LABORATORY MANUAL

METALLURGY AND MATERIAL SCIENCE LAB

II B.TECH -II Semester

AY-2017-2018

DEPARTMENT OF MECHANICAL ENGINEERING

CMR ENGINEERING COLEGE
(Approved by AICTE, New Delhi & Affiliated JNTU, Hyderabad)
Kandlakoya (V), Medchal Road, RR.Dist – 501401

VISION OF THE INSTITUTE

- To be recognized as a premier institution in offering value based and futuristic quality technical education to meet the technological needs of the society

MISSION OF THE INSTITUTE

1. To impart value based quality technical education through innovative teaching and learning methods
2. To continuously produce employable technical graduates with advanced technical skills to meet the current and future technological needs of the society
3. To prepare the graduates for higher learning with emphasis on academic and industrial research.

VISION OF THE DEPARTMENT

To be a center of excellence in offering value based and futuristic quality technical education in the field of mechanical engineering.

MISSION OF THE DEPARTMENT

M1. To impart quality technical education imbibed with values by providing state of the art laboratories and effective teaching and learning process.

M2. To produce industry ready mechanical engineering graduates with advanced technical and lifelong learning skills.

M3. To prepare graduates for higher learning and research in mechanical engineering and its allied areas.

PROGRAM EDUCATIONAL OBJECTIVES (PEOS):

PEO 1: The Graduates will exhibit strong knowledge in mathematics, sciences and engineering for successful employment or higher education in mechanical engineering.

PEO 2: The Graduates will design and implement complex modeling systems, conduct research and work with multi disciplinary teams.

PEO 3: The Graduates will be capable of communicating effectively with lifelong learning attitude and function as responsible members of global society.

PROGRAM OUTCOMES (POS):

1. Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

2. Problem analysis: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

3. Design/development of solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

4. Conduct investigations of complex problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

5. Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

6. The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

7. Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

8. Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

9. Individual and team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

10. Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

11. Project management and finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

12. Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

PROGRAM SPECIFIC OUTCOMES(PSOS):

PSO.1 Design a Thermal system for efficiency improvement as per industrial needs.

PSO.2 Design and manufacture mechanical components using advanced manufacturing technology as per the industrial needs.

Course Name: Metallurgy & Mechanics of Solids Lab

CO1	Examine the micro structure of pure metal and alloys by preparing using microscope.
CO2	Determine the hardenability of steel by jominy end quench test.
CO3	Determine the mechanical strength properties in tension, compression and shear using UTM.
CO4	Estimate the hardness number for metals and alloys using Brinells hardness test and Rockwell hardness test.
CO5	Estimate the impact strength of metal using izod and charpy test.
CO6	Calculate Torsional strength of a specimen using Torsion testing machine and strength in a helical spring.

Course Outcomes	**Relationship of Course Outcomes (CO) to Program Outcomes (PO)**											
CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	3	3	-	-	-	-	-	-	-	-
CO2	3	2	3	3	-	-	-	-	-	-	-	-
CO3	3	2	3	3	-	-	-	-	-	-	-	-
CO4	3	2	3	3	-	-	-	-	-	-	-	-
CO5	3	2	3	3	-	-	-	-	-	-	-	-
CO6	3	2	3	3	-	-	-	-	-	-	-	-

CO	PSO1	PSO2
CO1	-	2
CO2	-	2
CO3	-	2
CO4	-	2
CO5	-	2
CO6	-	2

-

GENERAL INSTRUCTIONS FOR LABORATORY CLASSES

1. All the students must follow the prescribed dress code (apron, formals, shoes) wear their ID cards
2. All the students should sign in login register.
3. All students must carry their observation books and records without fail.
4. Students must take the permission of the laboratory staff before handling the machines in order to avoid any injury.
5. The students must have basic understanding about the theory and procedure of the experiment to be conducted.
6. Power supply to the test table/test rig should be given in the presence of only through the lab technician.
7. Do not LEAN on and do not come CLOSE to the equipment.
8. Instruments like TOOLS, APPARATUS and GUAGE sets should be returned before leaving the lab.
9. Every student is required to handle the equipment with care and follow proper precautions
10. Students should ensure that their work areas are clean.
11. At the end of each experiment, the student must take initials from the staff on the data / observations taken after completing the necessary calculations.
12. The record should be properly written with following section in each experiment:
    a) Aim of the experiment
    b) Apparatus / Tools / Instruments required
    c) Procedure / Theory
    d) Model Calculations
    e) Schematic Diagram
    f) Specifications / Designs Details
    g) Tabulations.
    h) Graph
    i) Result and discussions.
13. Students should attend regularly to all lab classes.
14. Day- to- day evaluation of student performance is carried out and recorded for finalizing internal marks.

SCHEME OF EVALUATION FOR EXTERNAL LABS

Correctness of Write up and Precautions	Conduct Experiment & observations	Model Calculations	Results and Graphs	Viva
Marks: 10	**Marks: 20**	**Marks: 15**	**Marks: 15**	**Marks: 15**
Total Marks: 75 Marks				

SCHEME OF EVALUATION FOR INTERNAL LABS

Day to Day Evaluation ------15 Marks					**Internal Exam------10 Marks**				
Uniform	Observation &Record	Performance of experiment	Results	Viva Voce	Correctness of Write up and Precautions	Conduct Experiment & observations	Model Calculations	Results and Graphs	Viva Voce
Marks:2	**Marks:3**	**Marks:3**	**Marks:4**	**Marks:3**	**Marks:2**	**Marks:2**	**Marks:2**	**Marks:2**	**Marks:2**
Total Marks: 15+10=25 Marks									

LIST OF EQUIPMENT

S.NO	EQUIPMENT NAME
1	Optical Flat
2	Vernier Calipers
4	Vernier hight gauge
5	Outside Micrometer
6	Inside Micrometer
7	Gear tooth Micrometer
9	Dial gauge
12	Depth micrometer
13	Vernire Depth Gauge
14	Slip Gauge set
15	Sine bar
16	Screw thread plug gauge
18	Adjustable snap gauge
19	Feeler gauge
20	Bevel protector
21	Bore Gauge
22	Screw Thread Micrometer
23	C.I.Angle Plate
25	Screw Thread Micrometer
26	Gear tooth Vernier Caliper
27	Granite Surface plate
28	Three wire set with micrometer Holder for thread mount
29	Vernier Depth Gauge
30	Spirit level size
32	Tool Maker Microscope

CONTENTS

The Metallographic Laboratory Practice

Metallography means the study of microstructures and the structural characteristics of a metal or an alloy. It facilitates a metallurgist to determine the grain size and the size, shape and distribution of various phases and inclusions, which have a greatest effect on the mechanical properties of the metal or an alloy. The microstructure will reveal the mechanical and thermal treatment of the metal, and it may be possible to predict its expected behavior under a given set of conditions.

The success in the microscopic study depends upon the care taken in the preparation of the specimen. The ultimate objective is to produce a flat, scratch – free, mirror like surface. Thus, the prepared surface is observed with the help of a metallurgical microscopic at a required magnification.

Preparation of the metallographic sample:

The basic principles of abrasive polishing necessitate a sequence of operations which produces a distortion-free, polished surface capable of revealing the true microstructure. Equipment required to prepare an acceptable metallographic surface varies according to the factors --tests required, materials to be processed, work volume, operating philosophy, and other considerations.

The Steps involved in the preparation of a metallographic sample are:-

1. Sampling
2. Sample mounting
3. Rough Grinding
4. Intermediate Polishing
5. Fine Polishing
6. Etching.

1. Sampling:-

It is also called Sectioning. This process involves appropriate selection and collection of the metal piece from the parent part (a manageable size sample) for investigation. To investigate the failure of a component, the sample for the specimen is chosen from the close vicinity of the failure region. If the material is soft, such as non-ferrous metals or alloys and non heat-treated steels, the section may be

obtained by means of manual hack sawing. If the material is hard, the section is obtained by a conventional abrasive wheel cutter. The specimen should be kept cool during the cutting operation.

2. Specimen Mounting:-

Specimens that are small or awkwardly shaped should be mounted in a synthetic plastic viz., thermosetting resin(Bakelite), Thermoplastic resin(Lucitee) etc, to provide a safe means of holding the specimen and protect its edges from rounding. Wires, Small rods, sheet metal specimens, thin sections and irregular sample pieces do require mounting of uniform and convenient size. The sample metal piece in correct orientation is kept along with the Bakelite molding powder in the cylinder of Compression molding, with a mounting press. The temperature of the mould cylinder is gradually raised to 100ºc under a simultaneous molding pressure of about 28 MPa for mould setting/curing. The specimen in the Bakelite mould matrix is ejected for polishing. The thermoplastic resin Like Lucite is used for specimen mounting by cold setting.

3. Rough Grinding:-

The surface of the metal piece is made flat and smooth by removing surface deposits or leveling irregular surfaces .This is done by rubbing the sample specimen against a smooth file, if the specimen is soft. The specimen hard or soft, can be rough ground on a belt sanders finer successive abrasive sizes. While grinding or polishing the sample specimen, is kept cool by frequent dropping in water or by wet grinding. The rough grinding is continued until the surface is flat and free of nicks and burrs.

