder, Emery Papers (120, 220, 400, 600, 800 Grit) Etchant (2% Nital).

PROCEDURE:

1. **SAMPLING:**

   Select the specimen from various ferrous and non-ferrous metals and their alloys, and then cut the specimen with the help of hawk saw, power saw, abrasive wheel or machining by machine tools along the longitudinal sections which shows elongated grains for cold rolled materials and equiaxed grains for annealed materials. However, this will not be revealed by observing a transverse section. For study of case carburization or decarburization, the edge of the specimen must be preserved carefully.

   Size of the specimen should be convenient and comfortable for handling during polishing.

   Specimen size: 2 cm length and 1.5 to 2.5 cm in diameter.

   Specimen shape: cylindrical or chips (irregular shapes when small size and thin i.e., triangular, square, rectangular etc.)

2. **MOUNTING OF SPECIMEN:**

   Mounting of specimen required when then the specimens are too small, awkward (i.e. irregular shapes) like chips, wires, sheet metals of thin sections are mounted in a suitable plastic for convenient and comfortable handling during polishing. Since large specimens require more time for polishing than small specimens but too small, thin and irregular shape specimen needs mounting.

Method of Mounting:

Generally mounting of specimen can be carried out in two ways.

a). Cold Mounting (Manual Mounting)

b). Hot Mounting (Machine Mounting)

Cold Mounting (Manual Mounting):

Cold mounting is suitable heat-treated specimens because for certain heat-treated metals and an alloy heating is not permissible. It consists of cold setting die, specimen and setting powder and liquid. A proper sized die should be used for economy. Cold setting medium contains powder and liquid and they are thoroughly mixed in the proportions as recommended by the manufacturer.

Specimen = Powder + Liquid + Chip of Metal

Cold mounting procedure:

1. The given specimen is kept on a flat surface and a cold setting die is placed around the specimen.
2. For easy removal of mount grease is applied on the flat surface and to the inner surface of the die.
3. Prepare a polymeric solution by mixing polymer powder and a chemical liquid in appropriate proportion.
4. A polymeric solution is poured into the die.
5. Leave the arrangement for few minutes so that the polymeric solution becomes hard like cement in 10 to 15 minutes.
6. Take out the mount from the die. Now specimen is ready for polishing.

Hot Mounting (Machine Mounting):

Hot mounting is carried out by mounting press and it is suitable for any kind of non-heat treated specimens. In the hot mounting thermoplastic resin or some other low melting point alloys are used for mounting of a specimen.

Hot Mounting Procedure:

1. The given specimen is kept on the bottom surface the hot setting die.
2. For easy removal of mount grease is applied on the inner surface of the die.
3. Fill the die with thermoplastic resin or some other low melting point alloys.
4. Heat the die setup upto required temperature over a prescribed period of time.
5. Stop heating the die setup and leave the die setup arrangement for few minutes to cool down.
6. Take out the mount from the die. Now specimen is ready for polishing.

3. POLISHING:

The polishing operation may be divided into three steps: -

1. Grinding.
2. Rough Polishing.
3. Fine polishing.

GRINDING:

Grinding is the first step of preparation of specimen. This is done by belt sanding machine provided in the laboratory. The operation consists of slight holding of the specimen on the endless belt of the machine, the belt being rotated on the pulley and run by electrical motor. The grinding help in removing the uneven and rough corners of the specimen. Top and bottom surfaces of the specimen are made flat and parallel to each other by means of rough file, belt grinder and machining on machine tool. The surface of the specimen to be examined is made plane. During rough polishing specimen gets heated excessively, to avoid excessive heating, specimen is frequently dropped into the water. Whatever the markings or scratches left over, are to be removed by finer methods and this is done by rough polishing.

ROUGH POLISHING:

a). Dry Method

Rough polishing is done by a series of emery papers of increasing fineness. The emery papers are of 4 grades, 1/0, 2/0, 3/0, 4/0 last being the finest one. The operation of rough polishing involves the following steps. First 1/0 emery paper is placed on any clean, hard and flat surface such as glass plate and this emery paper is held with the left hand and specimen with right hand and specimen is slowly moved back and forth with moderate pressure such that the scratches from the abrasive will be formed in one direction only, at right angles to the file mark. The specimen is rubbed till the file marks and worked layer are removed, the specimen is cleaned by the cloth and transferred to 2/0 grade paper on which, after turning it through right angle of the scratches of previous paper are removed. the procedure of turning repeated on finer paper following the same procedure of turning at right angles while passing from one grade to the next. After polishing on the finest grade of emery paper, the finest scratches left should be polished by polishing machines.

As grade number increases fineness increases and surface finish also increases. The emery paper should be of very good quality with uniformity of abrasive particle size. The four grades of abrasives used are 220, 320, 400, and 600 grit (from coarse to fine). The emery papers are made up of silicon carbide pasted on the paper. For polishing of soft metals and some of the heat-treated alloys, it is essential to use a suitable lubricant on the emery papers. Some of the lubricants used are paraffin in kerosene, liquid soap, glycerin and glycerin – water mixtures.

b). Wet Method

The procedure of wet polishing almost similar to dry polishing method. In this method water proof emery papers of grade numbers 200, 300, 0400, 500, and 600 are used in succession. During wet polishing water flows continuously on the emery papers.

