MATERIAL SCIENCE LAB

(20A03201P)

LAB MANUAL

I – BTECH

Prepared by

P.KUMAR

Department of Mechanical Engineering

VEMU INSTITUTE OF TECHNOLOGY

(Approved by AICTE, New Delhi and Affiliated to JNTUA, Ananthapuramu)
Accredited by NAAC, NBA (EEE , ECE & CSE) & ISO 9001-2015 Certified Institution
Near Pakala. P. Kothakota, Chittoor-Tirupati Highway
Chittoor, Andhra Pradesh -517112
Website: *www.vemu.org*

Course Code	Strength of Materials Lab	L	T	P	C
20A03201P		0	0	2	1.5

Course Objectives

- To understand the microstructure and hardness of engineering materials
- To explain grain boundaries and grain sizes of different engineering materials.

Course outcomes (CO) : After completion of the course, the student can able to

CO-1: Differentiate various microstructures of ferrous and non-ferrous metals and alloys.

CO-2: Visualize grains and grain boundaries.

CO-3: Importance of hardening of steels.

CO-4: Evaluate hardness of treated and untreated steels.

CO-5: Differentiate hardness of super alloys, ceramics and polymeric materials.

LIST OF EXPERIMENTS

1. Specimen Preparation And Study Of Metallurgical Microsocpe
2. Preparation And Study Of Microstructure Of Aluminium
3. Preparation And Study Of Microstructure Of Copper
4. Preparation And Study Of Microstructure Of Silver
5. Preparation And Study Of microstructure Of Brass
6. Preparation And Study Of Microstructure Of Bronze
7. Jominey Quench Test
8. Study Of Microstructure Of Cast Iron
9. Study Of Microstructure Of Mild Steel
10. Study Of Microstructure Of Stainless Steel
11. Study Of Microstructure Of High Speed Steel (H.S.S)

SPECIMEN PREPARATION AND STUDY OF METALLURGICAL MICROSOCPE

Exp. No. **Date:**

AIM: : 1. To prepare the given specimen for metallographic examination.
2. To study the constructional details of Metallurgical Microscope and observe the micro structure of the prepared specimen.

APPARATUS AND MATERIALS REQUIRED : Metallurgical microscope, emery belt, 1/0, 2/0, 3/0, 4/0 emery papers, lapping cloth, alumina powder, etchants, sample of metal.

THEORY:

The microstructure of metal decides its properties. An optical microscope is used to study the microstructure. A mirror polished surface of the metal is required for metallographic study.

PROCEDURE OF SPECIMEN PREPARATION:

A. Cut the specimen to the required size (small cylindrical pieces of 10 to 15mm diameter with 15mm height (Or) 10mm cubes)

B. The opposite surfaces (circular faces in case of cylindrical pieces) are made flat with grinding or filling. A Small chamfer should be ground on each edge for better handling. (If the sample is small it should be mounted)

C. **Belt grinding:** One of the faces of the specimen is pressed against the emery belt of the belt grinder so all the scratches on the specimen surface are unidirectional

D. **Intermediate polishing: -** The sample is to be polished on 1/0, 2/0, 3/0, 4/0 numbered emery papers with Increasing fineness of the paper. While changing the polish paper, the sample is to be turned by 90^0 so that new scratches shall be exactly perpendicular to previous scratches.

E. **Disc polishing** (fine polishing):- After polishing on 4/0 paper the specimen is to be polished on disc Polishing machine (Buffing machine). In the disc-polishing machine a disc is rotated by a vertical shaft. The disc is covered with velvet cloth. Alumina solution is used as abrasive. Alumina solution is sprinkled Continuously over the disc and the specimen is gently pressed against it. In case of Non-ferrous metals Such as Brass, Brass is used instead of Alumina and water. The polishing should be continued till a Mirror polished surface is obtained.