4. Intermediate Polishing:-

After abrasive rough polishing and mounting the sample specimen is polished on a series of fine emery papers, successfully finer abrasives 1/0, 2/0. 3/0, 4/0. Generally the process being dry polishing, heating and smearing of the sample specimen alters the microstructure. Hence to avoid this, resin bonded abrasive papers with proper in process lubrication is preferred.

5. Fine Polishing:-

Upon completion of intermediate polishing, a flat and scratch free surface is obtained by the wet polishing on rotating wheel covered with a special cloth (Duro cloth or velvet cloth) which is charged with carefully sized abrasive particles. Gamma form of Aluminium oxide (Alumina) is preferred as an abrasive for ferrous and copper based materials. Cerium oxide and magnesium oxides are the other abrasive powders for fine polishing. The careful polishing will remove the remaining scratches and produce the smooth lustrous surface required for microscopic examination.

6. Etching:-

Etching is the process of application of appropriate chemical reagent to clearly visualize and differentiate the various parts of a microstructure i.e developing the microstructure not normally visible in the as-polished condition. Because of the the chemical attack by etching reagent the grain boundaries will appear as valleys in the polished surface. Light from the microscope hitting the side of these valleys will be reflected out of the microscope making the grained boundaries appear as dark lines.

The different etching agents are:-

1. Nitric Acid.
2. Picric Acid (Picral).
3. Ferric chloride and Hydrochloric Acid.
4. Ammonium Hydroxide with Hydrogen Peroxide.
5. Ammonium per sulphate.
6. Palmerton Reagent.
7. Ammonium Molybdate.
8. Hydrofluoric Acid.

Etchants

CAUTION: Safety is very important when etching. Be sure to wear the appropriate protective clothing and follow all WARNINGS & PRECAUTIONS while using the chemicals**.**

Low Carbon Steel Etchants

Etchant	Conc.	Conditions	Comments
Nital Ethanol Nitric acid	100 ml 1-10 ml	Seconds to minutes	Do not exceed 10% nitric acid - explosive
Picral Ethanol Picric acid	100 ml 2-4 grams	Seconds to minutes	Do not let etchant dry – explosive

High Carbon Steel Etchants

Etchant	Conc.	Conditions	Comments
Picral Ethanol Picric acid	100 ml 2-4 grams	Seconds to minutes	For heat treated steels Do not let etchant dry – explosive
Ethanol Nitric acid Hydrochloric acid Picric acid	80 ml 10 ml 10 ml 1 gram	Seconds to minutes	Grain boundaries
Nital Ethanol Nitric acid	100 ml 1-10 ml	Seconds to minutes	Do not exceed 10% nitric acid - explosive

Cast Iron

Etchant	Conc.	Conditions	Comments
Nital Ethanol Nitric acid	100 ml 1-10 ml	Seconds to minutes	Do not exceed 10% nitric acid -explosive

Aluminum and Aluminum Alloys

Etchant	**Conc.**	**Conditions**	**Comments**
Kellers Etch Distilled water Nitric acid Hydrochloric acid Hydrofluoric acid	190 ml 5 ml 3 ml 2 ml	10-30 second immersion Use fresh	For most aluminum and aluminum alloys
Methanol Hydrochloric acid Nitric acid Hydrofluoric acid	25 ml 25 ml 25 ml 1 drop	10-60 seconds	Pure aluminum, aluminum-magnesium, and aluminum-magnesium-silicon alloys
Kroll's Reagent Distilled water Nitric acid Hydrofluoric acid	92 ml 6 ml 2 ml	15 seconds	Aluminum-copper alloys

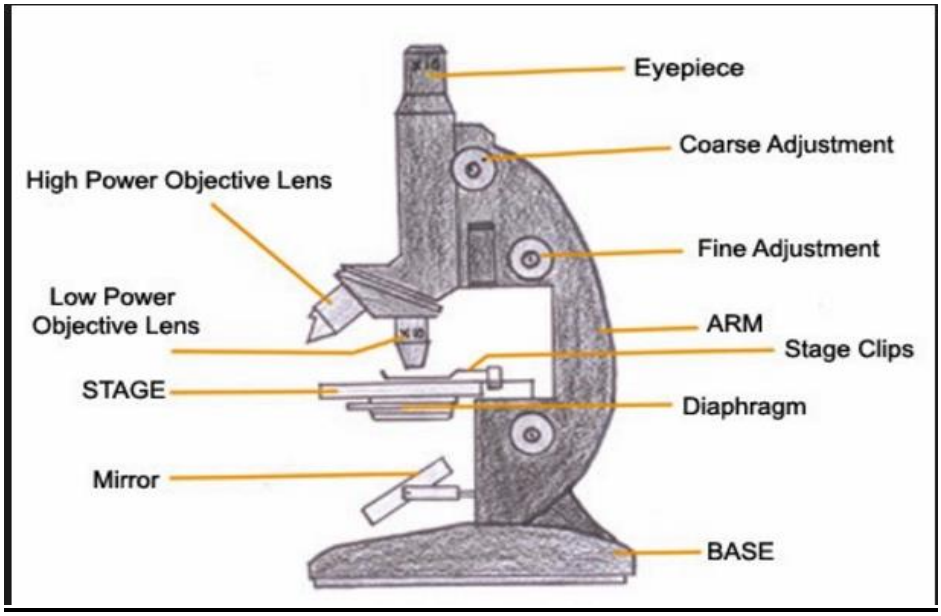
Brass and Bronze Alloys

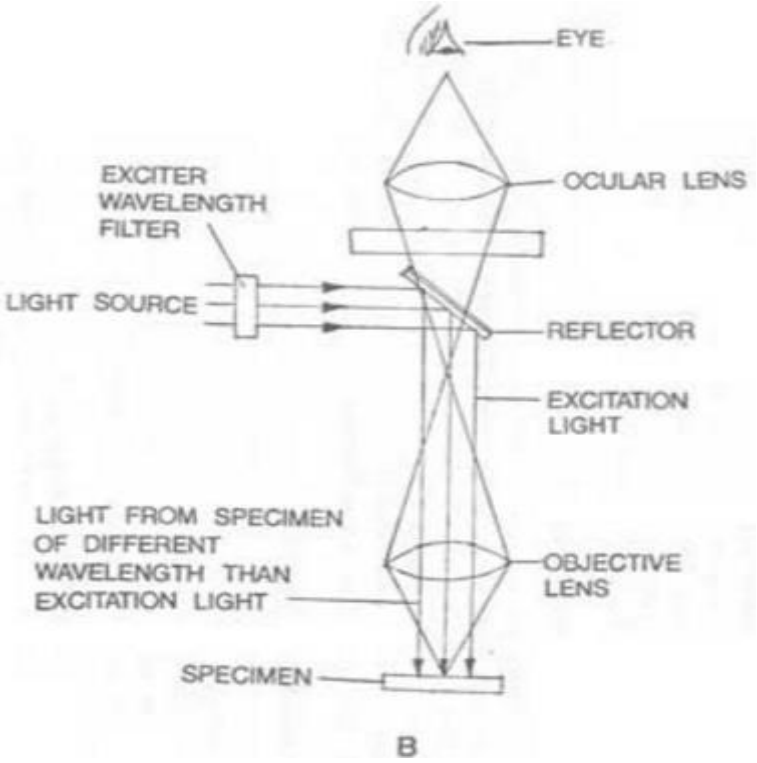
Etchant	Conc.	Conditions	Comments
Ammonium hydroxide (dilute solutions)	Dilute	Immersion	Attack polishing
Distilled water Ferric chloride Hydrochloric acid	100 ml 5 grams 50 ml	Immersion or swabbing	Brasses, bronzes, aluminum brass, alpha -phases in brass
Ethanol Hydrochloric acid Ferric chloride	100 ml 5-30 grams 5 grams	1 second to several minutes by immersion or swabbing	Darkens beta phase in alpha-beta brasses and aluminum

In uniform single phase alloys or pure metals, contrast is obtained and grain boundaries are made visible because of differences in the rate at which various grains are attacked by the reagent. In alloy composed of two or more phases, the components are revealed during etching by the preferential attack of one or more of these constituents by the reagent, because of the difference in chemical composition of the

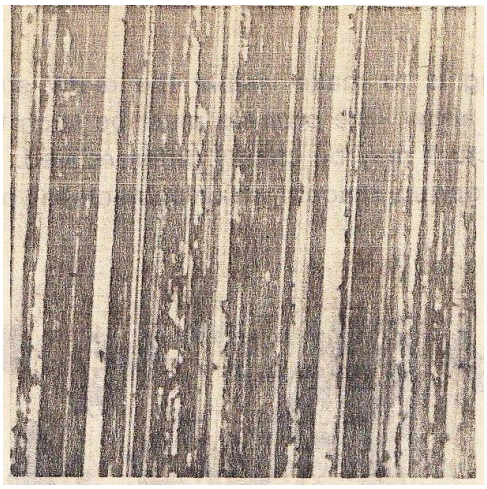
phases. The sample specimen is allowed to act upon it by the etching reagent for a specified amount of time (nearly 30 seconds). Then the specimen is washed with water and dried. The specimen is examined for its microstructure under metallurgical microscope.

Microscopy: Metallographic specimen prepared is observed, analyzed, and recorded for the true microstructure of the material.