FINE POLISHING:

During grinding and rough polishing stage scratches and very thin distortion layer are introduced on the surface of the specimen. Fine polishing is carried out to make scratch free and distortion free layer of the specimen. Amount of disc polishing depends on the care with which the previous operations are carried out and also on the quality of cloth and abrasive powder applied.

Disc polishing operation is done on polishing wheel or polishing laps which is made up of copper, brass, bronze or stainless steel disc of 20 to 25 cm diameter covered with velvet cloth. During the disc polishing abrasive suspension (distilled water+ abrasive powder) is poured on the cloth covered disc which acts as a lubricant and cutting tool.

The fine and the final polishing is done by polishing machines. the polishing machine consists of a polishing disc. The fine velvet cloth is mounted over the disc. the disc resolves horizontally. Fine Aluminium powder is poured upon the velvet cloth for abrasive action and the cloth is moistened periodically in order to prevent the flying off of the powder used. The operation is done by gently holdings the specimen on the revolving disc. The alumina powder and water should be poured periodically. the specimen after the final polishing should be free from all the scratches and should appear like a mirror.

Coarse: polishing abrasive consists of diamond powder, oil-soluble and nylon cloth.

Fine: polishing abrasive consists of aluminium oxide powder i.e. alumina (Al_2O_3) powder/ paste which provides cutting action; distilled water is used as a lubricant, and selvet cloth.

4. **WASHING**

Wash the specimen under running tap or rinse in methyl, ethyl or isopropyl alcohol.

5. **DRYING**

After washing properly dry the specimen. For this purpose, drier is used to blast the warm air.

6. **ETCHING:**

It is a process done on the polished surface so that the structural details are revealed by the microstructure. Polished surface is subjected to chemical attach by suitable chemical reagents under controlled conditions. Even after fine polishing the granular structure in a specimen usually cannot be seen under microscope, because grain boundaries in a metal have a thickness of the order of a few diameters of atoms at best and the resolving power of a microscope is too low to reveal their presence in order to make the grain boundary visible after the polishing.

To make the structure apparent under the microscope it is necessary to impart in like appearances to the different constituents, this is accomplished by what is known as “Etching” a selective corrosion of the polished surface. the polished specimen is immersed in the etch ant solution for a given time, removed with forceps, running water, rinsed with methyl alcohol (or spirit) and dried in hot air swilled in. the specimen is now ready for examination.

Method of Etching:

Etching can be done in two ways. They are

a). Immersion method

b). Swabbing technique

Etchant is selected based on the specimen material. Etching time is depends on the metal to be etched and etchant and it varies from few seconds to few minutes.

Etchant:

Inorganic or organic acids + water, alcohol, glycerin.

For iron and steels: Nital (Nitric acid + alcohol)

For aluminium and its alloys: hydroflourine acid + distilled water

For copper and its alloys: Ferric chloride + distilled water

For zinc and magnesium alloys: Nital

The common etching reagents are

(1) For Ferrous alloys:

Nital. (HNO_3 1-5 ml, Ethyl or Methyl Alcohol 100 ml),

(2) For Non-Ferrous Alloys:

(a) Hydrofluoric acid – HF (Concentrated) – 0.5 ml, H_2O – 99.5 ml.

(b) Keller's reagent – HF – 1 ml, HCl – 1.5 ml; HNO 2.5 ml (all concentrated) & H_2O – 95 ml.

7. PRECAUTIONS

1. Grinding should be done on the emery papers only in one direction
2. After etching the natal should be washed away within a few seconds

8. REFERENCES

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2. Introduction to Physical Metallurgy – S.H. AVNER.
3. Principles of Engineering Metallurgy – L. KRISHNA REDDY.

MUFFAKHAM JAH COLLEGE OF ENGINEERING AND TECHNOLOGY
MECHANICAL ENGINEERING DEPARTMENT

EXPERIMENT NO: 1

METALLOGRAPHIC STUDY AND ANALYSIS OF LOW CARBON STEEL

1. **AIM:**

   To identify the microstructure and analysis of given specimen

2. **APPARATUS & MATERIALS REQUIRED:**

   Specimen, metallurgical microscope, belt grinder, disc polisher, set of emery papers (i.e., 1/0, 2/0, 3/0, and 4/0), etchant, glass slab, abrasive powder (i.e., alumina or diamond powder), cotton.

   SPECIFICATIONS OF THE EQUIPMENT

   Optical Microscope:

   Magnification: Achromatic M 5x, M10x, M 45x and M100x.

   Observation: Binocular inclined at 45^0 and rotatable at 360^0

   Stage: Horizontal mechanical stand 120x140 mm

   Illumination: Incident bright light through epi-illuminator, 12V halogen lamp with iris diaphragm and filter slotObjective.

   Metallurgical Polishing Machine:

   Discs: 2 Nos with velvet cloth, Drive: Belt drive, Motors: 2 Nos, one HP motor, Power – 230 Volts and 0.75 Watts, Speed: 1440 RPM.

3. **THEORY**

   Low carbon steels are those in which the carbon content varies from 0.05 to 0.30 percent. These steels are further divided into two groups:(a) Dead mild steel (0.05-0.15 % C), and (b) Mild Steel (0.15-0.30 % C).