F. The sample is then washed with water and dried.

G. **Etching:** The sample is then etched with a suitable etching reagent, detailed in article 5.

H. After etching the specimen should be washed in running water and then with alcohol and then finally dried.

I. The sample is now ready for studying its microstructure under the microscope.

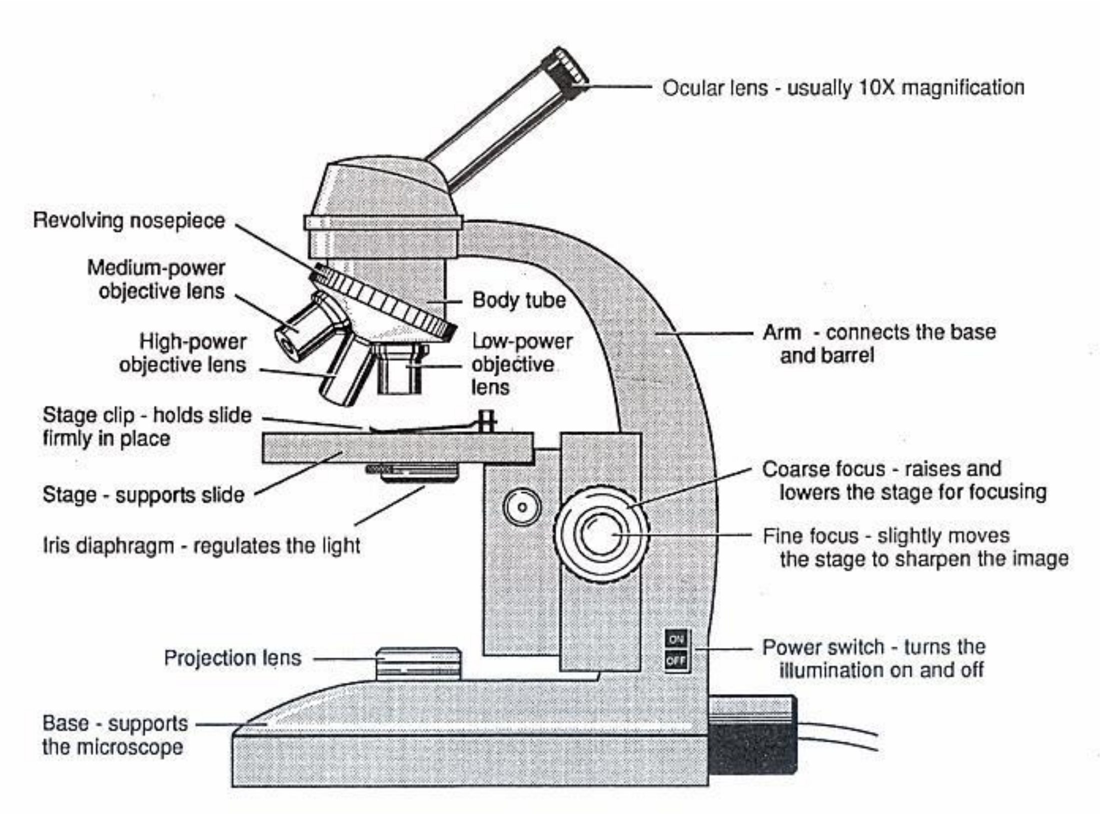

Fig 1.1 MICROSCOPE

ETCHING:

Except for few cases a polished metallic surface can't reveal the various constituents (phases).Hence specimen should be etched to reveal the details of the microstructure i.e. a chemical reagent should be applied on the polished surface for a definite period of time. This reagent preferentially attacks the grain boundaries revealing them as thin lines. Thus under the microscope the grain structure of the metal becomes visible after etching i.e. grain boundary area appears dark and grains appear bright. The rate of etching not only depends on the solution employed and composition of the material but also on the uniformity of the material. A few etching reagents, their composition and their application are given below

Sl. No.	Name of Etchant	Composition	Application
1.	Nital a) 5% Nital b) 2% Nital	Nitric. acid (5ml) and Abs. Methyl alcohol (95ml), Nitric acid (2ml) and Abs. Methyl alcohol (98ml)	General structure of iron and steel
2.	Picral	Picric acid (4gm) and Abs ethyl alcohol (96 ml)	General structure of iron and steel
3.	Marbel’s reagent	Copper sulphate (4 gm), Hydrochloric acid (20ml) and water (20ml)	General structure of iron and steel
4.	Murakami’s reagent	Potassium ferri cyanide, (10grms), KOH (10grms) and water (100ml).	Stainless steels
5.	Sodium hydroxide	Sodium hydroxide (10gm) and water(90ml)	Stainless steels
6.	Vilella’s reagent	Hydro fluoric acid (20ml), Nitric acid (10ml) and Glycerene (30ml).	Aluminium alloys
7.	Kellers reagent	Hydro fluoric acid (1 ml), Hydro chloric acid (1.5 ml), Nitric acid(2.5 ml) and Water (95 ml).	Aluminium & its alloys
8.	Ammonium persulphate Solution	Ammonium persulphate (10gm)And Water(90ml)	Duralumin
9.	FeCl3 solution	FeCl (5gm), HCl acid (2ml) and Ethyl alcohol (96ml)	Copper and copper Alloys Brass

METALLURGICAL MICROSCOPE:

Metallurgical microscope is used for micro and macro examination of metals. Micro examination of specimens yields valuable metallurgical information of the metal. The absolute necessity for examination arises from the fact that many microscopically observed structural characteristics of a metal such as grain size, segregation, distribution of different phases and mode of occurrence of component phases and non metallic inclusions such as slag, sulfides etc., and other heterogeneous condition (different phases) exert a powerful influence on mechanical properties of the metal. If the effect of such external characteristics on properties or the extent of their presence is known, it is possible to predict as to how metal will behave under gone by the metal. Study of structure of metals at magnifications ranging from 50X to 2000X is carried out with the aid of metallurgical microscope.