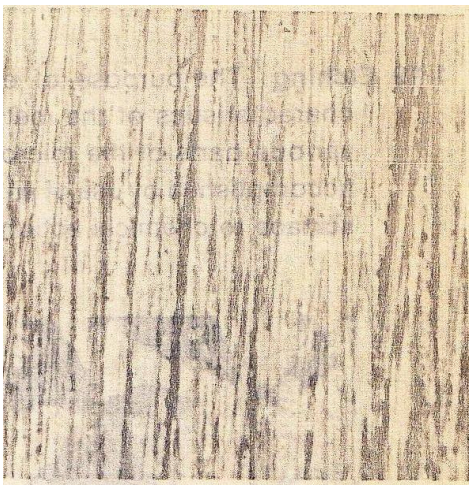




The Microscopy



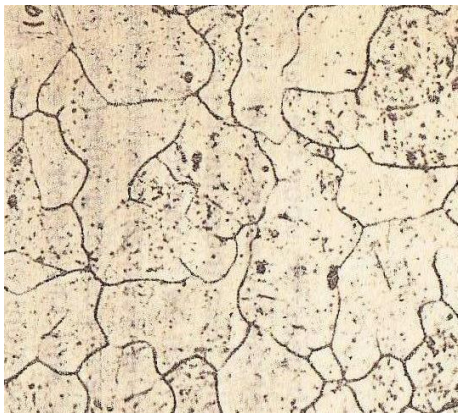
Surface after rough grinding,
Magnification 100 X



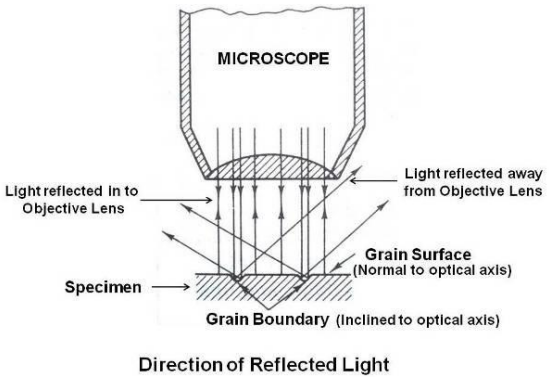
Surface after intermediate polishing
on 4/0 Emery paper
Magnification 100 X

Scratch free surface after final polishing
Magnification 50 X

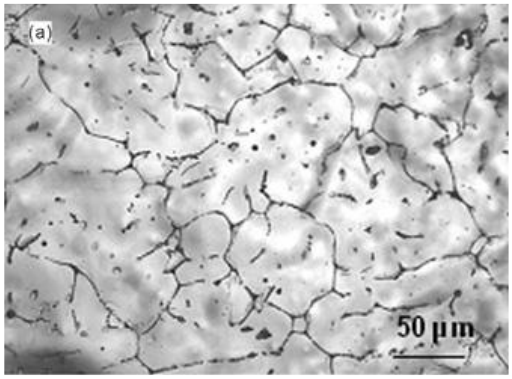
Photomicrograph revealed after Etching



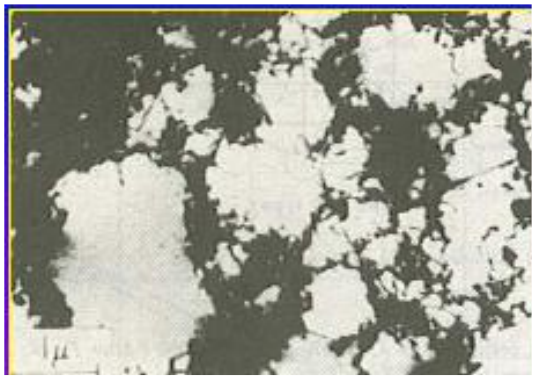
Photomicrograph of Iron



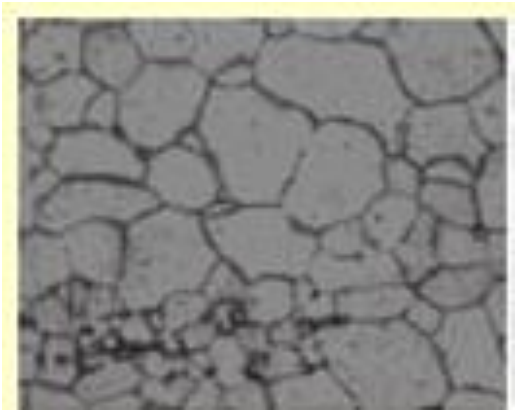
Microscopic appearance of grain boundaries as dark lines.



Optical Microstructure of a 99.5% pure aluminium



Optical Microstructure of a pure copper



Optical Microstructure of a pure iron

Experiment No.1

Aim: Preparation and Study of the microstructure of pure metals.

Type of Material:	Pure Iron
Geometrical description:	Circular specimen from the rod sample of Dia.25 mm
Heat Treatment:	Not applicable

Procedures:

Sampling procedure:	Cutting specimen from abrasive cutting wheel
Sequence of operations:	Sectioning, Mounting, Rough Grinding, Intermediate Polishing, Fine Polishing, Microscopic observation, Etching, Microscopic observation.
Specimen Mounting:	N/A.
Grinding:	Wet/ Dry Linisher was used and the scratches, nicks and Burrs were removed, sample with scratches being held Perpendicular to the grinding operation.
Intermediate Polishing: -	1/0, 2/0, 3/0, 4/0 Emery papers were used and they are rubbed 5 times in One direction perpendicular to the scratches.
Fine polishing: -	Double disc polishing machine with 2 types of velvet cloth and fine abrasive powder alumina with water was used to get a fine polished surface.
Etching Reagent Used: -	2% Nitric Acid + 98% Methyl Alcohol
Time duration of reagent Application -	20 - 30 secs.
Microscope Used –	Inverted binocular metallurgical optical microscope.
Magnification: –	50X.

Observation;

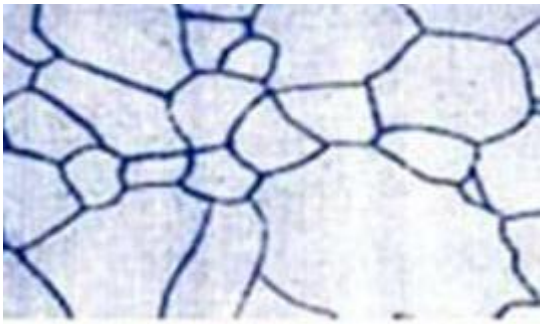
Metallurgical details of the specimen : Pure Iron has a F.C.C structure between 912°C and 1394°C .This is called the gamma iron(γ-Fe) . If the iron atoms, with a radius of 0.126 nm, are considered to be hard incompressible spheres, the γ-Fe structure is that in which each iron atom is in contact with a maximum number of neighbours.
Pure iron has a B.C.C structure between 1394°C and the melting point at 1538°C and below 912°C. In the high temperature the phase is known as δ iron, while the low temperatures form is designated α-Fe.

Theory : Iron : An element can exist in more than one crystalline form. This phenomenon is called polymorphism or allotropy
allotropy. In solid state pure Iron exist in three separate crystalline forms, which are designated as α iron, γ iron and δ iron, α iron and δ iron consist of BCC structures where as γ iron has FCC structure.

Result : Microstructure of Pure Iron is observed.

Microscopic Observation:

Before etching



After etching

VIVA QUESTIONS:

1. What bonds in solids?
2. What are the types of crystals imperfections?
3. Describe briefly Miller bravais indices?
4 .Give the relation b/t lattice parameter 'a' and atomic radius 'r' for simple cubic BCC, FCC and HCP
5 .Define packing factor?

Experiment No.2

Aim: Preparation and Study of the microstructure of pure metals.

Type of Material -	Pure Copper
Geometrical description –	Circular specimen from the rod sample of Dia.25 mm
Heat Treatment –	N/A

Procedures:

Sampling procedure:	Cutting specimen from abrasive cutting wheel
Sequence of operations –	Sectioning, Mounting, Rough Grinding, Intermediate Polishing, Fine Polishing, Microscopic observation, Etching, Microscopic observation.
Specimen Mounting –	Not Applicable
Grinding –	Wet/ Dry Linisher was used and the scratches, nicks and Burrs were removed, sample with scratches being held Perpendicular to the grinding operation.
Intermediate Polishing –	1/0, 2/0, 3/0, 4/0 Emery papers were used and they are rubbed 5 times in One direction perpendicular to the scratches.
Fine polishing –	Double disc polishing machine with 2 types of velvet cloth and fine abrasive powder alumina with water was used to get a fine polished surface.
Etching Reagent Used –	2% Hydrochloric acid + 98% Water.
Time duration of reagent application –	20 - 30 secs.
Microscope Used –	Inverted binocular metallurgical optical microscope.
Magnification –	50X.