   Properties:

   1. Dead mild steel is a soft, ductile material and can be easily cold worked.
   2. Dead mild steel has atensile strength of 390 N/mm^2 and a hardness of about 115 BHN.
   3. Mild steels have lower fluidity and enhanced tendency to form hot cracks in castings, but possess good tensile strength and ductility. The great disadvantage of mild steels is that it is subjected to corrosion when exposed to atmosphere.
   4. Mild steel has a tensile strength of 555 N/mm^2 and a hardness of 140 BHN.

Applications:

1. Low carbon steels are used for bolts and nuts, structural works, axles, shafts etc.
2. It is also used for boilerplates, rivets and wires.
3. It is used for chains, nails, seam welded pipes, car bodies.
4. It is used for machine parts, cams, gears, levers, cranks and shafting.
5. It is used for rivets, sheets, screws, pipe and wires.

4. **SEQUENCE OF OPERATIONS**

1. Preparation of specimen
2. Dry polishing
3. Wet polishing
4. Etching
5. Microstructure observation

5. **PROCEDURE**

1. **Rough Polishing:** the specimen is polished on a emery papers containing successively finer abrasives the first Paper is usually no. 1/0 then 2/0, 3/0 and finally 4/0.Polish the specimen under light pressure in forward direction only.
   Note: While changing from one paper to another, make the specimen surface free from the abrasive of the previous paper and turn it through 90^{o}, so that scratches made by the next paper are approximately at right angles to the scratches from the previous paper.
2. **Fine polishing**: The fine and the final polishing is done by polishing machines. the polishing machine consists of a polishing disc. The fine velvet cloth is mounted over the disc. the disc resolves horizontally. Fine Aluminium powder is poured upon the velvet cloth for abrasive action and the cloth is moistened periodically in order to prevent the flying off of the powder used. The operation is done by gently holdings the specimen on the revolving disc. The alumina powder and water should be poured periodically. The specimen after the final polishing should be free from all the scratches and shouldappear like a mirror.
3. **Etching**: To make the structure apparent under the microscope it is necessary to impart in like appearances to the different constituents, this is accomplished by what is known as "Etching" a selective corrosion of the polished surface. the polished specimen is immersed in the etch ant solution fora given time, removed with forceps, running water, rinsed with methyl alcohol (or spirit) and dried in hot air swilled in. the specimen is now ready for examination. The common etching

reagents are- (For Ferrous alloys - Nital. (HNO_3 1-5 ml, Ethyl or Methyl Alcohol 100 ml).

6. **PRECAUTION**
   1. Grinding should be done on the emery papers only in one direction
   2. After etching the natal should be washed away within a few seconds
7. **RESULT:**

   The given specimen is “Low Carbon Steel (LCS)”.
8. **QUESTIONS:**
   1. What is steel?
   2. What are different phases that exist in O.15% C steel, and what is the quantity of each?
   3. How do you make hard a steel containing 0.5%Cand 0.1%C.?
   4. What are the applications of LCS?
   5. What is Nital, 2%Nital is used for?

MICROSTRUCTURE OBSERVATION:

Magnification: 100 X **Etchant: Nital Solution**

The microstructure of low carbon steel which contains 0.2% C consists of around 25% pearlite in a matrix of ferrite.

This photomicrograph shows the microstructure of low carbon steel (carbon content less than 0.25%). This steel is austinitised and cooled in air (Normalizing). The microstructure consists of uniform grains of pearlite (Ferrite + Cementite) in a matrix of Ferrite. Note there are no flow lines due to cold working. This kind of steel is called Hypo eutectoid (steel containing less than 0,8% carbon as per the Iron-Carbon equilibrium diagram).

EXPERIMENT NO: 2

METALLOGRAPHIC STUDY AND ANALYSIS OF MEDIUM CARBON STEEL

1. **AIM:**

   To identify the microstructure and analysis of given specimen

2. **APPARATUS & MATERIALS REQUIRED:**

   Specimen, metallurgical microscope, belt grinder, disc polisher, set of emery papers (i.e., 1/0, 2/0, 3/0, and 4/0), etchant, glass slab, abrasive powder (i.e., alumina or diamond powder), cotton.

   SPECIFICATIONS OF THE EQUIPMENT

   Optical Microscope:

   Magnification: Achromatic M 5x, M10x, M 45x and M100x.

   Observation: Binocular inclined at 45^0 and rotatable at 360^0

   Stage: Horizontal mechanical stand 120x140 mm

   Illumination: Incident bright light through epi-illuminator, 12V halogen lamp with iris diaphragm and filter slotObjective.

   Metallurgical Polishing Machine:

   Discs: 2 Nos with velvet cloth, Drive: Belt drive, Motors: 2 Nos, one HP motor, Power - 230 Volts and 0.75 Watts, Speed: 1440 RPM.

3. **THEORY**

   Medium Carbon Steel

   Steel containing between 0.30 and 0.60% carbon is called medium carbon steel. It has a tensile strengthof 1230 N/mm^2 and a hardness of 400-450 BHN. These are used where strength and toughness are requisite conditions.