Principle:

A Metallurgical microscope (shown in **fig 1.1)** differs with a biological microscope in a manner by which specimen of interest is illuminated. As metals are opaque their structural constituents are studied under a reflected light. A horizontal beam of light from an appropriate source is directed by means of plane glass reflectors downwards and through the microscope objective on to the specimen surface. A certain amount of this light will be reflected from the specimen surface and that reflected light, which again passes through the objective, will form an enlarged image of the illuminated area. A microscope objective consists of a number of separate lens elements which are a compound group behave as positive and converging type lens system of an illuminated object. Specimen is placed just outside the equivalent front focus point of objective. A primary real image of greater dimension than those of object field will be formed at some distance beyond the real lens element. Objective size of primary image w.r.t object field will depend on focal length of objective and front focus point of objective. By appropriately positioning primary image w.r.t a second optical system, primary image may be further enlarged by an amount related to magnifying power of eyepiece. As separation between objective and eyepiece is fixed at same distance equivalent to mechanical tube length of microscope, primary image may be properly positioned w.r.t eye piece. By merely focusing microscope i.e. increase or decrease the distance between object plane and front lens of objective the image is located at focal point. Such precise positioning of primary image is essential in order that final image can be formed and rendered visible to observer when looking into eyepiece. If now entrance pupil of eye is made to coincide with exit pupil of eyepiece, eyepiece lens is in conjunction with cornea lens in eye will form a second real image on retina. This retrieval image will be erect, un reversed owing to the manner of response of human brain to excitation of retina. The image since it has no real existence, known as virtual image and appears to be inverted and reversed with respect to object field.

MAGNIFICATION:

The total magnification is the power of objective multiplied by power of eyepiece (Power of eye piece) (Distance from eye piece to object) / Focal length of object The magnification is marked on the side of objective.

CONSTRUCTION:

The microscope consists of a body tube (refer Fig 1.1), which carries an objective below, and an eyepiece above with plane glass vertical illuminator immediately above the objective. Incident light from a source strikes illuminator at 45^0 part of which is reflected on to the specimen. Rays after reflection pass through the eye again. Working table is secured on heavy base. The microscope has compound slide to give longitudinal and lateral movements by accurate screws having scale and venires. Vertical movement of specimen platform is made by a screw to proper focusing. For getting perfect focusing fine adjustment of focusing can be made use of.

Light filters: These are used in metallurgical microscope and are essentially of three types

a. Gelatin sheets connected between two planes of clean glass
b. Solid glass filters
c. Liquid dye solution

Solid glass filters are more preferable as they are more durable. Usually light filters are used principally to render a quality of illumination. Hence filters improve degree of resolution. A METZ - 57 model microscopes is used in the laboratory.

Optical compilation:

Eye pieces and objectives of different magnifications are available. Huygens eyepieces: 5X, 10X Achromatic objectives: 5X, 10X, 45X

PRECAUTIONS:

a. Ensure mirror polished surface of specimen before etching.
b. Fine focusing should be done only after correct focusing has been done.
c. The glass lens should not be touched with fingers.

RESULT:

PREPARATION AND STUDY OF MICROSTRUCTURE OF ALUMINIUM

Exp. No. **Date:**

AIM: To determine and to draw the microstructure of ALUMINIUM

APPARATUS:

- Aluminum Specimen
- Emery paper
- Alumina Paste
- Etching Agent
- Disc polishing machine
- Microscope

THEORY:

A non-ferrous metal is a metal, including alloys, that does not contain iron (ferrite) in appreciable amounts. Generally more expensive than ferrous metals, non-ferrous metals are used because of desirable properties such as low weight (e.g. aluminium), higher conductivity (e.g. copper), non-magnetic property or resistance to corrosion (e.g. zinc). Some non-ferrous materials are also used in the iron and steel industries.

Aluminium is a chemical element in the boron group with symbol Al and atomic number 13. It is a silvery-white, soft, nonmagnetic, ductile metal. Aluminium is the third most abundant element in the Earth's crust (after oxygen and silicon) and its most abundant metal. Aluminium makes up about 8% of the crust by mass, though it is less common in the mantle below. Aluminium metal is so chemically reactive that native specimens are rare and limited to extreme reducing environments. Instead, it is found combined in over 270 different minerals. The chief ore of aluminium is bauxite.