Observation:

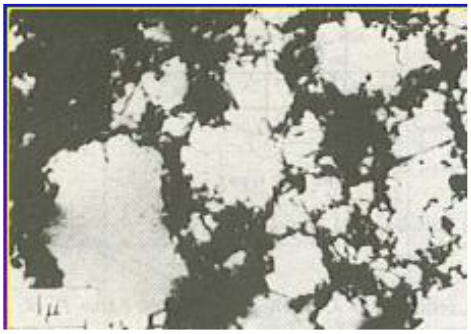
Metallurgical details of the specimen : The copper metal solidifies from the liquid state by the growth of crystals. crystals grow in preferred directions and form open, tree like structures called dendrites. The dendritic structure is very typical of cast metals. A lower melting point mixture of pure copper and cuprous oxide, called a eutectic, forms in the open spaces between the dendrites. The eutectic particles are usually dark, globular bodies dispersed in a copper background. The cuprous oxide particles form a network, outlining the dendritic cells. Pores, seen as dark spots in the microstructure, are also present in the as-cast material.

Theory : The properties of copper that are most important are high electrical and thermal conductivity, good corrosion resistant , machinability, strength, ease of fabrication.

Result : Large dendritic grains of α solid solution can be observed.

Microscopic Observation:

Before etching



After etching

VIVA QUESTIONS:

1 .What are the conditions that are favorable for extensive solid solubility of one element in another? Explain them.

2. What is lever rule? Explain how it is useful?

3. What is Phase rule? Explain how it is useful?

4. What do you understand by the term equilibrium diagram? Explain with an example.

5. Write applications of phase diagrams?

Experiment No.3

Aim: Preparation and Study of the microstructure of pure metals.

Type of Material:	Pure Aluminum.
Geometrical description –	Circular specimen from the rod sample of Dia.25 mm
Heat Treatment –	N/A

Procedures:

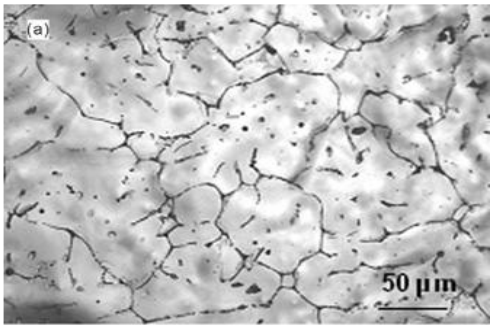
Sampling procedure:	Cutting specimen from abrasive cutting wheel
Sequence of operations –	Sectioning, Mounting, Rough Grinding, Intermediate Polishing, Fine Polishing, Microscopic observation, Etching, Microscopic observation.
Specimen Mounting –	N/A.
Grinding –	Wet/ Dry Linisher was used and the scratches, nicks and Burrs were removed, sample with scratches being held Perpendicular to the grinding operation.
Intermediate Polishing –	1/0, 2/0, 3/0, 4/0 Emery papers were used and they are rubbed 5 times in one direction perpendicular to the scratches.
Fine polishing –	Double disc polishing machine with 2 types of velvet cloth and fine abrasive powder alumina with water was used to get a fine polished surface.
Etching Reagent Used –	2% Hydro chloric acid + 98% Water.
Time duration of reagent application –	20 - 30 secs.
Microscope Used –	Inverted binocular metallurgical optical microscope.
Magnification –	50X.

Observation ;

Metallurgical details of the specimen	:	These images show the effect of grain refinement alloying additions in commercial purity aluminum. The grain size is very large, which would result in poor strength and toughness.
Theory	:	The best known characteristics of Al is its light weight. It has good Malleability and formability, high corrosion resistance and high electrical and thermal conductivity.
Result	:	Large equiaxed grains can be observed in the Al matrix.

Microscopic Observation:

Before etching

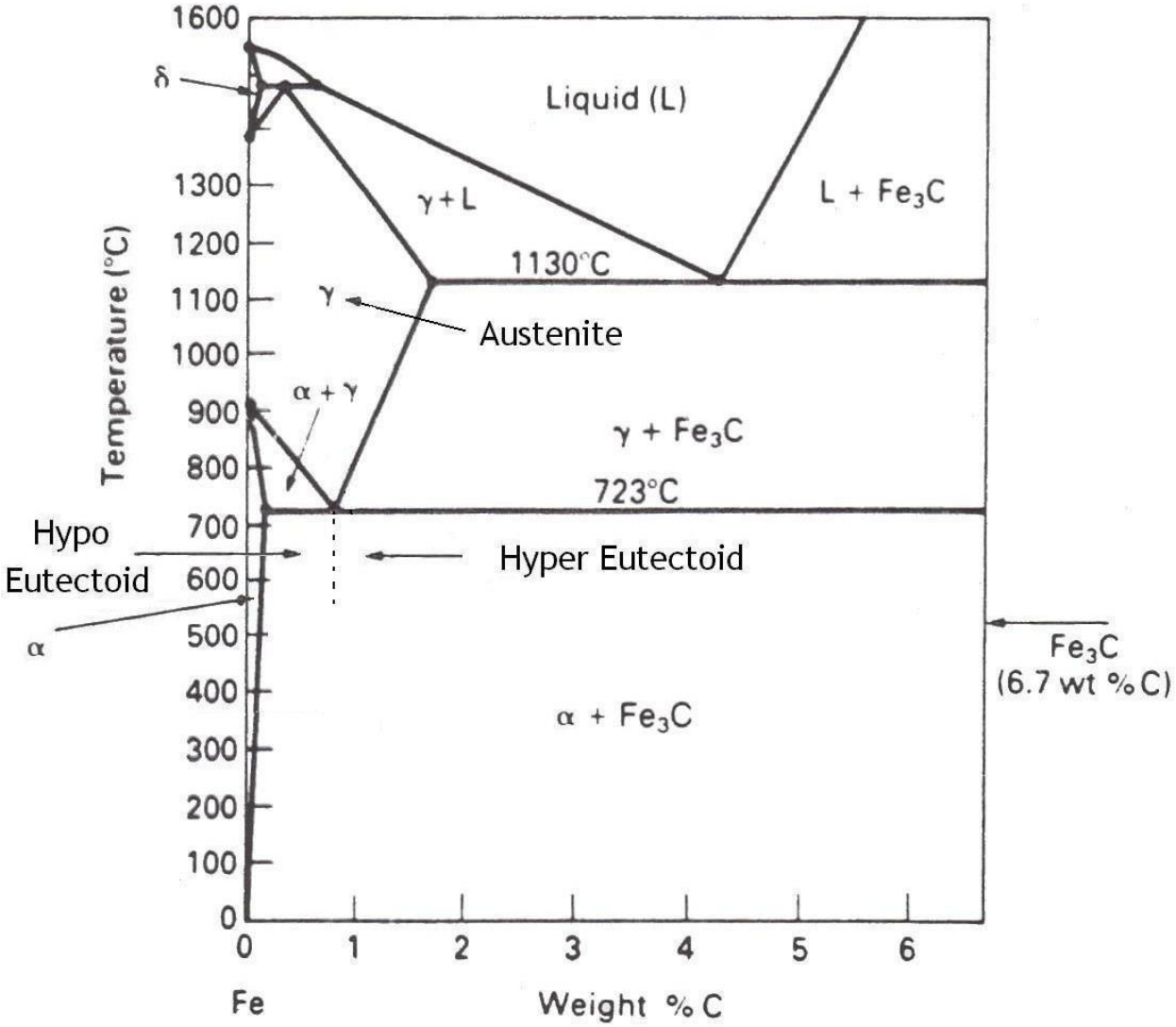


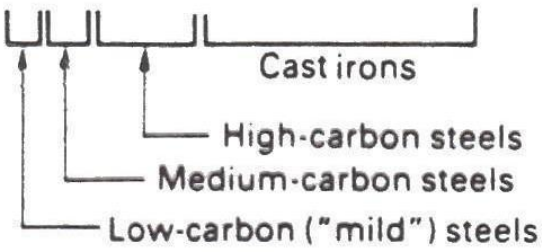
After etching

VIVA QUESTIONS:

1. Distinguish between I. Terminal phase & ii. Intermediate phase
2. Name types of grain size measurements?
3. Define eutectic reaction?
4. Define eutectoid reaction and invariant reaction?
5. What are different heat treatment processes?

STEELS: I—CARBON STEELS





Ferrite – α

Austenite – γ

Cementite – Fe_3C

Exercise No.4

Aim : Preparation and Study of the microstructure of Carbon Steels.

Type of Material:	Low Carbon Steels
Geometrical description –	Circular specimen from the rod sample of Dia.25 mm
Heat Treatment –	N/A

Procedures:

Sampling procedure:	Cutting specimen from abrasive cutting wheel
Sequence of operations –	Sectioning, Mounting, Rough Grinding, Intermediate Polishing, Fine Polishing, Microscopic observation, Etching, Microscopic observation.
Specimen Mounting –	N/A.
Grinding –	Wet/ Dry Linisher was used and the scratches, nicks and Burrs were removed, sample with scratches being held Perpendicular to the grinding operation.
Intermediate Polishing –	1/0, 2/0, 3/0, 4/0 Emery papers were used and they are rubbed 5 times in one direction perpendicular to the scratches.
Fine polishing –	Double disc polishing machine with 2 types of velvet cloth and fine abrasive powder alumina with water was used to get a fine polished surface.
Etching Reagent Used –	4% Nitric Acid + 96% Methyl Alcohol
Time duration of reagent Application –	20 - 30 secs.
Microscope Used –	Inverted binocular metallurgical optical microscope.
Magnification –	50X.