   Properties:

   1. These steels have better strength, toughness and casting properties than low-carbon steels.
   2. Medium carbon steel is suitable for components that are likely to be subjected to bending stresses.
   3. Because of their higher carbon content, they are generally used in the hardened and tempered condition.

4. A wide range of mechanical properties can be produced by varying the quenching medium.

Applications:

1. Typical applications of these steels are rails, crank pins, gear wheels etc.
2. It is used for making hand tools, pliers, open wrenches and screw drivers.
3. It is used for shafting, crane hooks, high tensile tubes, steel mill rolls, rifle barrels, wire ropes, locomotive tyres.
4. Typical components produced from medium carbon steel including agricultural tools, fasteners, motor shafts, crank shafts, connecting rods, clutch discs, cushion rings and gears.

4. SEQUENCE OF OPERATIONS

1. Preparation of specimen
2. Dry polishing
3. Wet polishing
4. Etching
5. Microstructure observation

5. PROCEDURE

1. **Rough Polishing:** the specimen is polished on a emery papers containing successively finer abrasives the first Paper is usually no. 1/0 then 2/0, 3/0 and finally 4/0.Polish the specimen under light pressure in forward direction only.

   Note: While changing from one paper to another, make the specimen surface free from the abrasive of the previous paper and turn it through 90^{o}, so that scratches made by the next paper are approximately at right angles to the scratches from the previous paper.
2. **Fine polishing**: The fine and the final polishing is done by polishing machines. the polishing machine consists of a polishing disc. The fine velvet cloth is mounted over the disc. the disc resolves horizontally. Fine Aluminium powder is poured upon the velvet cloth for abrasive action and the cloth is moistened periodically in order to prevent the flying off of the powder used. The operation is done by gently holdings the specimen on the revolving disc. The alumina powder and water should be poured periodically. The specimen after the final polishing should be free from all the scratches and shouldappear like a mirror.
3. **Etching**: To make the structure apparent under the microscope it is necessary to impart in like appearances to the different constituents, this is accomplished by what is known as “Etching” a selective corrosion of the polished surface. the

polished specimen is immersed in the etch ant solution fora given time, removed with forceps, running water, rinsed with methyl alcohol (or spirit) and dried in hot air swilled in. the specimen is now ready for examination. The common etching reagents are- (For Ferrous alloys - Nital. (HNO3 1-5 ml, Ethyl or Methyl Alcohol 100 ml).

6. PRECAUTION

1. Grinding should be done on the emery papers only in one direction
2. After etching the natal should be washed away within a few seconds

7. RESULT:

From the above Microstructure observation, the given specimen is medium carbon steel and its carbon percentage is 0.30 – 0.60 % C.

8. QUESTIONS

1. Draw the microstructure of pearlite.?
2. What is the range of %C in M.C. Steel?
3. What do you mean by eutectoid, Hypo and hyper eutectoid steels?
4. What are the applications of MCS?
5. What is meant by heat treatment?

MICROSTRUCTURE OBSERVATION:

Magnification: 100 X **Etchant: Nital Solution**

The microstructure of medium carbon steel which contains 0.4% C consists of around 50% of pearlite in a background of ferrite.

This specimen is a medium carbon steel (carbon content is around 0.45%). This photomicrograph shows the microstructure of the medium carbon steel, which was austinitised and cooled slowly inside the furnace (Annealing). The microstructure shows large grains of pearlite in a matrix of ferrite. Note the pearlite grains, which are larger than that of steel that is normalized.

EXPERIMENT NO: 3

METALLOGRAPHIC STUDY AND ANALYSIS OF GREY CAST IRON

1. AIM:

To identify the microstructure and analysis of given specimen

2. APPARATUS & MATERIALS REQUIRED:

Specimen, metallurgical microscope, belt grinder, disc polisher, set of emery papers (i.e., 1/0, 2/0, 3/0, and 4/0), etchant, glass slab, abrasive powder (i.e., alumina, cotton).

3. THEORY

Grey Cast Iron

Composition: 2.8 to 3.6%C, 1.0 to 2.75% Si, 0.4 to 1.0 % Mn, 0.1 to 1.0% P, 0.06 to 0.12% S.

Gray cast iron always contains more carbon and silicon than white cast iron. Carbon is always present in form as graphite flakes. The tendency of carbon to form as graphite flakes is due to increase in carbon and siliconcontent and decrease in the cooling rate gray cast iron receives its name from the colour of a freshly made fracture. The approximate composition of Gray cast iron C - 2.8%, Si – 1-2%, M – 0.4-1%, P – 0.1-1%, S - 0.06-0.12%.

Properties:

1. It is alloy of carbon in iron
2. It is readily cast into desired shape in a sand mould.
3. It is marked by the presence of flakes of graphite in matrix of ferrite or pearlite or austenite.
4. Graphite flakes occupy about 10% of the metal volume.
5. Length of flakes may vary from 0.05 mm to 0.1 mm.
6. When fractured, a bar of cast iron gives grey appearance.
7. It has good bearing properties and good corrosion resistance.
8. It is low melting alloy, having good castability and machinability. It has low tensile strength, high compressive strength and very little ductility.
9. It has excellent damping capacity.
10. The presence of graphite flakes provides lubrication effects to sliding bodies.