Properties: Low density Ability to resist corrosion through the phenomenon of passivation.

Applications: Aluminium and its alloys are vital to he aerospace industry and important in transportation and structures, such as building facades and window frames. The oxides and sulfates are the most useful compounds of aluminium.

PROCEDURE:

1. Before observing the microstructure, it is essential that the surface is to be free from scratches and cracks.
2. The specimen is polished with a series of emery papers 120, 220, 400, 600, 1/0, 2/0, 3/0, 4/0 in the same order.
3. According to the order the specimen is rotated at right angles while passing from one paper to another. The scratches left by first paper can be completely removed by next paper.
4. Then polishing is done on the disc polisher, which consists of fine micron cloth (Velvet).
5. The specimen is cleaned with water and the moisture is removed completely by using drier.
6. Then it is subjected to etching with the help of etching agent, distilled water and Hydrogen Peroxide and kept for 10-15 sec.
7. Finally the specimen is kept under the Metallurgical Microscope and structure is observed.

PRECAUTIONS:

1. Don't touch the surface of the specimen after polishing till the end of the experiment.
2. Grinding the specimen on emery paper is carried out in one direction only
3. Velvet cloth is kept wet continuously while polishing
4. To avoid parallax errors observe the specimen with both eyes

RESULT:

PREPARATION AND STUDY OF MICROSTRUCTURE OF COPPER

Exp. No. **Date:**

AIM: To determine and to draw the microstructure of COPPER

APPARATUS:

- Copper Specimen
- Emery paper
- Alumina Paste
- Etching Agent
- Disc polishing machine
- Microscope

THEORY:

A non-ferrous metal is a metal, including alloys, that does not contain iron (ferrite) in appreciable amounts. Generally more expensive than ferrous metals, non-ferrous metals are used because of desirable properties such as low weight (e.g. aluminum), higher conductivity (e.g. copper), non-magnetic property or resistance to corrosion (e.g. zinc). Some non-ferrous materials are also used in the iron and steel industries.

Copper is a chemical element with symbol Cu (from Latin: *cuprum*) and atomic number 29. Copper is found as a pure metal in nature, and this was the first source of the metal to be used by humans. It was the first metal to be smelted from its ore, the first metal to be cast into a shape in a mold, and the first metal to be purposefully alloyed with another metal, tin, to create bronze.

Properties: It is a soft, malleable and ductile metal with very high thermal and electrical conductivity. A freshly exposed surface of pure copper has a reddish-orange color.

Applications: It is used as a conductor of heat and electricity, as a building material and as a constituent of various metal alloys, such as sterling silver used in jewelry, cupronickel used to make marine hardware and coins and constantan used in strain gauges and thermo couples for temperature measurement.

PROCEDURE:

1. Before observing the microstructure, it is essential that the surface is to be free from scratches and cracks.
2. The specimen is polished with a series of emery papers 120, 220, 400, 600, 1/0, 2/0, 3/0, 4/0 in the same order.
3. According to the order the specimen is rotated at right angles while passing from one paper to another. The scratches left by first paper can be completely removed by next paper.
4. Then polishing is done on the disc polisher, which consists of fine micron cloth (Velvet).
5. The specimen is cleaned with water and the moisture is removed completely.
6. Then it is subjected to etching with the help of etching agent, distilled water and Hydrogen Peroxide and kept for 10-15 sec.
7. Finally the specimen is kept under the Metallurgical Microscope and structure is observed.

PRECAUTIONS:

1. Don’t touch the surface of the specimen after polishing till the end of the experiment.
2. Grinding the specimen on emery paper is carried out in one direction only
3. Velvet cloth is kept wet continuously while polishing
4. To avoid parallax errors observe the specimen with both eyes

RESULT:

PREPARATION AND STUDY OF MICROSTRUCTURE OF SILVER

Exp. No. **Date:**

AIM: To determine and to draw the microstructure of silver

APPARATUS:

- Silver Specimen
- Emery paper
- Alumina Paste
- Etching Agent
- Disc polishing machine
- Microscope

THEORY:

Nonferrous metals and their alloys do not contain iron as a principle ingredient, although they may contain small percentages. These include the radioactive metals uranium, thorium, and plutonium that are used as nuclear fuels.

Silver also finds application in photographic films and papers. At one time, it was used to plate mirrors. It is now used in the manufacture of photochromatic lenses. Photochromatic lenses darken when exposed to ultraviolet light. Silver is also used in brazing alloys and long-life batteries. Silver fulminate ($Ag_2C_2N_2O_2$) is used as an explosive. Silver and silver compounds are found in many creams, ointments, and salves used for medicinal purposes. Silver iodide has been used to seed clouds to make rain.