Observation;

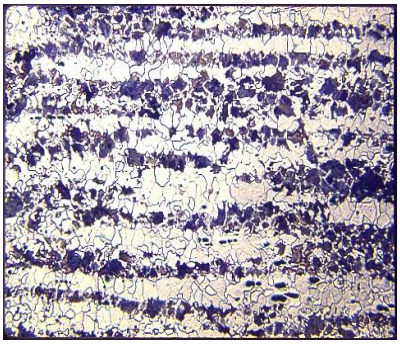
Metallurgical details of the specimen : This is a medium carbon steel, consisting of ferrite and pearlite (a lamellar mixture of ferrite and cementite). It is banded (dark bands = pearlite; light bands = ferrite) an undesirable condition. . The etchant used Nital

Theory : Steels with 0.20% to 0.5% carbon are referred to as medium carbon steels. The response of these steels to heat treatment is much better than that of low carbon steels. In order to have maximum advantage these are always used in heat treatment condition. The desired level of strength, ductility and toughness can be obtained by a proper combination of hardening and tempering of these steels. Before heat treatment, the microstructure of these steels at room temperature shows ferrite grains and pearlite grains with varying composition depending upon the percentage of carbon. In case of normalizing, because of the moderate cooling rate, time is not sufficient for the formation of pre-eutectoid constituent i.e ferrite. The steel becomes hard as there is less percentage of ferrite with its softer grains, compared to the steel before heat treatment.

Result: The microstructure of medium carbon steel is revealed by etching with natal and white ferrite grains and dark pearlite grains are observed.

Microscopic Observation:

Before etching



After etching

VIVA QUESTIONS

1. Define annealing?
2. Define normalizing?
3. Define hardening?
4. What is the difference between the hardening and surface hardening?
5. What different critical temperatures in Iron Carbide diagram?

Exercise No.5

Aim : Preparation and Study of the microstructure of Carbon Steels.

Type of Material: Medium Carbon Steels

Geometrical description – Circular specimen from the rod sample of Dia.25 mm

Heat Treatment – N/A

Procedures :

Sampling procedure : Cutting specimen from abrasive cutting wheel

Sequence of operations – Sectioning, Mounting, Rough Grinding, Intermediate Polishing, Fine Polishing, Microscopic observation, Etching, Microscopic observation.

Specimen Mounting – N/A.

Grinding – Wet/ Dry Linisher was used and the scratches, nicks and Burrs were removed ,sample holded with scratches being perpendicular to the grinding operation.

Intermediate Polishing – 1/0, 2/0, 3/0,4/0 Emery papers were used and 5 times in one direction perpendicular to the sctratches.

Fine polishing – Double disc polishing machine with 2 types of velvet cloth and fine abrasive powder alumina with water was used to get a fine polished surface.

Etching Reagent Used – 4% Nitric Acid + 96% Methyl Alcohol

Time duration of reagent application – 20 - 30 secs.

Microscope Used – Inverted binocular metallurgical optical microscope.

Magnification – 50X.

Observation ;

Metallurgical details of the specimen : This is the microstructure of a low carbon steel, also known as mild steel. It contains about 0.1% C by weight, alloyed with iron. The steel has two major constituents, which are ferrite and pearlite.The light coloured region of the microstructure is the ferrite. The grain boundaries between the ferrite grains can be seen quite clearly.The dark regions are the pearlite. It is made up from a fine mixture of ferrite and iron carbide, which can be seen as a "wormy" texture.Small

spots within the ferrite grains. These are inclusions or impurities such as oxides and sulphides.The properties of the steel depends upon the microstructure. Decreasing the size of the grains and decreasing the amount of pearlite improves the strength, ductility and the toughness of the steel.

Theory : In low carbon steels the only alloying element is carbon and steels containing upto 0.25% carbon are known as low carbon steels.
The eutectoid transformation is expressed as

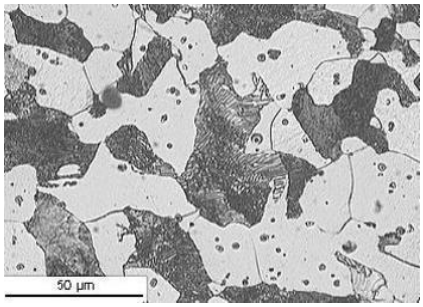
Solid 1 ~ Solid 2 + Solid 3

Austenite ~ Ferrite + Cementite

Austenite is stable above 1333º F The maximum solubility of C is @% at 2065º F. At 1333º F the solubility of carbon is less and is 0.8%. So the surplus carbon gets precipitated in the form of the plates of cementite. In the area immediately adjacent to the cementite plate is depleted or carbon and the atoms now rearrange themselces to form B.C.C ferrite. Thin layers of ferrite are formed on each side of cementite plate. The process continues by the formation of alternate layers of cementite and ferrite to give fingerprint mixture known as pearlite. Ferrite appears white and pearlite appears dark with most common etching agent such as nital.

Result : Ferrite and pearlite can be observed after etching in 2% Nitric acid(Nital).

Microscopic Observation :



Before etching **After etching**

VIVA QUESTIONS

1.what is purpose of TTT diagram and CCT diagram ?

2.waht is martempering?

3.what is austempering?

4.Define alloy and name different copper alloys?

5.what are the applications and properties of copper?

Exercise No.6

Aim : Preparation and Study of the microstructure of Carbon Steels.

Type of Material :	High Carbon Steels
Geometrical description –	Circular specimen from the rod sample of Dia.25 mm
Heat Treatment –	N/A

Procedures :

Sampling procedure :	Cutting specimen from abrasive cutting wheel
Sequence of operations –	Sectioning, Mounting, Rough Grinding, Intermediate Polishing, Fine Polishing, Microscopic observation, Etching, Microscopic observation.
Specimen Mounting –	N/A.
Grinding –	Wet/ Dry Linisher was used and the scratches, nicks and Burrs were removed ,sample holded with scratches being perpendicular to the grinding operation.
Intermediate Polishing –	1/0, 2/0, 3/0,4/0 Emery papers were used and 5 times in one direction perpendicular to the sctratches.
Fine polishing –	Double disc polishing machine with 2 types of velvet cloth and fine abrasive powder alumina with water was used to get a fine polished surface.
Etching Reagent Used –	4% Nitric Acid + 96% Methyl Alcohol
Time duration of reagent application –	20 - 30 secs.
Microscope Used –	Inverted binocular metallurgical optical microscope.
Magnification –	50X.

Observation ;

Metallurgical details of the specimen	**:**	This is the microstructure of a high carbon steel. It contains about 0.8% C by weight, alloyed with iron. The steel has one major constituent, which is pearlite.It is made up from a fine mixture of ferrite and iron carbide, which can be seen as a "wormy" texture.The pearlite has a very fine structure, which makes the steel very hard.

Theory : The carbon contents of high carbon steels generally vary from 0.5% to 1.0%. The higher the carbon percentage, The greater the hardness and brittleness. Therefore steels with more than 1.3% C are arel used in practice. These steels have poor fabricability, formability and machinability as compared to medium carbon steels. Later these two properties can be improved to a great extent by spheroidizing and normalizing. These steels cannot be cold worked . Befor e heat treatment the microstructure shows pearlite areas surrounded by white cementite network. The width of cementite network increases with the increase of carbon percentage.

Result : The microstructure of high carbon steel is revealed by etching with Nital solution and the microstructure of hogh carbon steel shows pearlite grains with a white cementite network on the boundary.

Microscopic Observation :

Before etching

After etching

VIVA QUESTIONS

1.what are the applications and properties of copper ?

2.Define alloy and name different copper alloys?

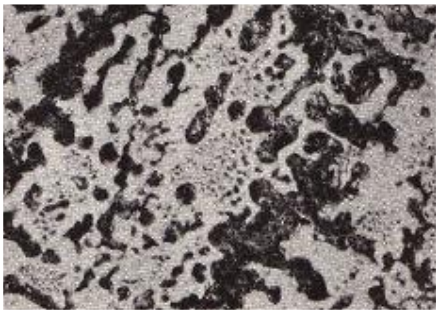
3.waht is martempering?

4.what is austempering?

5.what is the purpose of iron-carbide diagram?