Applications:

1. It is used for machine tool structures, man holes cover, tunnel segments, gas or water pipes for underground purposes.
2. It is used for cylinder blocks and heads for IC engines, frames for electric motors, ingot mould, piston rings.
3. It is used for house-hold appliances, rolling mills and machinery parts.
4. It is used for lathe beds, sanitary fittings, valves, machine frames, brake drums etc.

4. SEQUENCE OF OPERATIONS

1. Preparation of specimen
2. Dry polishing
3. Wet polishing
4. Etching
5. Microstructure observation

5. PROCEDURE

1. **Rough Polishing:** the specimen is polished on a emery papers containing successively finer abrasives the first Paper is usually no. 1/0 then 2/0, 3/0 and finally 4/0.Polish the specimen under light pressure in forward direction only.

   Note: While changing from one paper to another, make the specimen surface free from the abrasive of the previous paper and turn it through 90^{o}, so that scratches made by the next paper are approximately at right angles to the scratches from the previous paper.
2. **Fine polishing**: The fine and the final polishing is done by polishing machines. the polishing machine consists of a polishing disc. The fine velvet cloth is mounted over the disc. the disc resolves horizontally. Fine Aluminium powder is poured upon the velvet cloth for abrasive action and the cloth is moistened periodically in order to prevent the flying off of the powder used. The operation is done by gently holdings the specimen on the revolving disc. The alumina powder and water should be poured periodically. The specimen after the final polishing should be free from all the scratches and shouldappear like a mirror.
3. **Etching**: To make the structure apparent under the microscope it is necessary to impart in like appearances to the different constituents, this is accomplished by what is known as “Etching” a selective corrosion of the polished surface. the polished specimen is immersed in the etch ant solution fora given time, removed with forceps, running water, rinsed with methyl alcohol (or spirit) and dried in hot

air swilled in. the specimen is now ready for examination. The common etching reagents are- (For Ferrous alloys - Nital. (HNO_3 1-5 ml, Ethyl or Methyl Alcohol 100 ml).

6. PRECAUTION

1. Grinding should be done on the emery papers only in one direction
2. After etching the natal should be washed away within a few seconds

7. RESULT:

From the above Microstructure observation, the given specimen is grey cast iron and its carbon percentage is 0.60 – 0.90 % C.

8. QUESTIONS

1. Draw the microstructure of grey cast iron
2. What are the applications of GCI?
3. Give the composition of GCI
4. What is the raw material of GCI?
5. Give the importance of GCI

MICROSTRUCTURE OBSERVATION:

Magnification: 100 X **Etchant: Nital Solution**

The microstructure reveals flakes of graphite in a matrix of ferrite. The microstructure shows free carbon as graphite flakes in a matrix of pearlite.

The specimen is a annealed cast iron containing carbon 3.8% and silicon 2.6%. after casting the specimen is annealed in a furnace at 800^0 C for 1 hour and cooled. The polished (not etched) specimen shows free carbon in the form of flakes (like worms or snakes). The cast iron will have carbon content more than 2%. The carbon in cast iron will be in two forms.

1. Combined carbon (as carbides namely cementite).
2. Free carbon as graphite.

The microstructure shows free carbon as graphite flakes in the pearlite matrix (matrix can be ferrite and pearlite).

EXPERIMENT NO: 4

METALLOGRAPHIC STUDY AND ANALYSIS OF MALLEABLE CAST IRON

1. AIM:

To identify the microstructure and analysis of given specimen

2. APPARATUS & MATERIALS REQUIRED:

Specimen, metallurgical microscope, belt grinder, disc polisher, set of emery papers (i.e., 1/0, 2/0, 3/0, and 4/0), etchant, glass slab, abrasive powder (i.e., alumina, cotton).

3. THEORY

Malleable Cast Iron

Composition: around 2 to 2.8% C and approximately Si – 1.4%, Mn – 0.4-6%, Sulphur - 0.1%, Phosphorus – 0.2%

The Malleable Cast Iron obtained from heat treatment of white cast iron.

Properties:

1. Malleable Cast Iron is ductile, tough, strong, and easily machinable.
2. Carbon is present as irregular nodules.

Applications:

1. It is used for a wide range of applications such as agricultural implements, automobile parts, manhole covers, railroad equipment.
2. It is used where resistance to wear is most important and the service does not require ductility, such as liners for cement mixers, ball mills, certain types of drawing dies and extrusion nozzles.
3. A large tonnage of white cast iron is used as a starting material for manufacturing of malleable cast iron.