PROCEDURE:

1. Before observing the microstructure, it is essential that the surface is to be free from scratches and cracks.
2. The specimen is polished with a series of emery papers 120, 220, 400, 600, 1/0, 2/0, 3/0, 4/0 in the same order.
3. According to the order the specimen is rotated at right angles while passing from one paper to another. The scratches left by first paper can be completely removed by next paper.
4. Then polishing is done on the disc polisher, which consists of fine micron cloth (Velvet).

5. The specimen is cleaned with water and the moisture is removed completely by using drier.
6. Then it is subjected to etching with the help of etching agent, distilled water and Hydrogen Peroxide and kept for 10-15 sec.
7. Finally the specimen is kept under the Metallurgical Microscope and structure is observed.

PRECAUTIONS:

1. Don't touch the surface of the specimen after polishing till the end of the experiment.
2. Grinding the specimen on emery paper is carried out in one direction only.
3. Velvet cloth is kept wet continuously while polishing.
4. To avoid parallax errors observe the specimen with both eyes.

RESULT:

PREPARATION AND STUDY OF MICROSTRUCTURE OF BRASS

Exp. No. **Date:**

AIM: To determine and to draw the microstructure of BRASS

APPARATUS:

- Brass Specimen
- Emery paper
- Alumina Paste
- Etching Agent
- Disc polishing machine
- Microscope

THEORY:

Non ferrous metals ad alloys contain other than iron as a main constituent. They exhibit different properties compared to ferrous metals and alloys. Hence their application also differs from ferrous metals. We shall study the microstructures of Al, Cu, and alloys.

CU – ALLOYS (BRASS): Brasses are the copper alloys containing zinc up to 30% they possess relatively good corrosion resistance and good working propewrties. They also posses high ductility hence they are suitable for drastic cold working. In common to relieve the stresses annealing is done. Most normally used brass contains 30% zinc and 70% copper which is known as cartridge brass. This shows higher ductility and malleability. The microstructure shows a typical equi axied grain structure with twins in annealed structure. This brass is used for making cartridge cases. Other applications include4s radiator cases, head light reflectors, hardware, and plumbing accessories.

PROCEDURE:

1. Before observing the microstructure, it is essential that the surface is to be free from scratches and cracks.
2. The specimen is polished with a series of emery papers 120, 220, 400, 600, 1/0, 2/0, 3/0, 4/0 in the same order.
3. According to the order the specimen is rotated at right angles while passing from one paper to another. The scratches left by first paper can be completely removed by next paper.

4. Then polishing is done on the disc polisher, which consists of fine micron cloth (Velvet).
5. The specimen is cleaned with water and the moisture is removed completely by using drier.
6. Then it is subjected to etching with the help of etching agent, distilled water and Hydrogen Peroxide and kept for 10-15 sec.
7. Finally the specimen is kept under the Metallurgical Microscope and structure is observed.

PRECAUTIONS:

1. Don't touch the surface of the specimen after polishing till the end of the experiment.
2. Grinding the specimen on emery paper is carried out in one direction only.
3. Velvet cloth is kept wet continuously while polishing.
4. To avoid parallax errors observe the specimen with both eyes.

RESULT:

PREPARATION AND STUDY OF MICROSTRUCTURE OF BRONZE

Exp. No. **Date:**

AIM: To determine and to draw the microstructure of BRONZE

APPARATUS:

- Bronze Specimen
- Emery paper
- Alumina Paste
- Etching Agent
- Disc polishing machine
- Microscope

THEORY:

Non-ferrous alloy metals including: aluminum alloys magnesium alloys, titanium alloys, zinc alloys, nickel alloys, pewter, precious metal alloys, brass, and bronze. Then there is brass and bronze, which look very similar since they are both mainly made up of copper. Brass can vary in color from red to yellow, gold to silver. Both bronze and brass patina over time, making them looks antique after a while. Both are metals that exude wrath and are softer on the eye than a highly polished white metal.

Bronze is an alloy of copper and any other metal. As with brasses, there are many formulas for bronzes, depending on the application. Aluminum bronzes, tin bronzes, phosphor bronzes, nickel bronzes, and silicon bronzes are all examples of varying alloys. The principle alloying element determines the nomenclature. Bronzes are used in applications such as bearings, some limited structural applications, decorative uses, and applications which require them not to spark when struck with another metal. This makes them useful in the transport and handling of items such as explosives, fuels, and flammable materials. Bronzes are often used in statues and can be seen to form the familiar green oxidized coating.