CAST IRON

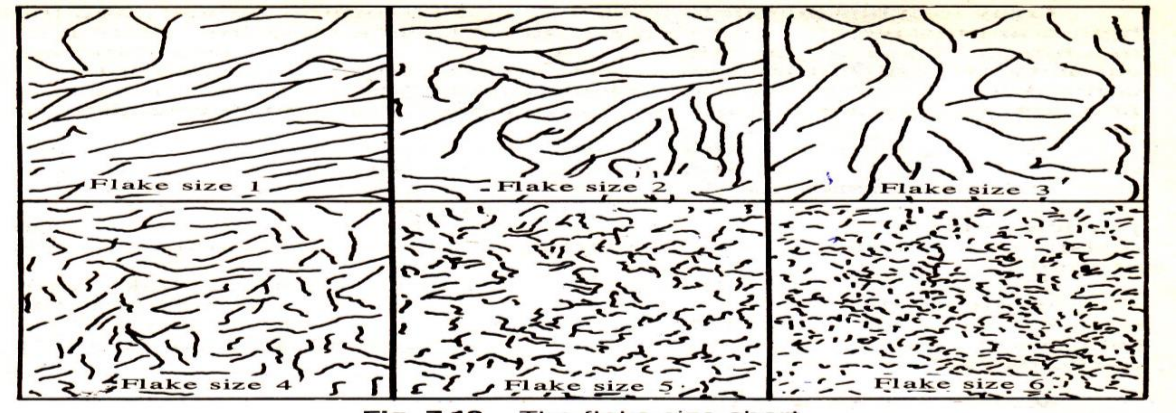
Microstructure of Grey Cast Iron

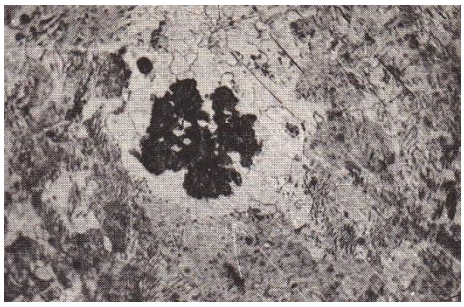


Microstructure of White Cast Iron

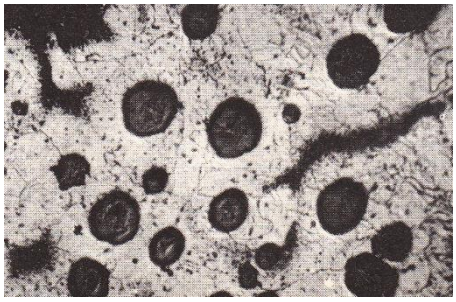
The size of the flakes is specified by a number as given in the following table:

Size number	1	2	3	4	5	6
Length of the largest flake	> 4"	2" – 4"	1" – 2"	½" – 1"	¼" – ½"	⅛" – ¼"





Microstructure of Malleable Cast Iron
Temper Carbon is in the form of irregular aggregates.



Microstructure of White Cast Iron
Spherical Nodules of graphite

Experiment No.7

Aim : Preparation and Study of the microstructure of Cast Irons.

Type of Material:	Grey Cast Irons
Geometrical description –	Circular specimen from the rod sample of Dia.25 mm
Heat Treatment –	N/A

Procedures :

Sampling procedure :	Cutting specimen from abrasive cutting wheel
Sequence of operations –	Sectioning, Mounting, Rough Grinding, Intermediate Polishing, Fine Polishing, Microscopic observation, Etching, Microscopic observation.
Specimen Mounting –	N/A.
Grinding –	Wet/ Dry Linisher was used and the scratches, nicks and Burrs were removed, sample with scratches being held perpendicular to the grinding operation.
Intermediate Polishing –	1/0, 2/0, 3/0, 4/0 Emery papers were used and they are rubbed 5 times in one direction perpendicular to the scratches.
Fine polishing –	Double disc polishing machine with 2 types of velvet cloth and fine abrasive powder alumina with water was used to get a fine polished surface.
Etching Reagent Used –	2% Nitric Acid + 98% Methyl Alcohol
Time duration of reagent application –	20 - 30 secs.
Microscope Used –	Inverted binocular metallurgical optical microscope.
Magnification –	50X.

Observation ;

Metallurgical details of the specimen : Graphite flakes are embedded in the matrix of ferrite. Flakes are in fact curved plates often interconnected in three dimensions. Graphite flakes are sharp at their tips and acts like internal cracks or stress raisers. Gray iron depends on the morphology and size of the graphite flakes and the matrix. Fine and randomly oriented flakes are the most desirable microstructure.

Theory : With proper control of the cooling rate, the carbon percentage , high temperature, amount of graphitizing elements during solidification graphite is formed at eutectic temperature. During continued cooling additional precipitation of graphite takes place from pre eutectoid cementite. These graphite flakes interrupt the continuity of matrix, thereby reducing the strength and ductility of the Gray cast iron. The graphite flakes embedded in ferritic matrix are shown.

Result : The graphite flakes embedded in ferritic matrix are seen.

Microscopic Observation:

Before etching

After etching

VIVA QUESTIONS

1. What are the applications and properties of Grey cast iron?
2. Define alloy and name different iron alloys?
3. What is martempering?
4. What is austempering?
5. What we observe in the microscopic test before and after etching?

Experiment No.8

Aim: Preparation and Study of the microstructure of Cast Iron.

Type of Material:	Malleable Cast Iron
Geometrical description –	Circular specimen from the rod sample of Dia.25 mm
Heat Treatment –	N/A

Procedures:

Sampling procedure:	Cutting specimen from abrasive cutting wheel
Sequence of operations –	Sectioning, Mounting, Rough Grinding, Intermediate Polishing, Fine Polishing, Microscopic observation, Etching, Microscopic observation.
Specimen Mounting –	N/A.
Grinding –	Wet/ Dry Linisher was used and the scratches, nicks and Burrs were removed, sample with scratches being held perpendicular to the grinding operation.
Intermediate Polishing –	1/0, 2/0, 3/0, 4/0 Emery papers were used and they are rubbed 5 times in One direction perpendicular to the scratches.
Fine polishing –	Double disc polishing machine with 2 types of velvet cloth and fine abrasive powder alumina with water was used to get a fine polished surface.
Etching Reagent Used –	2% Nitric Acid + 98% Methyl Alcohol
Time duration of reagent application –	20 - 30 secs.
Microscope Used –	Inverted binocular metallurgical optical microscope.
Magnification –	50 X

Observation;

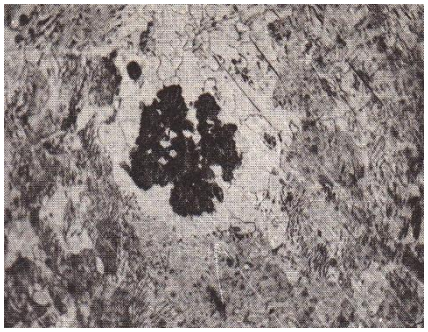
Metallurgical details of the specimen : Some carbon is lost by the combination with residual oxygen. In the white heart malleable iron, most of the carbon is lost by oxidation, leaving behind an essentially ferritic matrix. In black heart malleable, temper carbon is present in the form of irregular aggregates.

Theory : The purpose of malleabilisation is to convert all the combined white cast iron into irregular nodules of temper carbon and ferrite. Commercially this process is carried out in two stages of annealing. In the form of compact nodules the temper carbon does not break the continuity of the tough ferrite matrix resulting in high strength and ductility.

Result : The irregular shaped black spot is the temper carbon seen in the ferritic matrix.

Microscopic Observation:

Before etching



After etching

VIVA QUESTIONS

1. What are the applications and properties of malleable cast iron?
2. Define alloy and name different iron alloys?
3. What is martempering?
4. What is austempering?
5. What we observe in the microscopic test before and after etching?

Exercise No.9

Aim: Preparation and Study of the microstructure of Cast Irons.

Type of Material:	White Cast Iron.
Geometrical description –	Circular specimen from the rod sample of Dia.25 mm
Heat Treatment –	N/A

Procedures:

Sampling procedure:	Cutting specimen from abrasive cutting wheel
Sequence of operations –	Sectioning, Mounting, Rough Grinding, Intermediate Polishing, Fine Polishing, Microscopic observation, Etching, Microscopic observation.
Specimen Mounting –	N/A.
Grinding –	Wet/ Dry Linisher was used and the scratches, nicks and Burrs were removed, sample with scratches being held perpendicular to the grinding operation.
Intermediate Polishing –	1/0, 2/0, 3/0, 4/0 Emery papers were used and they are rubbed 5 times in one direction perpendicular to the scratches.
Fine polishing –	Double disc polishing machine with 2 types of velvet cloth and fine abrasive powder alumina with water was used to get a fine polished surface.
Etching Reagent Used –	2% Nitric Acid + 98% Methyl Alcohol
Time duration of reagent application –	20 - 30 secs.
Microscope Used –	Inverted binocular metallurgical optical microscope.
Magnification –	50X.

Observation;

Metallurgical details of the specimen	:	The solubility of carbon in austenite decreases from 2.11% at 1146ºC to 0.77% at 727ºC. The excess carbon

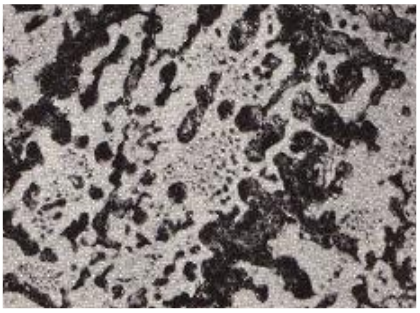
precipitates as cementite both from the proeutectic and the eutectic austenite. On cooling throough the eutectoid temperature (727ºC), the austenite decomposes to pearlite.

Theory : Carbon in the cast iron is present in the form of cementite, Hence it is called white cast iron because it shows white fractured surface. Miscrostructure consists of pearlite, cementite and ledeburite. When carbon content less than 4.3% , called hypo eutectic cast iron , microstructure consists of pearlite, cementite and small amount of ledeburite .If carbon content more than 4.3% called hyper eutectic cast iron, microstructure consists of ledeburite and cementite plates.