4. SEQUENCE OF OPERATIONS

1. Preparation of specimen
2. Dry polishing
3. Wet polishing
4. Etching
5. Microstructure observation

5. PROCEDURE

1. **Rough Polishing:** the specimen is polished on a emery papers containing successively finer abrasives the first Paper is usually no. 1/0 then 2/0, 3/0 and finally 4/0.Polish the specimen under light pressure in forward direction only.
   Note: While changing from one paper to another, make the specimen surface free from the abrasive of the previous paper and turn it through 90^{o}, so that scratches made by the next paper are approximately at right angles to the scratches from the previous paper.
2. **Fine polishing**: The fine and the final polishing is done by polishing machines. the polishing machine consists of a polishing disc. The fine velvet cloth is mounted over the disc. the disc resolves horizontally. Fine Aluminium powder is poured upon the velvet cloth for abrasive action and the cloth is moistened periodically in order to prevent the flying off of the powder used. The operation is done by gently holdings the specimen on the revolving disc. The alumina powder and water should be poured periodically. The specimen after the final polishing should be free from all the scratches and shouldappear like a mirror.
3. **Etching**: To make the structure apparent under the microscope it is necessary to impart in like appearances to the different constituents, this is accomplished by what is known as "Etching" a selective corrosion of the polished surface. the polished specimen is immersed in the etch ant solution fora given time, removed with forceps, running water, rinsed with methyl alcohol (or spirit) and dried in hot air swilled in. the specimen is now ready for examination. The common etching reagents are- (For Ferrous alloys - Nital. (HNO3 1-5 ml, Ethyl or Methyl Alcohol 100 ml).

6. PRECAUTION

1. Grinding should be done on the emery papers only in one direction
2. After etching the natal should be washed away within a few seconds

7. RESULT:

From the above Microstructure observation, the given specimen is white cast iron and its carbon percentage is 0.60 – 0.90 % C.

8. QUESTIONS

1. Give the applications of Malleable Cast Iron
2. Give the composition of MCI
3. Draw the Structure of MCI
4. Give the importance of MCI
5. What do you mean by martensite and tempered martensite?

MICROSTRUCTURE OBSERVATION:

Magnification: 100 X **Etchant: Nital Solution**

The microstructure shows the irregular black patches (rosettes) of tempered carbon in a matrix of ferrite or pearlite.

Malleable iron is one type of cast iron made from white cast iron. White cast iron is obtained from grey cast iron by pouring molten grey cast iron with chilled moulds. Due to sudden cooling the graphite's are not precipitated. This white cast iron is subjected to malleablizing heat treatment in a furnace. During this process the graphite (free carbon) are made to form globules (in almost spherical form). This heat treatment improves the mechanical properties of cast iron. Particularly percentage elongation and bending. The microstructure in as polished condition shows only temper carbon nodules and in the etched condition temper carbon nodules in a matrix of total ferrite. Hence this type of cast iron is called pearlitic-malleable cast iron.

BRASS

ALPHA BRASS

Alpha brass are known as copper alloy where as the cu-is 70%and Zn is 30%. The Melting point of cu is 1083^0 C, and Zn is 473^0 C. As per micro-structure the background is known as beta phase and Electron compound of Cu Zn. The grain structure in Alpha Phase is the Solid –Solution of Zn in Cu.

Properties:

- Cold working increases the strength
- Annealing temperature 500^0 C– 600^0 C
- Brass acquire Max relative elongation at a Zn contain 30-32%

α + β Brass (α - β Brass) also known as 'duplex brasses' or 'hot-working brasses'

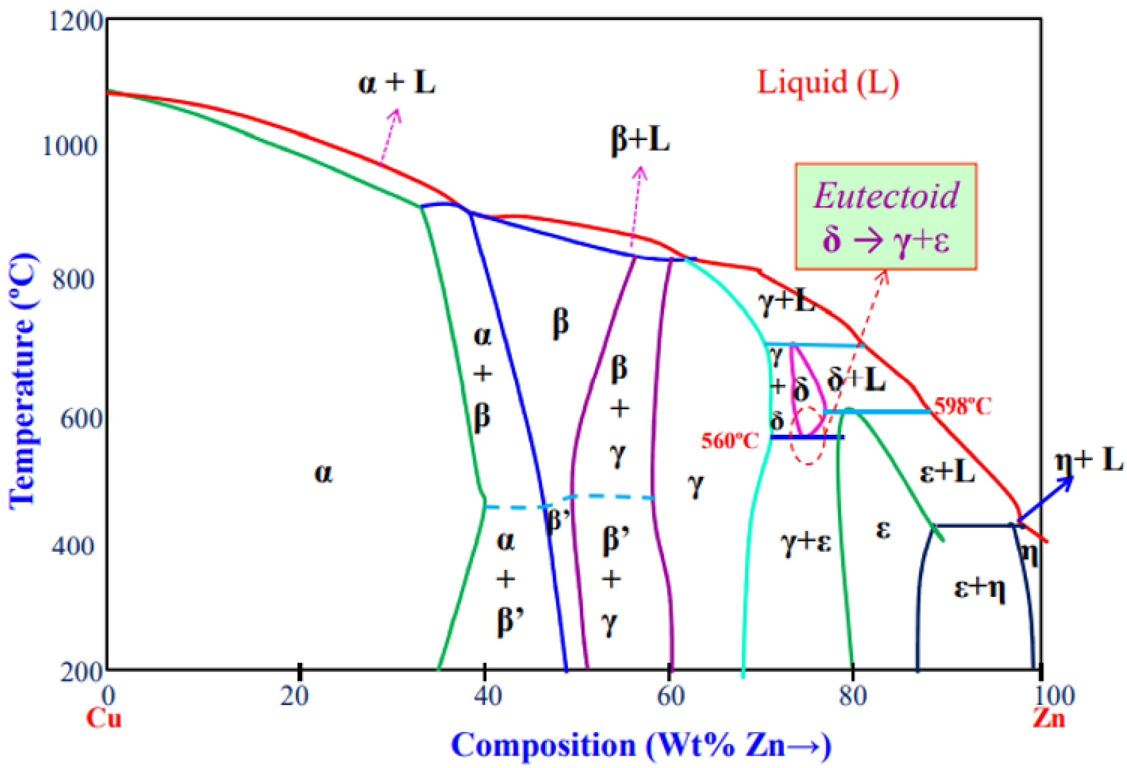
Brasses are copper alloys in which the principal alloying constituent is zinc. Their properties depend primarily upon the proportion of zinc present but can be usefully modified by the introduction of additional elements such as lead, tin, iron, aluminum, silicon, and manganese to further improve specific characteristics such as strength, machinability and resistance to particular forms of corrosion.