PROCEDURE:

1. Before observing the microstructure, it is essential that the surface is to be free from scratches and cracks.
2. The specimen is polished with a series of emery papers 120, 220, 400, 600, 1/0, 2/0, 3/0, 4/0 in the same order.
3. According to the order the specimen is rotated at right angles while passing from one paper to another. The scratches left by first paper can be completely removed by next paper.
4. Then polishing is done on the disc polisher, which consists of fine micron cloth (Velvet).
5. The specimen is cleaned with water and the moisture is removed completely by using drier.
6. Then it is subjected to etching with the help of etching agent, distilled water and Hydrogen Peroxide and kept for 10-15 sec.
7. Finally the specimen is kept under the Metallurgical Microscope and structure is observed.

PRECAUTIONS:

1. Don't touch the surface of the specimen after polishing till the end of the experiment.
2. Grinding the specimen on emery paper is carried out in one direction only
3. Velvet cloth is kept wet continuously while polishing
4. To avoid parallax errors observe the specimen with both eyes

RESULT:

JOMINEY QUENCH TEST

Exp. No. **Date:**

AIM : To determine the hardenability of a given steel.

APPARATUS : Jominey Test, furnace, Mild steel, Stop watch, Tongs

THEORY:

Heat treatment is a combination of heating and cooled operations timed and applied to a metal or alloy so as to produce the desired properties. Heat treated steels amount to about 5 percent of total steel production, but it is indispensable for tools, dies, ad a variety of special purpose steels.

SPECIMEN: Medium carbon (plain Carbon) steel. The percentage of composition is Carbon 0.35% to 0.45% Silicon 0.35 %(max) Manganese 0.60% to 0.8% Sulphur 0.05% (max) Phosphorus 0.05% (max).

PROCEDURE:

1. The austenitising temperature and time for the given steel is to be determined depending on its chemical composition.
2. The furnace is setup on the required temperature and sample is kept in the furnace.
3. 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.
4. The water flow is directed onto the bottom end of the sample. The water flow is adjusted such that it obtains shape of umbrella over bottom of sample.
5. The quenching to be continued for approximately 15 minutes.
6. A flat near about 0.4 mm deep is grounded on the specimen.
7. The hardness of the sample can be determined at various points starting from the quenched end and the results are tabulated.

PRECAUTIONS:

1. The specimen is to be handled carefully while transferring from furnace to test APPARATUS:.
2. Proper water flow (at high pressure) over the bottom end of specimen is to be ensured.

RESULT:

STUDY OF MICROSTRUCTURE OF CAST IRON

Exp. No. **Date:**

AIM : To determine and to draw the microstructure of CAST IRON

APPARATUS:

- Cast iron Specimen
- Emery paper
- Alumina Paste
- Etching Agent
- Disc polishing machine
- Microscope

THEORY:

Cast irons contain 2 to 6.67 % of carbon. Since high carbon content tends to make the Cast iron very brittle, most commercially manufactured types are in the range of2.5 to 4% of carbon. The ductility of Carbon is very low and it cannot be rolled, drawn or worked at room temperature. However they melt readily and can be cast to complicated shapes which are usually machined to final dimensions. Since the casting is only the suitable process applied to these alloys, they are known as cast irons.

Although the common cast irons are brittle and have lower strength properties than most steels, they are cheap, can cast more readily than steel and have other useful properties. In addition by proper alloying good foundry control and appropriate heat treatment is possible. The properties of any cast iron can be varied over a wide range.

WHITE CAST IRON: In white cast iron most of the carbon is present in the combed forms as cementite.This is obtained by rapid cooling of the iron. White cast irons contains large amount of cementite as continuous inter dendritic network. It makes the cast iron hard, wear resistance but extremely brittle and difficult to machine.

White cast irons are limited in engineering applications because of brittleness and lack of mach inability. They are used where resistant to wear is important and service does not require, such as cement mixer, ball mills certain types of drawing dies and extrusion nozzle. A large tonnage of white cast iron is used as a raw material for manufacture of malleable cast iron.

The composition of typical malleable cast iron is as follows

Carbon: 2.9%

Silicon: 1.15%

Manganese: 0.6%

Phosphorous: 0.15%

Sulphur: 0.5%

MALLEBLE CAST IRON: In which most of the carbon is uncombined form of irregular particles known as tempered carbon. This is obtained by heating the white cast iron to 920 to 1000 degree centigrade for about 50 hours followed by slow cooling to room temperature. While on heating, the cementite structure tends to decompose in to ferrite plus tempered carbon (Graphite). The lubrication action of the graphite imports high machinability to malleable cast iron and lower the melting point makes it much easier to cast than steel. Malleable cast irons are tough, strong and shock resistant. The addition of copper and molybdenum in combination produces malleable cast iron of superior corrosion resistance and mechanical properties. The malleable cast iron is used for wide applications such as agricultural implements, automobile parts, man hole covers, rail road equipment gears, cams and pipe fittings etc.