Result : The microstructure observed has cementite (white regions) and pearlite (dark regions).

Microscopic Observation:

Before etching



After etching

VIVA QUESTIONS

1. What are the applications and properties of White cast iron ?
2. Define alloy and name different iron alloys?
3. What is martempering?
4. What is austempering?
5. What we observe in the microscopic test before and after etching?

Exercise No.10

Aim : Preparation and Study of the microstructure of Non Ferrous Alloys.

Type of Material: - Brass

Geometrical description – Circular specimen from the rod sample of Dia.25 mm

Heat Treatment – N/A

Procedures:

Sampling procedure: Cutting specimen from abrasive cutting wheel

Sequence of operations – Sectioning, Mounting, Rough Grinding, Intermediate Polishing, Fine Polishing, Microscopic observation, Etching, Microscopic observation.

Specimen Mounting – N/A.

Grinding – Wet/ Dry Linisher was used and the scratches, nicks and Burrs were removed, sample with scratches being held perpendicular to the grinding operation.

Intermediate Polishing – 1/0, 2/0, 3/0, 4/0 Emery papers were used and they are rubbed 5 times in one direction perpendicular to the scratches.

Fine polishing – Double disc polishing machine with 2 types of velvet cloth and fine abrasive powder alumina with water was used to get a fine polished surface.

Etching Reagent Used – 5% Hydrogen peroxide, + 5% Ammonium Hydroxide + 90% Water.

Time duration of reagent application – 20 - 30 secs.

Microscope Used – Inverted binocular metallurgical optical microscope.

Magnification – 50X.

Observation;

Metallurgical details of the specimen : This is an alloy of copper (Cu) with 30% zinc (Zn) by weight. The polycrystalline grain structure of the brass is clearly seen. The parallel sided bands across the grains are annealing twins. These are regions of different crystallographic orientation within the brass grains. They show that the alloy

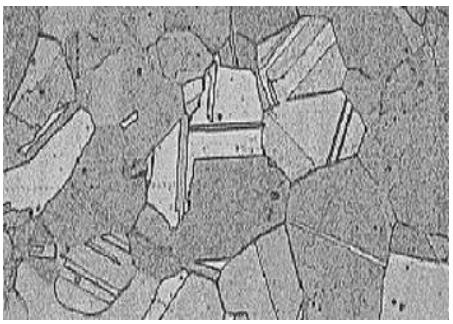
has been shaped by cold working (deformation at room temperature) followed by annealing (high temperature heat treatment).

Theory : Brass is the alloy of copper and zinc. From the copper-zinc equilibrium diagram one can observe that the region of α solid solution is quite wide extending from 1 to 38% of zinc. If zinc percentage is more than 38% a second solid solution is formed. With zinc content more than 50% another solid solution called gamma is found. Useful Cu – Zn alloys are those that contain less than 40 % Zn. Different brasses are cap copper (contains 2 to 5% zinc), Gliding metals (contains 5 to 15% zinc), Cartridge Brass (70% copper, 30% zinc). Admirality Brass (69% copper, 30% zinc, 1% tin), Muntz metal (60% copper, 40% zinc), Naval brass (60% copper, 39% zinc,1% tin).

Result : The polycrystalline grains structure observed with Parallel sided bands across the grains.

Microscopic Observation:

Before etching



After etching

VIVA QUESTIONS

1. Define magnification in microscope?
2. What is the purpose of etchants?
3. What is grain and grain boundary?
4. Define composite material?
5. What are different applications and properties of composite materials?

Exercise No.11

Aim: Preparation and Study of the microstructure of Non Ferrous Alloys.

Type of Material: Bronze

Geometrical description – Circular specimen from the rod sample of Dia.25 mm

Heat Treatment – N/A

Procedures:

Sampling procedure : Cutting specimen from abrasive cutting wheel

Sequence of operations – Sectioning, Mounting, Rough Grinding, Intermediate Polishing, Fine Polishing, Microscopic observation, Etching, Microscopic observation.

Specimen Mounting – N/A.

Grinding – Wet/ Dry Linisher was used and the scratches, nicks and burrs were removed ,sample with scratches being held perpendicular to the grinding operation.

Intermediate Polishing – 1/0, 2/0, 3/0, 4/0 Emery papers were used and they are rubbed 5 times in one direction perpendicular to the scratches.

Fine polishing – Double disc polishing machine with 2 types of velvet cloth and fine abrasive powder alumina with water was used to get a fine polished surface.

Etching Reagent Used – 5% Hydrogen peroxide, + 5% Ammonium Hydroxide + 90% Water.

Time duration of reagent application – 20 - 30 secs.

Microscope Used – Inverted binocular metallurgical optical microscope.

Magnification – 50X

Observation;

Metallurgical details of the specimen : This cast sample of a Copper-4wt%Tin bronze shows a grain structure with Traces of cored dendrites. The coarse grain structure is due to grain growth after solidification. Coring develops due to non-equilibrium solidification of the casting, which causes a non-uniform distribution of the alloying

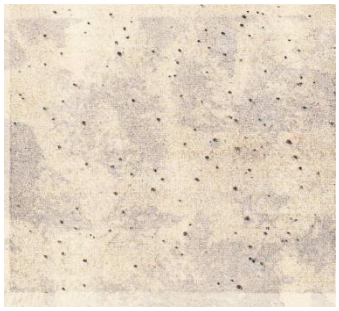
elements. The coring could be removed by a high temperature annealing heat treatment to allow redistribution of the copper and tin. The sample also contains a number of pores (the dark regions).

Theory : Alloys containing principally copper and tin are called Bronzes. Bronzes posses desirable properties of strength, wear resistance and salt water corrosion resistance. From copper-Tin equilibrium diagram one can observe that the solubility of tin copper is 13.5% at 798º C and it increases to 15.8% at 586ºC, and remains constant upto 520ºC, decreases to 11% at 350º C and to about1% at room temperature with larger proportions of tin the hard compounds like CU3 Sn, may appear in the structure. Useful engineering alloy in this system are those containing less than 20% tin. General range of composition of bronzes with respect to copper and tin content may be divided into four groups as follows:

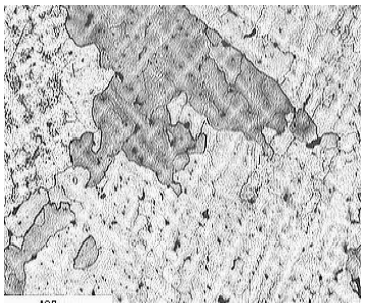
- Alloys containing up to 8% tin are used for sheets and wires.
- Alloys containing between 8% to 12 % tin are used for gears.
- Alloys containing between 12% to 20% tin are used for bearings.
- Alloys containing between 20% to 25% tin are used for bells.

Result : Course grain structure with traces of cored dendrites are observed **.**

Microscopic Observation:



Before etching



After etching

VIVA QUESTIONS

1. Define magnification in microscope?
2. What is the purpose of etchants?
3. What is grain and grain boundary?
4. Define composite material of Bronze?
5. What are different applications and properties of Bronze?

Experiment 12

Aim : To determine the hardenability of a given steel.

Apparatus : Jominy End Apparatus, Furnace, Rockwell Hardness Tester and grinder.

Theory : Jominy end quench test is used to determine hardenability of steels. The process of Increasing the hardness of steel is known as hardening. Specific specimen with standard Dimensions, used for the test is given in the figure. The hardened bar is measured along Its length

Hardenability : The depth upto which steel can be hardened is defined as hardenability. A steel having high hardness need not have hardenability. Hardenability may be defined as susceptibility to hardening by quenching. A material that has high hardenability is said to be hardened more uniformly throughout the section than one that has lower hardenability. M.A. Gross man devised a method to decide hardenability.

Critical diameter: The size of the bar in which the zone of 50% martensite occurs at center is taken as critical diameter. This is a measure of hardenability of steel for a particular Quenching medium employed.

Severity of Quench :

The severity of quench is indicated by heat transfer equivalent H=f/k.
(Where f = Heat Transfer factor or quenching medium and the turbulence of the bath)
K= Thermal conductivity of bar material.
The most rapid cooling is possible with severity of quench as infinity.

Ideal Critical diameter :

The Hardenability of steel can be expressed as the diameter of bar that will form a structure composed of 50% martensite at the center when quenched with H = infinity, This diameter is defined as critical diameter.

Description of Apparatus :

Jominy end quench apparatus is shown in the figure. The apparatus consists of a cylindrical drum. At the top of the drum provision is made for fixing the test specimen. A pipe line is connected for water flow, which can be controlled by means of a stop cock.