The ‘alpha-beta brasses’, ‘duplex brasses’ or ‘hot working brasses’ usually contain between 38% and 42% zinc. Difficult to work at room temperature, but significantly more workable at elevated temperatures and can be extruded into bars of complex section, either solid or hollow, and hot forged in closed dies (hot stamped) to complex shapes.

EFFECT OF ALLOYING ADDITIONS

Alloying additions are made to the basic copper-zinc alloys for a variety of reasons:-

- To improve machinability
- To improve strength and wear resistance
- To improve corrosion resistance
- For other special reasons



Applications:

Brass sheet is broadly used in industrial, architectural, marine applications, and Air Condition or Refrigerator, Water Tube, Water Heater, Oil Cooler Pipe. These brasses have relatively good corrosion resistance, are moderately high in strength.

Architecture: Handrails, Grillwork

Automotive: Tanks, Radiator Cores

Builders Hardware: Push Plates, Finish Hardware, Hinges, Stencils, Kick Plates, Locks

Electrical: Socket Shells, Screw Shells, Reflectors, Lamp Fixtures, Flash light Shells

Fasteners: Grommets, Eyelets, Screws, Rivets, Fasteners, Pins

Industrial: Bead Chain, Springs, Chain

Marine: Fasteners

Plumbing: Sink Strainers, Plumbing Accessories

EXPERIMENT NO: 5

METALLOGRAPHIC STUDY AND ANALYSIS Of α - β BRASS

1. **AIM:**

   To identify the microstructure and analysis of given specimen

2. **APPARATUS & MATERIALS REQUIRED:**

   Specimen, metallurgical microscope, belt grinder, disc polisher, set of emery papers (i.e., 1/0, 2/0, 3/0, and 4/0), etchant, glass slab, abrasive powder (i.e., alumina, cotton).

3. **THEORY**

   α - β BRASS

   Composition: around 39 to 45% Zn in Cu.

   Brass can be classified into α brass, α + β' brass, and β' brass, and their microstructures are changes with Zn content. The strength and ductility of α brass are superior than that of pure Cu at room temperature; β' brass is hard and less tough; α + β' brass stronger than α brass and tougher than β' brass, hence its applications are wider. Moreover, the high-temperature β phase is softer than the low-temperature β' phase, which results better hot workability of α + β' brass. The most widely used α-β Brass is "MUNTZ" metal, which contains 60% Cu and 40% Zn. It has a excellent hard working properties, higher strength. It is used for condenser heads, springs, chains etc.,

Properties:

1. The mechanical properties of cooper-zinc alloys depend on zinc content. As amount of zinc increases, the strength and plasticity of alloy improves.
2. Corrosion and wear resistance are better.

Applications:

1. Typical applications include automotive radiator cores, tanks, headlight reflectors, electrical-flash lights shells, lamp fixtures, socket shells, screw shells, hardware-eyelets, fasteners, grommets, rivets, springs, plumbing accessories and ammunition components.

4. SEQUENCE OF OPERATIONS

1. Preparation of specimen
2. Dry polishing
3. Wet polishing
4. Etching
5. Microstructure observation

5. PROCEDURE

Rough Polishing:

1. the specimen is polished on a emery papers containing successively finer abrasives the first Paper is usually no. 1/0 then 2/0, 3/0 and finally 4/0.Polish the specimen under light pressure in forward direction only.

   Note: While changing from one paper to another, make the specimen surface free from the abrasive of the previous paper and turn it through 90^{o}, so that scratches made by the next paper are approximately at right angles to the scratches from the previous paper.

2. **Fine polishing**: The fine and the final polishing is done by polishing machines. the polishing machine consists of a polishing disc. The fine velvet cloth is mounted over the disc. the disc resolves horizontally. Fine Aluminium powder is poured upon the velvet cloth for abrasive action and the cloth is moistened periodically in order to prevent the flying off of the powder used. The operation is done by gently holdings the specimen on the revolving disc. The alumina powder and water should be poured periodically. The specimen after the final polishing should be free from all the scratches and shouldappear like a mirror.

3. **Etching**: To make the structure apparent under the microscope it is necessary to impart in like appearances to the different constituents, this is accomplished by what is known as “Etching” a selective corrosion of the polished surface. the polished specimen is immersed in the etch ant solution fora given time, removed with forceps, running water, rinsed with methyl alcohol (or spirit) and dried in hot air swilled in. the specimen is now ready for examination. The common etching reagents are- (For Ferrous alloys - Nital. (HNO3 1-5 ml, Ethyl or Methyl Alcohol 100 ml).