GREY CAST IRON: In which most or all of the carbon is uncombined form of graphite flakes. The tendency of carbon to form as graphite flakes is due to increased silicon and carbon content and there by decreasing the cooling rate. It is a low melting alloy, having good cast ability and machanibility. It has low tensile strength, high compression strength and very low ductility. Grey cast iron has excellent damping capacity and is often used as base for machinery or any equipment subject to vibration. It is also used for machine tool bodies, pipes and agricultural implements. The presence of graphite flakes provides lubricating effect to sliding bodies.

The composition of typical grey cast iron is as follows

Carbon: 2.8 to 3.6%

Silicon: 1 to 2.75%

Manganese: 0.4 to 1%

Phosphorous: 0.1 to 1%

Sulphur: 0.06 to 0.12%

PROCEDURE:

1. Before observing the microstructure, it is essential that the surface is to be free from scratches and cracks.
2. The specimen is polished with a series of emery papers 120, 220, 400, 600, 1/0, 2/0, 3/0, 4/0 in the same order.
3. According to the order the specimen is rotated at right angles while passing from one paper to another. The scratches left by first paper can be completely removed by next paper.
4. Then polishing is done on the disc polisher, which consists of fine micron cloth (Velvet).
5. The specimen is cleaned with water and the moisture is removed completely by using drier.
6. Then it is subjected to etching with the help of etching agent, distilled water and Hydrogen Peroxide and kept for 10-15 sec.
7. Finally the specimen is kept under the Metallurgical Microscope and structure is observed.

PRECAUTIONS:

1. Don’t touch the surface of the specimen after polishing till the end of the experiment.
2. Grinding the specimen on emery paper is carried out in one direction only.
3. Velvet cloth is kept wet continuously while polishing
4. To avoid parallax errors observe the specimen with both eyes

RESULT:

STUDY OF MICROSTRUCTURE OF MILD STEEL

Exp. No. **Date:**

AIM: To determine and to draw the microstructure of MILD STEEL

APPARATUS:

- Mild Steel Specimen
- Emery paper
- Alumina Paste
- Etching Agent
- Disc polishing machine
- Microscope

THEORY:

Plain carbon steels are steels having carbon as the predominant alloying element and the other alloying elements are either Nil or negligible though some amount of sulphur and phosphorous are present. Normally the amounts are less than 0.05 percent and hence they are not considered. The plain carbon steels are broadly classified in to low carbon steels with carbon content less than 0.3 percent and medium carbon steels contain Carbon between 0.3 to 0.7. The high carbon steels contain carbon from 0.7 to 1.5 percent.

Mild steel (steel containing a small percentage of carbon, strong and tough but not readily tempered), also known as plain-carbon steel, is now the most common form of steel because its price is relatively low while it provides material properties that are acceptable for many applications. Low-carbon steel contains approximately 0.05–0.25% carbon making it malleable and ductile. Mild steel has a relatively low tensile strength, but it is cheap and easy to form; surface hardness can be increased through carburizing. It is often used when large quantities of steel are needed, for example as structural steel. The density of mild steel is approximately 7.85 g/cm^3 (7850 kg/m^3 or 0.284 lb/in^3) and the Young's modulus is 200 GPa (29,000,000 psi). Low-carbon steels suffer from yield-point runout where the material has two yield points. The first yield point (or upper yield point) is higher than the second and the yield drops dramatically after the upper yield point. If a low-carbon steel is only stressed to some point between the upper and lower yield point then the surface develop Lüder bands.[6] Low-carbon steels contain less carbon than other steels and are easier to cold-form, making them easier to handle.

PROCEDURE:

1. Before observing the microstructure, it is essential that the surface is to be free from scratches and cracks.
2. The specimen is polished with a series of emery papers 120, 220, 400, 600, 1/0, 2/0, 3/0, 4/0 in the same order.
3. According to the order the specimen is rotated at right angles while passing from one paper to another. The scratches left by first paper can be completely removed by next paper.
4. Then polishing is done on the disc polisher, which consists of fine micron cloth (Velvet).
5. The specimen is cleaned with water and the moisture is removed completely by using drier.
6. Then it is subjected to etching with the help of etching agent, ethanol, and hydrochloric acid and kept for 10-15 sec.
7. Finally the specimen is kept under the Metallurgical Microscope and structure is observed.

PRECAUTIONS:

1. Don’t touch the surface of the specimen after polishing till the end of the experiment.
2. Grinding the specimen on emery paper is carried out in one direction only.
3. Velvet cloth is kept wet continuously while polishing.
4. To avoid parallax errors observe the specimen with both eyes.