PROCEDURE:

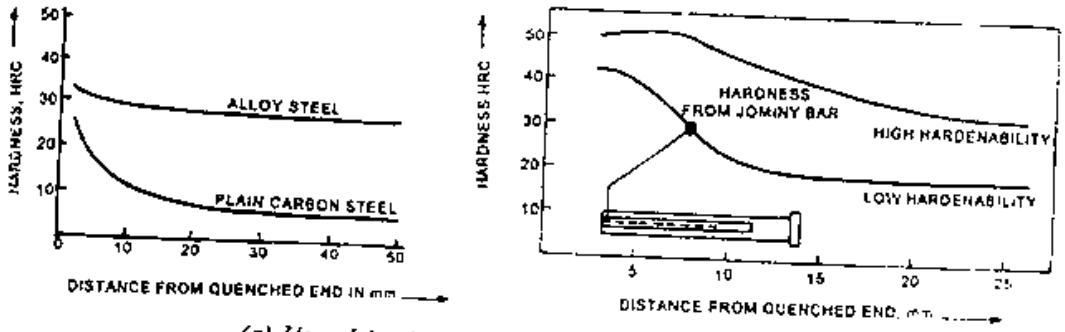
1. Out of the given steel bar, the standard sample is to be prepared as per the dimensions shown in the figure.

2. The austenizing temperature and time for the given steel is to be determined depending on its chemical composition.
3. The furnace is setup on the required temperature and sample is kept in the furnace.
4. The sample is to be kept in the furnace for a predetermined time(based on chemical composition of steel) then it is taken out of the furnace and is kept fixed in the test apparatus.
5. The water flow is directed onto the bottom end of the sample.
6. The water flow is adjusted such that it obtains the shape of umbrella over bottom of the sample.
7. The quenching is to be continued for approximately 15 minutes.
8. A flat near about 0.4 mm deep is grounded on the specimen.
9. The hardness of the sample can be determined at various points starting from the quenched end and the results are tabulated.
10. The graph is plotted with hardness values versus distance from quenched end.

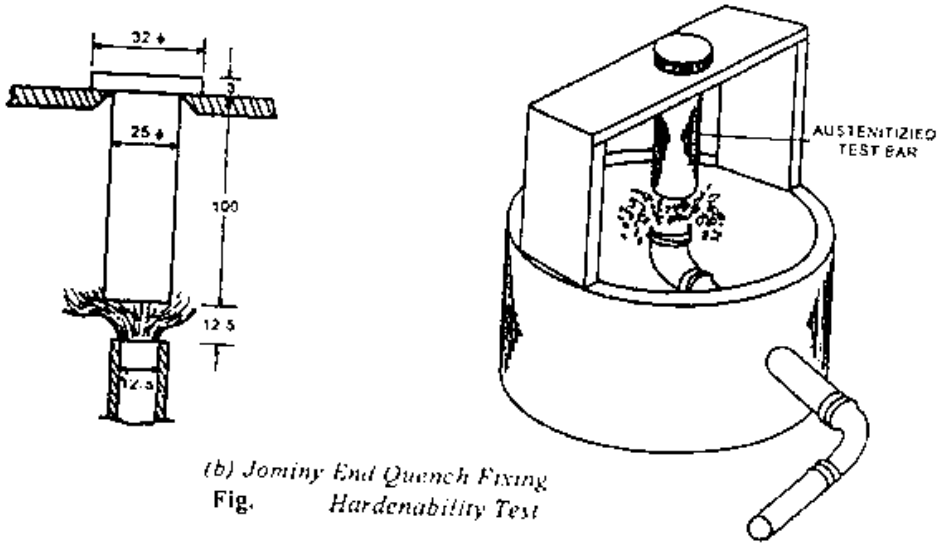
From the results and graph plot, the depth of hardening of the given steel sample can be determined.

The hardenability of the specimen is found by observing the structure under the microscope. As detailed above the diameter at which the percentage of martensite is 50" indicates hardenability of material. More this diameter, high will be the hardenability. Now the important factor is the relationship between size and diameter of a steel bar quenched in an ideal quenching medium which as the same cooling rate at it centre as a given position along the surface of a jominy bar. This information is furnished in the figure its importance is associated with the fact that if the position on the Jominy bar where the structure is 50% martensite is known the the curves shown in the figure makes its possible to determine ideal critical diameter.

Result : The hardenability of a given steel is determined.



(a) Use of Jominy Data to Measure Hardenability



(b) Jominy End Quench Fixing

Fig. *Hardenability Test*

TABLE:

S.No.	Distance from Quenched End	Hardness.

VIVA QUESTIONS

1. Define composite material?
2. What are different applications and properties of composite materials?
3. What are different applications and properties of polymers?
4. What are different applications and properties of ceramics?
5. Define Hardenability?

Experiment -13

FIND THE HARDNESS OF THE VARIOUS TREATED AND UNTREATED STEELS.

AIM:

To find the hardness of the given treated and untreated steel specimens by conducting the hardness test

APPARATUS:

- The given specimens
- Hardness tester
- Diamond penetrant

THEORY:

The method of testing introduced by J.A.Brinell in 1900 consisting of indenting the metal with a "d" mm diameter and tempered steel ball subjected to a definite load. ball of 10 mm , 5 mm , ad 2.5 mm are generally used. The load is maintained for a definite period (usually 10 or 15 sec) after which the load is removed and the diameter of the impression or indentation is measured. The hardness of the material expressed as number and represented by the symbol "HB".

h= depth of indentation

$$(D- \sqrt{(D2 – d 2)}/ 2$$

Brinnel's hardness number HB = Total load / surface area of indentation

$$\frac{2F}{\Pi D (D- \sqrt{(D 2 – d 2)})}$$

PROCDEDURE:

- The face of the specimen is lightly grind and rubbed with fine emery paper if required.
- Select the proper test table based on the size and shape of the specimen and place it on main screw or elevating screw
- Select the diameter of the indenter as 10mm or 5 mm based on the thickness of the specimen and place it I the corresponding ball holder and fix the ball holder.
- Place the required weights on the weight hanger based on the type of material of the specimen and diameter of the indenter
- Check and keep the operating level in horizontal position
- Place the specimen securely on testing table
- Turn the hand wheel in clock wise direction so that the specimen touches the ball indenter
- Lift the operating lever from the horizontal position upwards slightly, after which it rotates automatically.
- Wait for 10 to 15 sec after lever becomes stand still.

- Bring the lever back to horizontal position
- Turn back the hand wheel and remove the specimen
- Measure the diameter of impression of indentation by Brinnel microscope and find the Brinnel hardness number.
- Repeat the above procedure for three to four times

PRECAUTIONS:

- Apply the load slowly and gradually on the sample
- Distance between old impression and location for new impression should be 3D (Three times the ball diameter)
- After applying the specified load wait for 15 sec then remove the load
- The thickness of the test piece must not be less than 8 times the depth of impression
- The surface o which the brinnel impression is to be made should be sufficiently smooth and clean.

RESULT: The Brinnel hardness number of the give material is ----

Experiment -13

Preparation and study of microstructure of heat treated steels

Type of Material: low carbon steel

Heat Treatment – annealing

Procedures:

Sampling procedure: Cutting specimen from abrasive cutting wheel

Sequence of operations – Sectioning, Mounting, Rough Grinding, Intermediate Polishing, Fine Polishing, Microscopic observation, Etching, Microscopic observation.

Specimen Mounting – N/A.

Grinding – Wet/ Dry Linisher was used and the scratches, nicks and burrs were removed ,sample with scratches being held perpendicular to the grinding operation.

Intermediate Polishing – 1/0, 2/0, 3/0, 4/0 Emery papers were used and they are rubbed 5 times in one direction perpendicular to the scratches.

Fine polishing – Double disc polishing machine with 2 types of velvet cloth and fine abrasive powder alumina with water was used to get a fine polished surface.

Etching Reagent Used – 5% Hydrogen peroxide, + 5% Ammonium Hydroxide + 90% Water.

Time duration of reagent application – 20 - 30 secs.

Microscope Used – Inverted binocular metallurgical optical microscope.

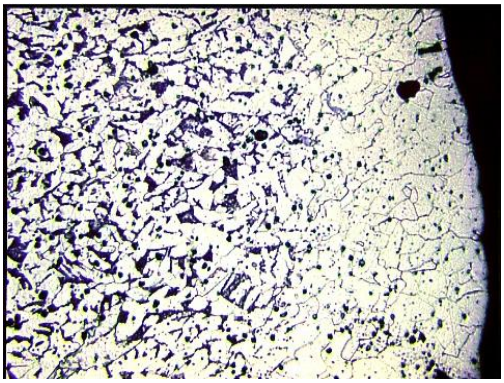
Magnification – 50X- 450X

Theory: Heat treatment is defined as "A combination of heating and cooling operations, timed and applied to a metal or alloy in the solid state in a way that will produce desired properties"

Annealing is the one of the basic heat treatment process. This process consists of heating the steel just above upper critical temperature, holding at this temperature for a definite period and slow cooling to room temperature usually in the furnace. Annealing is very slow cooling Process and therefore similar equilibrium cooling.

Microstructural change in the specimen during annealing are as follows, on heating, when the temp of the specimen reaches 30 - 50oC above the lower critical temperature and soaking it for definite period all Pearlite transforms intofine austenite , subsequent cooling in the furnace will result in small areas of fine Pearlite surrounded by pro – eutectoid ferrite
Annealing process refines grain structure, induces softness, and improves electrical and magnetic properties.

Observation: The microstructure consists of ferrite plus spheroidized pearlite (which isn't resolved here). The specimen was cold rolled and then process annealed (i.e., recrystallized by heating just below the eutectoid temperature). The machinability of this low carbon steel rod (shown here at 200X after a Nital etch) was poor because of the saft, decarburized surface.



After etching