6. PRECAUTION

1. Grinding should be done on the emery papers only in one direction
2. After etching the natal should be washed away within a few seconds

7. RESULT:

From the above Microstructure observation, the given specimen is white cast iron and its carbon percentage is 0.60 – 0.90 % C.

8. QUESTIONS

1. What is α – β Brass?
2. Give the applications of α – β Brass
3. Draw the structure of α – β Brass
4. What is difference between α Brass, β Brass & α – β Brass
5. Give composition of α – β Brass

MICROSTRUCTURE OBSERVATION:

Magnification: 100 X **Etchant: Ferric chloride solution (Ammonia & H_2O_2)**

The microstructure shows the black regions are beta phase around the matrix of white alpha phase.

The specimen is a conventional brass with the chemical composition of 60% Cu and 40% Zn. The microstructure shows uniform grains of alpha about 50% in a matrix of beta. The alpha is a eutectoid of copper and zinc and the beta is the solid solution of copper. The grains are in dendritic pattern as the specimen is casting.

EXPERIMENT NO: 6

STUDY OF MICROSTRUCTURE OF ALLUMINIUM ALLOY

1. **AIM:**

   To identify the microstructure and analysis of given specimen

2. **APPARATUS & MATERIALS REQUIRED:**

   Specimen, metallurgical microscope, belt grinder, disc polisher, set of emery papers (i.e., 1/0, 2/0, 3/0, and 4/0), etchant, glass slab, abrasive powder (i.e., alumina, cotton).

3. **THEORY**

   Aluminium Alloy

   Composition: Aluminium-silicon alloy

   Properties:

   1. The modification process for Aluminium-silicon alloy raises the tensile strength from 120 to 200 n/mm2 and percentage of elongation from 5 to 15%.
   2. It has relatively high ductility due to the presence of solid solution phase in the eutectic constitutes nearly 90% of the total structure.
   3. Due to its continuous structure, it acts like a cushion against much of the brittleness arising from the hard silicon phase.
   4. It has higher fluidity, low shrinkage, and narrow freezing range.
   5. It has higher corrosion resistance and it is lighter than Aluminium-copper alloy.

   Applications:

   1. It is used for die casting, marine work, aero and automobile application.
   2. Alloy B (12% silicon) and alloy 43 (5% silicon) are used for intricate castings, food-handling equipment and marine fittings.

4. **SEQUENCE OF OPERATIONS**

   1. Preparation of specimen
   2. Dry polishing
   3. Wet polishing
   4. Etching
   5. Microstructure observation

5. **PROCEDURE**

Rough Polishing:

1. the specimen is polished on a emery papers containing successively finer abrasives the first Paper is usually no. 1/0 then 2/0, 3/0 and finally 4/0.Polish the specimen under light pressure in forward direction only.

   Note: While changing from one paper to another, make the specimen surface free from the abrasive of the previous paper and turn it through 90^{o}, so that scratches made by the next paper are approximately at right angles to the scratches from the previous paper.

2. **Fine polishing**: The fine and the final polishing is done by polishing machines. the polishing machine consists of a polishing disc. The fine velvet cloth is mounted over the disc. the disc resolves horizontally. Fine Aluminium powder is poured upon the velvet cloth for abrasive action and the cloth is moistened periodically in order to prevent the flying off of the powder used. The operation is done by gently holdings the specimen on the revolving disc. The alumina powder and water should be poured periodically. The specimen after the final polishing should be free from all the scratches and shouldappear like a mirror.

3. **Etching**: To make the structure apparent under the microscope it is necessary to impart in like appearances to the different constituents, this is accomplished by what is known as "Etching" a selective corrosion of the polished surface. the polished specimen is immersed in the etch ant solution fora given time, removed with forceps, running water, rinsed with methyl alcohol (or spirit) and dried in hot air swilled in. the specimen is now ready for examination. The common etching reagents are- (For Ferrous alloys - Nital. (HNO3 1-5 ml, Ethyl or Methyl Alcohol 100 ml).

6. **PRECAUTION**

   1. Grinding should be done on the emery papers only in one direction
   2. After etching the natal should be washed away within a few seconds

7. **RESULT:**

From the above Microstructure observation, the given specimen is white cast iron and its carbon percentage is 0.60 – 0.90 % C.

8. QUESTIONS

1. What are the different types of Aluminium alloys?
2. What are the applications of Aluminium alloys?
3. Give the composition of Aluminium alloys

MICROSTRUCTURE OBSERVATION:

Magnification: 100 X **Etchant: Hydrofluoric Acid + Water**

The microstructure shows the matrix of alpha solid solution of silicon in Aluminium with needle like eutectic mixture of Aluminium and Silicon. Clear crystals of silicon also seen.

The specimen is a 3% copper and 6% silicon Aluminium alloy. The microstructure shows very fine grains of Al-Si Eutectic in a matrix of Al solid solution. The eutectic particles are rounded and agglomerated. The entire matrix is free from spike/script like Al-Si eutectics. As it is a casting some porosities are also present. Dark grains are Al-Si eutectics and light grains are $Cu\text{-}Al_2$ grains (eutectics). The $Cu\text{-}Al_2$ particles are precipitated and can be resolved at higher magnification.