RESULT:

STUDY OF MICROSTRUCTURE OF STAINLESS STEEL

Exp. No. **Date:**

AIM: To determine and to draw the microstructure of STAINLESS STEEL

APPARATUS:

- Stainless Steel Specimen
- Emery paper
- Alumina Paste
- Etching Agent
- Disc polishing machine
- Microscope

THEORY:

Stainless steel, also known as inox steel is a steel alloy with a minimum of 10.5% chromium content by mass. Stainless steel does not readily corrode, rust or stain with water as ordinary steel does. However, it is not fully stain-proof in low-oxygen, high-salinity, or poor air-circulation environments.[2] There are various grades and surface finishes of stainless steel to suit the environment the alloy must endure. Stainless steel is used where both the properties of steel and corrosion resistance are required.

Stainless steel differs from carbon steel by the amount of chromium present. Unprotected carbon steel rusts readily when exposed to air and moisture. This iron oxide film (the rust) is active and accelerates corrosion by forming more iron oxide]; and, because of the greater volume of the iron oxide, this tends to flake and fall away. Stainless steels contain sufficient chromium to form a passive film of chromium oxide, which prevents further surface corrosion by blocking oxygen diffusion to the steel surface and blocks corrosion from spreading into the metal's internal structure. Passivation occurs only if the proportion of chromium is high enough and oxygen is present.

PROCEDURE:

1. Before observing the microstructure, it is essential that the surface is to be free from scratches and cracks.

2. The specimen is polished with a series of emery papers 120, 220, 400, 600, 1/0, 2/0, 3/0, 4/0 in the same order.
3. According to the order the specimen is rotated at right angles while passing from one paper to another. The scratches left by first paper can be completely removed by next paper.
4. Then polishing is done on the disc polisher, which consists of fine micron cloth (Velvet).
5. The specimen is cleaned with water and the moisture is removed completely by using drier.
6. Then it is subjected to etching with the help of etching agent, distilled water and Hydrogen Peroxide and kept for 10-15 sec.
7. Finally the specimen is kept under the Metallurgical Microscope and structure is observed.

PRECAUTIONS:

1. Don’t touch the surface of the specimen after polishing till the end of the experiment.
2. Grinding the specimen on emery paper is carried out in one direction only.
3. Velvet cloth is kept wet continuously while polishing
4. To avoid parallax errors observe the specimen with both eyes

RESULT:

STUDY OF MICROSTRUCTURE OF HIGH SPEED STEEL (H.S.S)

Exp. No. **Date:**

AIM: To determine and to draw the microstructure of HIGH SPEED STEEL (H.S.S)

APPARATUS:

- High speed steel (H.S.S) Specimen
- Emery paper
- Alumina Paste
- Etching Agent
- Disc polishing machine
- Microscope

THEORY:

High speed steels are alloys that gain their properties from either tungsten or molybdenum, often with a combination of the two. They belong to the Fe–C–X multi-component alloy system where X represents chromium, tungsten, molybdenum, vanadium, or cobalt.

Generally, the X component is present in excess of 7%, along with more than 0.60% carbon. The alloying element percentages do not alone bestow the hardness-retaining properties; they also require appropriate high-temperature heat treatment to become true HSS; see History above. In the unified numbering system (UNS), tungsten-type grades (e.g. T1, T15) are assigned numbers in the T120xx series, while molybdenum (e.g. M2, M48) and intermediate types are T113xx. ASTM standards recognize 7 tungsten types and 17 molybdenum types.[8]

The addition of about 10% of tungsten and molybdenum in total maximises efficiently the hardness and toughness of high speed steels and maintains those properties at the high temperatures generated when cutting metals.

PROCEDURE:

1. Before observing the microstructure, it is essential that the surface is to be free from scratches and cracks.
2. The specimen is polished with a series of emery papers 120, 220,

400, 600, 1/0, 2/0, 3/0, 4/0 in the same order.

3. According to the order the specimen is rotated at right angles while passing from one paper to another. The scratches left by first paper can be completely removed by next paper.
4. Then polishing is done on the disc polisher, which consists of fine micron cloth (Velvet).
5. The specimen is cleaned with water and the moisture is removed completely by using drier.
6. Then it is subjected to etching with the help of etching agent, ethanol and hydrochloric acid and kept for 10-15 sec.
7. Finally the specimen is kept under the Metallurgical Microscope and structure is observed.

PRECAUTIONS:

1. Don't touch the surface of the specimen after polishing till the end of the experiment.
2. Grinding the specimen on emery paper is carried out in one direction only.
3. Velvet cloth is kept wet continuously while polishing
4. To avoid parallax errors observe the specimen with both eyes

RESULT: