SVR ENGINEERING COLLEGE

NANDYAL-518501, KURNOOL (DIST.) A.P

APPROVED BY AICTE NEW DELHI- AFFILIATED TO JNTU, ANANTAPURAM.

DEPARTMENT OF MECHANICAL ENGINEERING

MATERIAL SCIENCE & ENGG. LAB MANUAL

SUBJECT CODE: 20A03201P

NAME : ______________________________

ROLL NO : ______________________________

CLASS/SEM: ______________________________

ACADEMIC YEAR :______________________

SVR ENGINEERING COLLEGE

Service Virtue Reverence

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JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY ANANTAPUR

B.Tech (ME) – II Sem **L T P C**

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(20A03201P) MATERIAL SCIENCE & ENGINEERING LAB

Course Objectives:

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

List of Experiments:

1. Metallography sample preparation
2. Microstructure of pure metals – Iron, copper and aluminum as per ASTM standards
3. Microstructure of low carbon steel, mild steel and high carbon microstructure of cast irons.
4. Microstructure of non-ferrous alloys – aluminum, copper, titanium, nickel and their alloys.
5. Hardenability of steels by Jominy End Quench Test.
6. Microstructure of heat treated steels.
7. Hardness of various untreated and treated steels.
8. Microstructure of ceramics, polymeric materials.
9. Microstructure of super alloy and nano-materials.
10. Hardness of ceramics, super alloys, nano-materials and polymeric materials (one sample oneach)

Course Outcomes:

The student is able to

- Differentiate various microstructures of ferrous and non-ferrous metals and alloys. (l4)
- Visualize grains and grain boundaries. (l3)
- Importance of hardening of steels. (l2)
- Evaluate hardness of treated and untreated steels. (l4)
- Differentiate hardness of super alloys, ceramics and polymeric materials

SVR ENGINEERING COLLEGE

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www.svrec.ac.in

Department of Mechanical Engineering

VISION

To Become An Innovative Knowledge Center In Mechanical Engineering Through State Of The Art Teaching –Learning And Research Practices, Promoting Creative Thinking Professionals.

MISSION

The Department Of Mechanical Engineering Is Dedicated For Transforming The Students Into Highly Competent Mechanical Engineers to meet the needs of the industry, by Strongly focusing in the fundamentals of engineering sciences for achieving excellent Results in their professional pursuit

Program Outcomes as defined by NBA (PO)

Engineering Graduates will be able to:

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 (PSO)

At the end of the program, the student

PSO 1: should be able to understand the concepts of Electronics & Communication engineering and their applications in the field of semiconductor technology, consumer electronics, embedded system, communication/ networking and other relevant areas.

PSO 2: Should have an ability to apply technical knowledge and usage of modern hardware & software tools related to Electronics & Communication engineering for solving real world problems.

PSO 3: Should have the capability to analyze, comprehend, design & develop electronic subsystems/ systems for a variety of engineering applications and thus demonstrating professional ethics & concern for societal well being.

Program Educational Objectives (PEO):

PEO-1: To produce graduates having a strong background of basic science, Mathematics & Engineering and ability to use these tools.

PEO-2: To produce graduates who can demonstrate technical competence in the field of electronics and communication engineering and develop solutions to the complex problems.

PEO-3: To produce graduates having professional competence through life-long learning such as advanced degrees, professional skills and other professional activities related globally to engineering & society.

PEO- 4: To produce graduates who function effectively in a multi-disciplinary environment and individually, within a societal and environmental context.

PEO-5: To produce graduates who would be able to take individual responsibility and work as a part of a team towards the fulfillment of both individual and organizational goals.

LIST OF ETCHANTS

S.NO	Etching Regent	Composition	Suitable for
1	Nitric Acid (Nital)	HNO_3 1 to 5 ml Ethyl or methyl Alcohol 100 ml	For low carbon and medium carbon steel
2	Picric Acid (Picral)	Picric Acid 4 gm Ethyl or methyl alcohol 100ml	For all grades of carbon steel
3	Ferric Chloride and Hydrochloric acid	$FeCl_3$ 5g HCl 50 ml H_2O 100 ml	Stainless Steel
4	Ferric Chloride and Hydrochloric acid	$FeCl_3$ 5 to 10 g HCl 15 to 20 ml Water 100 ml	Copper, Brass
5	Nitric Acid (Nital)	HNO_3 5ml Water 95ml	Lead, Tin and its alloys
6	Hydrochloric acid	HCl 50 ml Water 50 ml	Zinc and its alloys

LIST OF ABRASIVES

S.NO	Abrasive	Suitable for
1.	Alumina paste grade 1	ferrous &nonferrous metals
2	Alumina paste grade 2	--
3	Alumina paste grade 3	iron and steel metals

Experiment 1

1. Introduction of Metallography sample preparation

Objective:

1. Metallographic Sample Preparation.
2. To study the importance of the various steps in sample preparation.
3. To understand the need of mounting, polishing and etching.

Introduction:

Metallography is the study of the microstructure of metals and alloys by means of microscopy. It is an art and science of preparing, interpreting, and analyzing microstructures in materials, to better understand materials behavior and performance. The method is used for the evaluation of metallic materials in the various industries, including the aerospace industry, the automotive industry and parts of the construction industry. It is also used for process control including the examination of defects that appear in finished or partly finished products, as well as the studies of parts that have failed during service. It is an important branch of the Metallurgical Engineering.

A well prepared metallographic specimen is:

a. A representative sample
b. Sectioned, ground and polished so as to minimize disturbed or flowed surface metal caused by mechanical deformation, and thus to allow the true microstructure to be revealed by etching.
c. Free from polishing scratches and pits and liquid staining
d. Flat enough to permit examination by optical microscope or SEM

Various steps involved in the specimen preparation, and the significance of each step:

Many steps in the preparation of metallographic specimens described here are also applicable in other types of metallographic studies, such as electron microscopy, micro hardness testing, quantitative measurement of constituents of structures, and electron microprobe analysis. Preparation of metallographic specimens generally requires five major operations:

a. Sectioning
b. Mounting (which is necessary when the sample cannot be held properly due to itsshape and/or size, while polishing)
c. Grinding
d. Polishing
e. Etching

These operations are listed below in the order they are performed

Sectioning

Separate test pieces or coupons attached to castings or forgings should be designed so that a minimum of sectioning is required for producing metallographic specimens sectioning becomes necessary when studying parts that have failed in service where specimen has to be taken from a large block of material. Therefore, metallographic studies of such samples often involve more than one sectioning operation.

Many metallographic studies require more than one specimen. For example, a study of deformation in wrought metals usually requires two sections- one perpendicular to, and the other parallel to, the major axis of the direction of deformation. Failed parts may best be studied by selecting a specimen that intersects the origin of the failure, if the origin can be identified on the surface. Depending on the type of failure, it may be necessary to take several specimens from the area of failure and from adjacent areas.

- **Mounting of Specimens**

The primary purpose of mounting is to make it convincement to handle specimens of arbitrary shape and/or small sizes during various steps of metallographic sample preparation and examination. A secondary purpose is to protect and preserve extreme edges or surface defects during metallographic preparation. Specimens may also require mounting to accommodate various types of automatic devices used in metallographic laboratories or to facilitate placement on the microscope stage. An additional benefit of mounting is the identification of the sample (name, alloy number or laboratory code number) without damaging the specimen.

Compression mounting: It is most common mounting method, which involves molding around the metallographic specimen by heat and pressure using the molding materials such as Bakelite, Diallyl Phthalate resins, and acrylic resins. Bakelite and Diallyl phthalate are thermosetting, and acrylic resins are thermoplastic.

Not all materials or specimens can be mounted in thermosetting or thermoplastic mounting. The heating cycle may cause changes in the microstructure, or the pressure may cause delicate specimens to collapse or deform. The size of the selected specimen may be too large to be accepted by the available mold sizes. These difficulties are usually overcome by cold mounting.

Cold Mounting requires no pressure and little heat, and is a mean of mounting large numbers of specimens more rapidly than possible by compression mounting. Epoxy resins are most widely used cold mounting materials. They are hard, and adhere tenaciously to most metallurgical, mineral and ceramic specimens.

- **Grinding**

Grinding is a most important operation in specimen preparation. During grinding, the operator has the opportunity of minimizing mechanical surface damage, that can be removed by subsequent polishing operations. Even if sectioning is done in a careless manner resulting into a severely damaged surface, the damage can be eliminated by prolonged grinding. However, prolonged grinding should be avoided since it might lead to excess heating or surface damage

Particle Size vs. Common Grit Sizes for Abrasive Papers

GRIT NUMBER		
European (P-grade)	Standard grit	Median Diameter, (microns)
60	60	250
80	80	180
100	100	150
120	120	106
150	150	90
180	180	75
220	220	63
P240	240	58.5
P280		52.2
P320	280	46.2
P360	320	40.5
P400		35
P500	360	30.2
P600	400	25.75
P800		21.8
P1000	500	18.3
P1200	600	15.3
P2400	800	6.5
P4000	1200	2.5

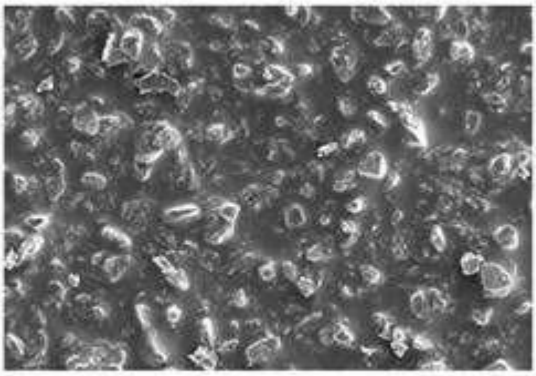


Figure SEM micrograph of 600 grit SiC Abrasive Paper (original mag. 150x)

Grinding is accomplished by abrading the specimen surface through a sequence of operations using progressively finer abrasive grits. Grit sizes ranging from 60 mesh to 150 mesh are usually regarded as coarse abrasives, and grit sizes ranging from 180 mesh to 600 mesh as fine abrasives. Grinding should commence with the coarse grit size for making initial flat surface and remove the effects of sectioning. Hack-sawed, band-sawed, or other rough surfaces usually require abrasive grit sizes in the range of 80 to 150 mesh. Grinding should be done sequentially starting from the coarser one to finer one. A satisfactory grinding sequence might involve grit sizes of 180, 240, 400 and 600 mesh. The purpose of grinding is to remove the oxide layer or damaged layer or uneven surfaces that might have formed during last sectioning operation. However, the depth of cold worked metal is roughly inversely proportional to the hardness of the specimen and may be 10 to 50 times the depth of penetration of the abrasive particle.

To ensure the complete elimination of the previous grinding scratches found by visual inspection, the direction of grinding must be changed by 90^o from the one stage of grinding to the next stage. In addition, microscopic examination of the various ground surfaces during the grinding sequence may be worthwhile in evaluating the effect of grinding. Each ground surface should have scratches that are clean-cut and uniform in size, with no evidence of previous grinding scratches. Cleaning before going to next stage grindingis always helpful.

Grinding Mediums

Grinding media are silicon carbide (SiC), aluminium oxide (Al_2O_3), emery (Al_2O_3- Fe_3O_4), and diamond particles. All except diamond are generally bonded to paper or cloth backing material of various weights in the form of sheets, disks, and belts of various sizes. The abrasives may be used also in t h e powder form by charging the grinding surfaces with loose abrasive particles.

Automatic grinding, as the name implies, is done without hand assistance. All automatic grinding devices use lap surfaces on which paper-based disks are placed or abrasive powder is charged. The lap is either a rotating or a vibrating disk, where the use of the latter is described as vibratory grinding.

Polishing

Polishing is the final step in producing a surface that is flat, scratch free, and mirror-like in appearance. Such surface is necessary for subsequent accurate metallographic interpretation, both the qualitative and quantitative. The polishing technique used should not introduce extraneous structure, such as disturbed metal, pitting, dragging out of inclusions, and staining.

Mechanical Polishing

Mechanical polishing is frequently used to describe the various final polishing procedures involving the use of cloth-covered laps and suitable polishing abrasives basically Al_2O_3 slurry. The laps have either a rotating or a vibrating motion, and the specimens are held by hand, held mechanically, or merely confined within the polishing area. Polishing should be done in a relatively dust-free area, preferably removed from the area for sectioning, mounting and rough grinding. Any contamination of a polishing lap by abrasive particles carried over from preceding operations or by dust, dirt or other foreign matter in the air cannot be tolerated. Carryover as a result of improper cleaning between final polishing steps is another prime source of contamination. It is just as important for the operator to wash his/her hands meticulously as it is for him/her to remove all traces of polishing abrasive from the specimen before proceeding to the next finer polishing operation.

Electrolytic Polishing

Even with the most careful mechanical polishing, some disturbed metal, even very small the amount, will remain after preparation of a metallographic specimen. This is no problem if the specimen is to be etched for structural investigation because etching is usually sufficient to remove the slight layer of disturbed metal. However, if the specimen is to be examined in the as polished condition, or if no surface disturbance can be tolerated, then either electrolytic polishing or chemical polishing is preferred. The basic principle involved in this technique is anodic dissolution of surface of the sample which results in a leveling and brightening of its surface.

Electro polishing does not disturb any metal on the specimen surface, and therefore, ideally suited for the metallographic preparation of soft metals, most single phase alloys, and alloys that works harden readily. The disadvantages of electro polishing include preferential attack in multiphase alloys caused by differences in electrical potential between phases. Proper choice of electrolyte and operating conditions will minimize these disadvantages.

- **Etching**

Metallographic etching is used to reveal particular structural characteristics of a metal. This is essential since these structural characteristics are not visible in the as polished mirror like surface in the metal. It can be used for phase identification, for dislocation density calculation (etch pitting), and for orientation studies. The principle of etching multiphase alloys is based on the preferential attack (different rates of electrochemical dissolution of phases in the etchant) or preferential staining of one or more phases, because of differences in chemical composition and, because of differences in grain-orientation. Before being etched, a specimen should be inspected for polishing defects, such as scratches, pits, relief polish, comet tails, pulled out inclusions, and voids.

Chemical Etching

Chemical etching is accomplished by immersing the specimen in (or swabbing it with) a suitable etchant until the required structure is revealed. Etching is done in Petri-dishes or in other suitable containers with loose covers to prevent excessive evaporation of the solvent, particularly alcohol solutions. Glass containers can be used for all etchants except hydrofluoric acid solutions, where the container should be made of polyethylene or other suitable material. By the use of tongs or other convenient handling device, the surface of the specimen is immersed in the etchant with some agitation to ensure that fresh etchant is in contact with the specimen all the times. During etching, most metals lose their bright appearance, indicating that etching is taking place. With practice, one can ascertain the completion of etching by the degree of dullness of the surface. If the etching procedure calls for swabbing, the surface of the specimen can be swabbed with cotton saturated with the etchant, or the specimen can be immersed and swabbed while in the solution. When etching is complete, the specimen is rinsed in running water and then in alcohol, followed by drying in a stream of warm air (hand dryer). After etching the specimen surface is observed under the optical-microscope for studying its microstructure. Care should be taken while etching so that the hand is not affected by the etching.

To report:

1. What is mounting?
2. Differentiate between hot and cold mounting?
3. Define terms polishing, grinding, and mesh size?
4. Explain the importance of etchant?
5. Which types of materials are basically polished by electrolytic polishing?
6. What are the effects you have observed on changing etchant time?
7. HF should not be kept in glass bottle. Why?
8. Which type of precaution should be taken care of before etching?

Microstructure of pure metals – Iron, copper and aluminum As per ASTM standards

AIM:

To Prepare & Study the given pure metal like IRON, COPPER &ALUMINUM and observe the microstructure of the same

APPARATUS:

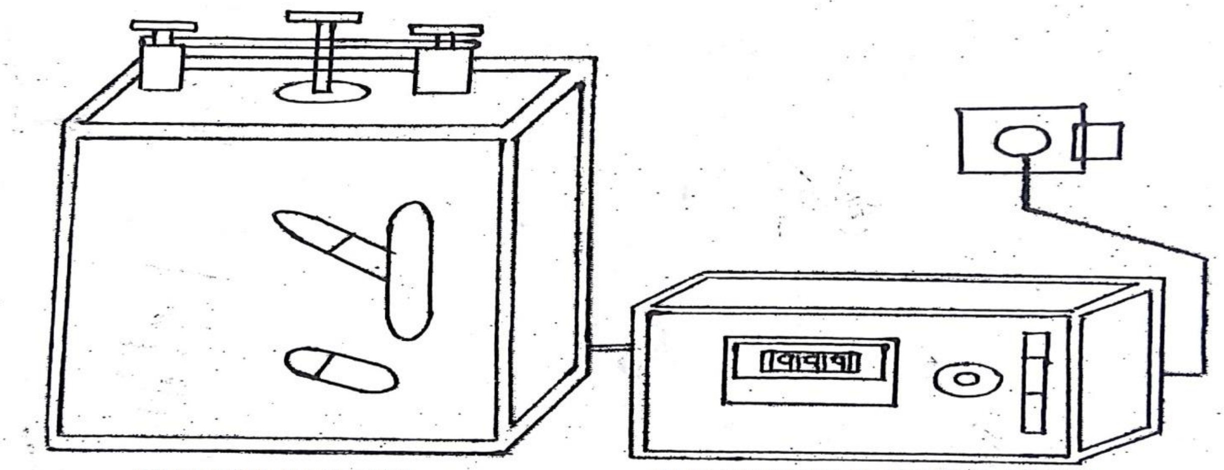
- Mounting Press
- Thermosetting Powder (Bakelite Powder)
- Specimens
- Belt Grinder
- Emery Papers (80,120,240,400,600)
- Alumina Paste (Grade-1, 2 & 3)
- Disc Polishing Machines
- Suitable Etching Agents
- Air Blower
- Metallurgical Microscope

DESCRIPTION:

Iron is an allotropic material which means that exists in more than one type of lattice structure depending upon temperature. The percentage of carbon in the iron is 0.8.pure iron is soft and malleable. Depending upon the percentage of carbon it is classified as steels and cast irons.

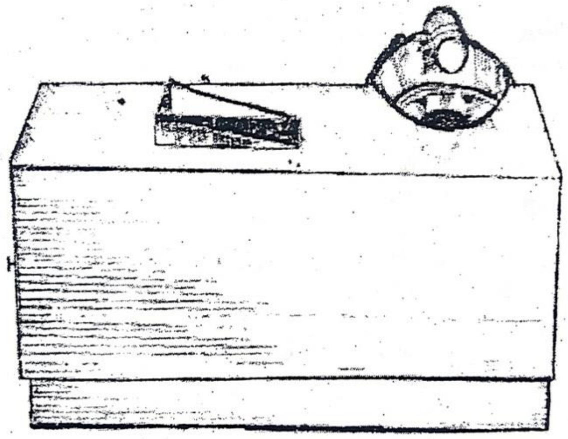
PROCEDURE:

1. The given specimen is mounted in a thermosetting material by using mounting press.
2. Polish the specimen by using belt grinding machine.
3. Polish the specimen by using (80,120,240,400,600& 1000) grade emery papers.
4. Polish the specimen by using (1/0, 2/0, 3/0, 4/0,) grade emery papers.



HYDRAULIC PRESS ELECTRONIC CONTROL PANEL

SPECIMEN MOUNTING PRESS



BELT GRINDING MACHINE

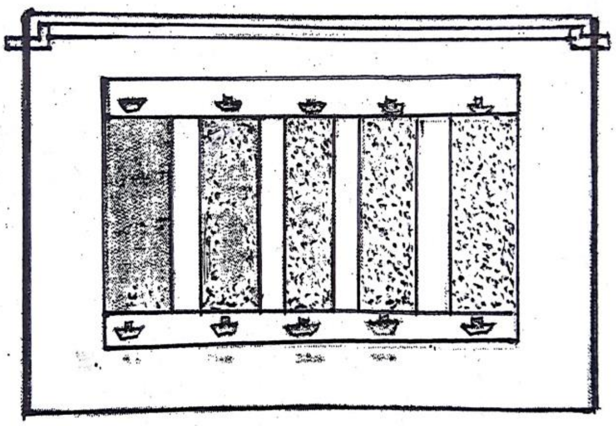
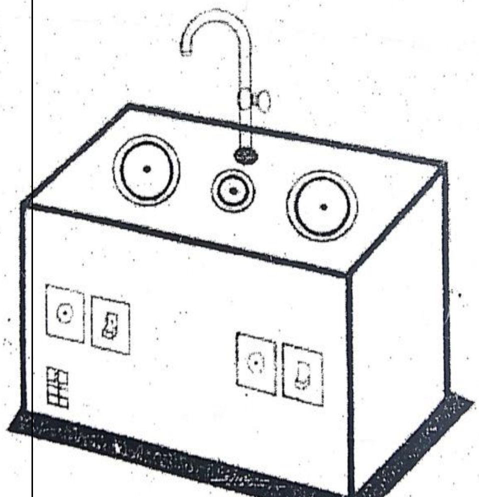
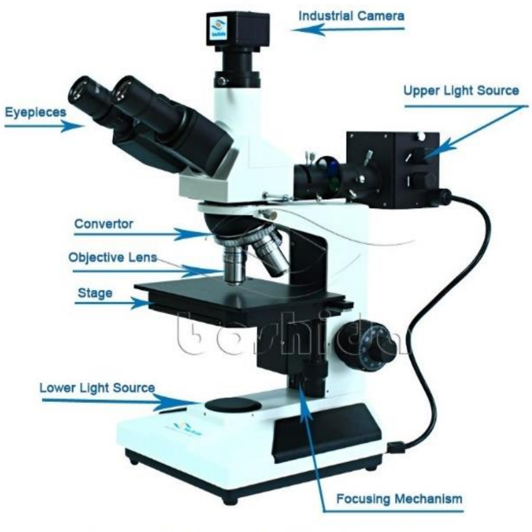


PLATE POLISHING MACHINE



DISC POLISHING MACHINE



METALLURGICAL MICROSCOPE

5. Subject the given specimen to mirror like finish by using disc polishing machine and with suitable abrasive i.e. Alumina paste.
6. Clean the specimen with alcohol and wash it under the stream of flowing water.
7. After washing, the specimen is dried.
8. After drying apply the suitable etching agent for 30 to 60 sec.
8. After etching wash the specimen under the stream of flowing water.
9. Dry the specimen with the help of air blower.
10. Place the specimen under the microscope for metallurgical studies.
11. Draw the micro structure and identify the material for the given specimen.

PRECAUTIONS:

- Pressure should be applied uniformly.
- Polishing should be slow, smooth and flat.
- Proper Care Should be Taken While Etching.
- Wash Your Hands Thoroughly After Experiment.

RESULT:

CONCLUSION:

EXPERIMENT-3 **DATE:**

Microstructure of low carbon steel, mild steel and high carbon microstructure of cast irons.

AIM:

To Study the specimens of metals like mild steel, low carbon steel, medium carbon steel and high carbon steel and observe the microstructure of the same.

APPARATUS:

- Given Specimens
- Belt Grinder
- Emery Papers (80,120,240,400,600)
- Alumina Paste (Grade-1, 2 & 3)
- Disc Polishing Machines
- Suitable Etching Agents
- Air Blower
- Metallurgical Microscope

THEORY

Plain carbon steels are steels having carbon as the predominant alloying element andthe other alloying elements are either Nil or negligible though some amount of sulphurand 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

1. Low carbon steels with carbon content less than 0.3 percent.
2. Medium carbon steels contain Carbon between 0.3 to 0.7 percent.
3. The high carbon steels contain carbon from 0.7 to 1.5 percent.

LOW CARBON STEEL:

As the microstructure shows the structure of the mild steel, it contains 25% pearlite and 75% ferrite. The dark region defines the pearlite and bright portion is of ferrite. The properties of low carbon steels are:

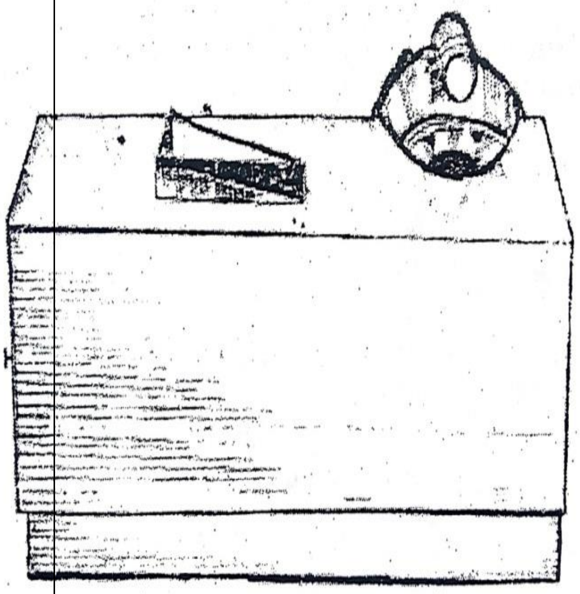
- The material is soft and ductile.
- It is easily weldable.
- It is cold workable.
- The tensile strength varies between 390 to 550 N/ mm^{2}.
- The Brinell hardness number varies from115 to 140.
- The application includes making steel wire, sheets, rivets, screws, pipe, chain and Struct uralparts.

MEDIUM CARBON STEEL:

The microstructure reveals two phases are to be about 50% each. Hence the carbon content can be accessed to be equal to it. The properties of medium carbon steels are invariably between low and high carbon steels. The tensile strength varies between 75 to 800 N/ mm^{2} . The medium carbon steels are used in manufacture of drop forging dies, die block plates, punches, screws and valve springs etc.

HIGH CARBON STEEL:

Microstructure of high carbon steels consists of continuous network of cementite in matrix to pearlite. This cementite structure is hard and brittle and hence has poor machinability. As carbon content increases weldability and cold working decreases. They have high strength and hardness. Its Tensile strength is up to 1400 N/mm^{2} hardness varies from 450 to 500 BHW. High carbon steels are used in cutting machine tools, manufacturing cold dies and wheels for railways.



BELT GRINDING MACHINE

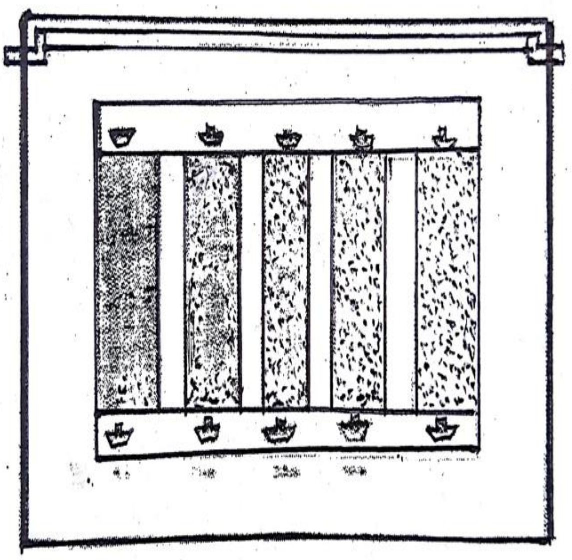
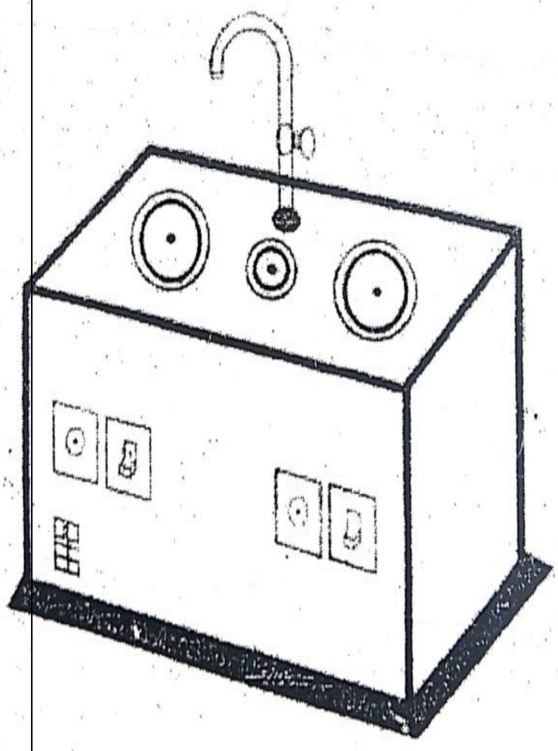
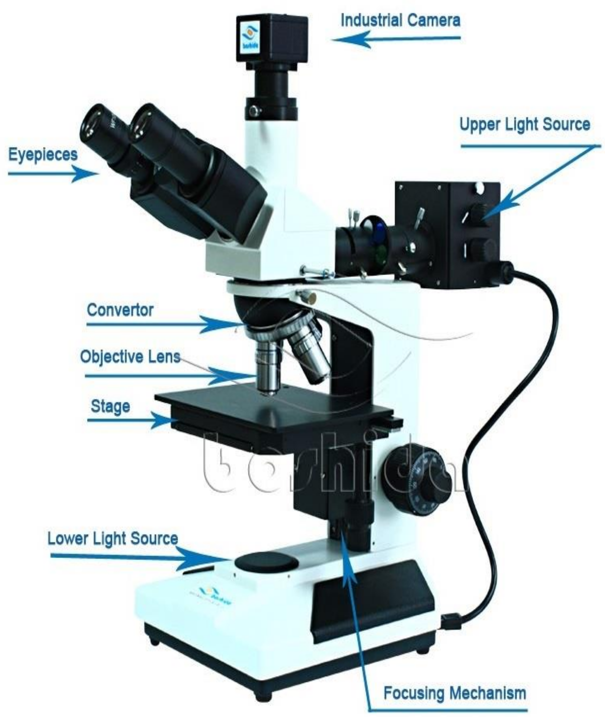


PLATE POLISHING MACHINE



DISC POLISHING MACHINE



METALLURGICAL MICROSCOPE

PROCEDURE:

1. Polish the specimen by using belt grinding machine.
2. Polish the specimen by using (80,120,240,400,600& 1000) grade emery papers.
3. Polish the specimen by using (1/0, 2/0, 3/0, 4/0,) grade emery papers.
4. Subject the given specimen to mirror like finish by using disc polishing machine and with suitable abrasive.
5. Clean the specimen with alcohol and wash it under the stream of flowing water.
6. After washing the specimen is dried.
7. After drying, apply the suitable etching agent for 30 to 60 sec.
8. After etching wash the specimen under the stream of flowing water.
9. Dry the specimen with the help of air blower.
10. Place the specimen under the microscope for metallurgical studies.
11. Draw the micro structure and identify the material for the given specimen.

PRECAUTIONS:

1) Polishing should be slow, smooth and flat.
2) Uniform pressure is applied throughout the polishing.
3) Proper Care should be Taken While Etching.
4) Wash Your Hands Thoroughly After Experiment.

RESULT:

CONCLUSION:

DATE:

STUDY OF MICROSTRUCTURE OF THE CAST IRONS

AIM:

To identify and draw the microstructures of Cast Iron specimens like Grey Cast Iron, White Cast Iron, Malleable Cast iron, and S.G. Cast iron etc.

APPARATUS:

- Given Specimens
- Belt Grinder
- Emery Papers (80,120,240,400,600& 1000)
- Alumina Paste (Grade-1, 2 & 3)
- Disc Polishing Machines
- Suitable Etching Agents
- Air Blower
- Metallurgical 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 of 2.5 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 machinability. 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.

MALLEBLE CAST IRON:

In malleable cast iron 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 + 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.

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%

GREY CAST IRON:

In grey cast iron 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 thereby 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%.
-

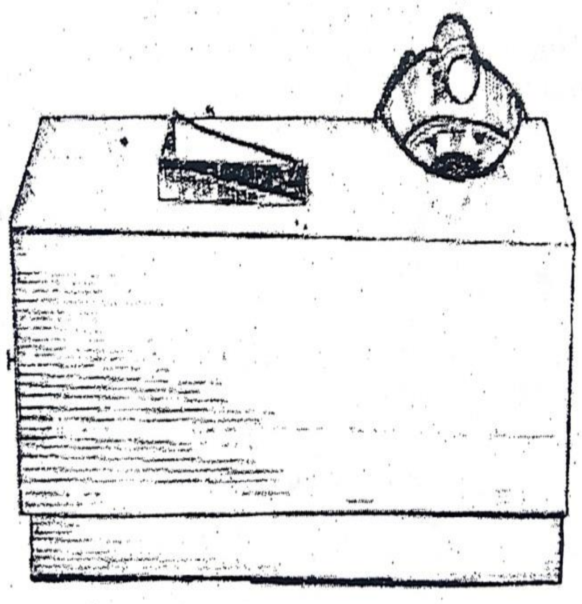
NODULAR CAST IRON: (SPHEROIDAL GRAPHITE CAST IRON)

Nodular cast iron is also known as ductile iron. Spheroidal graphite iron is a cast iron in which graphite is present as tiny balls or spheroids. The compact spheroids interrupt the continuity of the matrix much less than graphite flakes. This result in higher strength and toughness compared with a similar structure of grey cast iron.

Nodular cast iron differs from malleable cast iron in that it is usually obtained as a result of solidification and does not require heat treatment. The spheroids are more rounded than irregular aggregates of temper carbon found in malleable cast iron. The formation of spherical graphite is due to addition of magnesium to the molten grey iron.

The composition of typical S.G.cast iron is as follows:

- Carbon : 3 to 3.5%
- Silicon : 2 to 2.5%
- Manganese : 0.15 to 0.6%
- Phosphorous : 0.025 to 0.4%
- Sulphur : 0.015 to 0.04 %



BELT GRINDING MACHINE

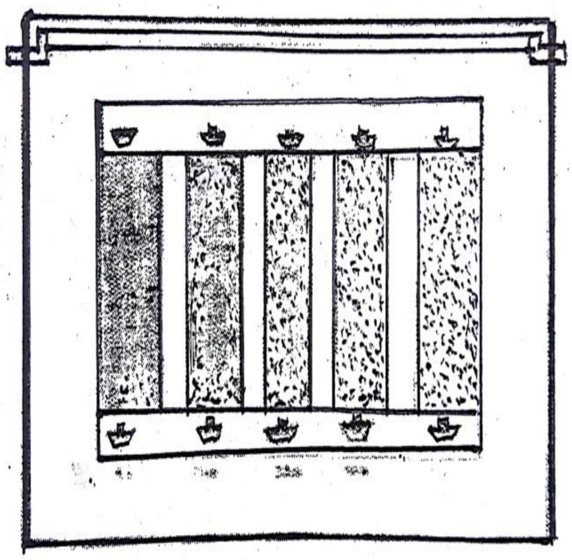
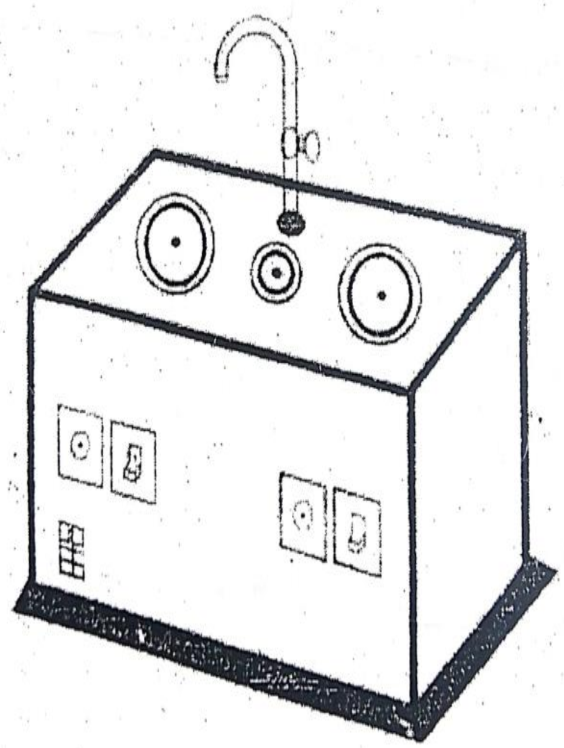
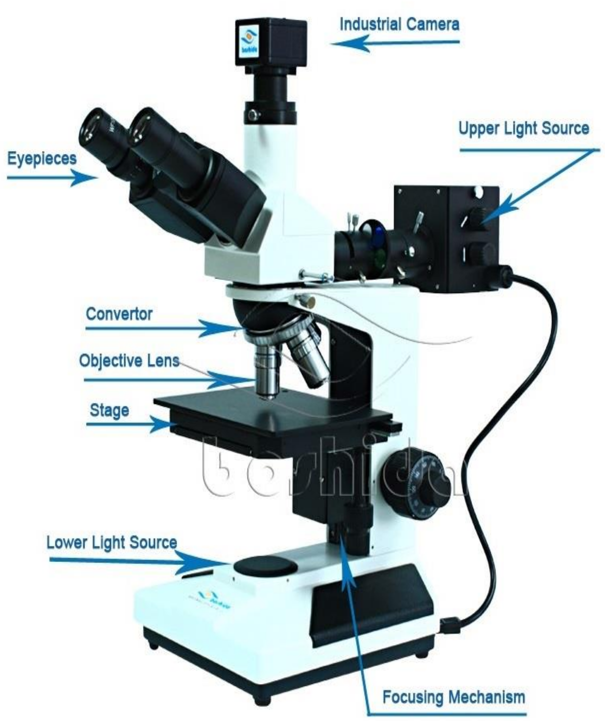


PLATE POLISHING MACHINE



DISC POLISHING MACHINE



METALLURGICAL MICROSCOPE

PROCEDURE:

1. Polish the specimen by using belt grinding machine.
2. Polish the specimen by using (80,120,240,400,600& 1000) grade emery papers.
3. Polish the specimen by using (1/0, 2/0, 3/0, 4/0,) grade emery papers.
4. Subject the given specimen to mirror like finish by using disc polishing machine and with suitable abrasive.
5. Clean the specimen with alcohol and wash it under the stream of flowing water.
6. After washing the specimen is dried. After drying apply the suitable etching agent for 30 to 50 sec.
7. After etching wash the specimen under stream of flowing water.
8. Dry the specimen with the help air drier.
9. Place the specimen for metallurgical studies.
10. Draw the microstructure and analyze the properties

APPLICATIONS:

Agricultural tractor and implement parts, automotive and diesel crank shafts, piston and cylinder heads, electrical fittings, motor frames, hoist drums, flywheels and elevator buckets, steel mill, furnace doors and bearings wrenches levers and handles.

RESULT:

CONCLUSION:

EXPERIMENT- 4 **DATE:**

STUDY OF MICROSTRUCTURE OF NON-FERROUS ALLOYS LIKE ALUMINUM, COPPER AND THEIR ALLOYS.

AIM:

To study the microstructures of Nonferrous alloy specimens like Al, Cu alloys and bearing metal.

APPARATUS:

- Given Specimens
- Belt Grinder
- Emery Papers (80,120,240,400,600& 1000)
- Alumina Paste (Grade-1, 2 & 3)
- Disc Polishing Machines
- Suitable Etching Agents
- Air Blower
- Metallurgical Microscope

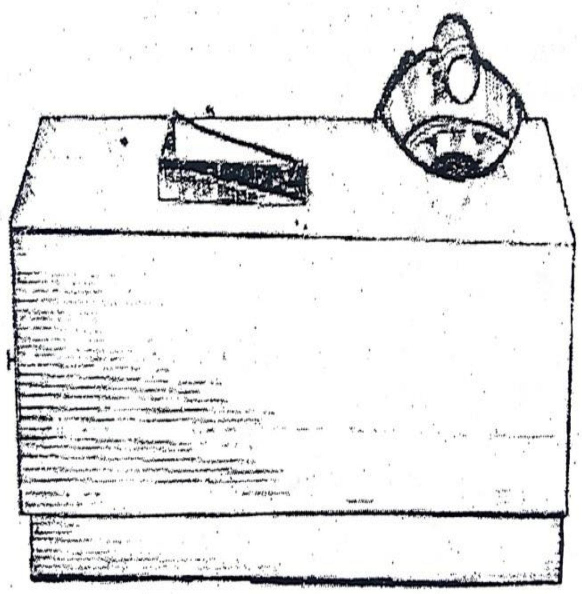
THEORY:

Nonferrous metals and 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 properties. They also possess 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 hows a typical equiaxied grain structure with twins in annealed structure. This brass is used for making cartridge cases. Other applications includes radiator cases, head light reflectors, hardware, and plumbing accessories.



BELT GRINDING MACHINE

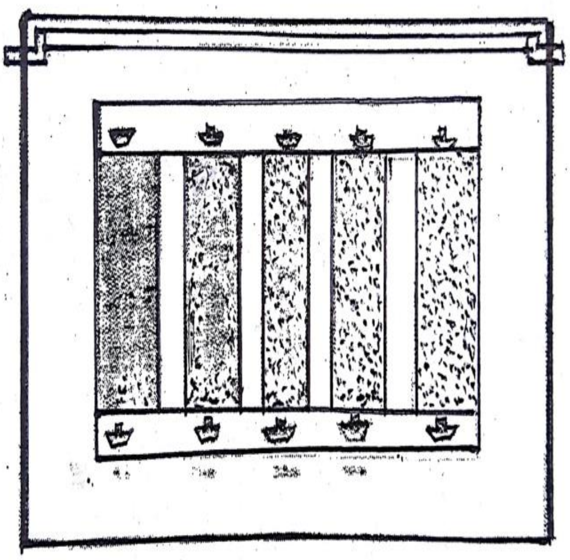
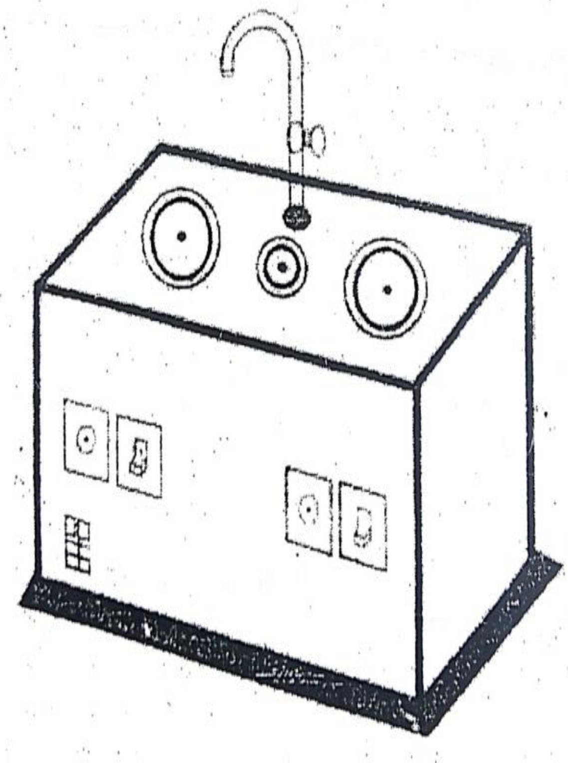
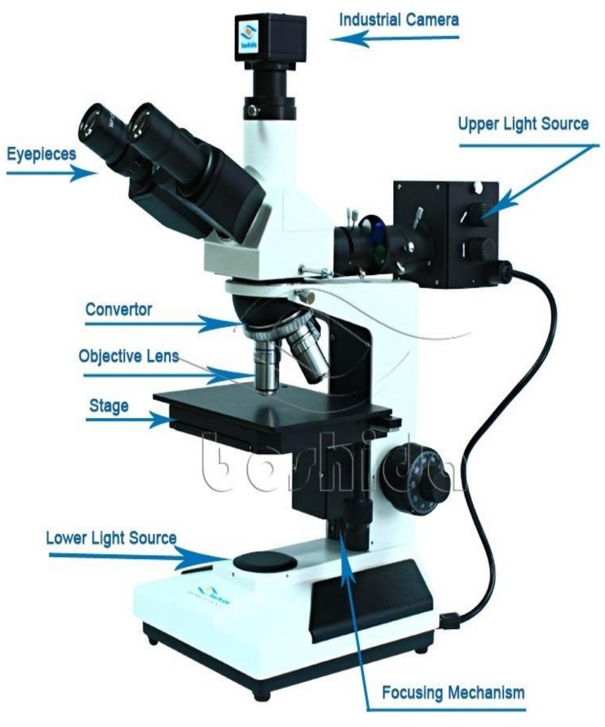


PLATE POLISHING MACHINE



DISC POLISHING MACHINE



METALLURGICAL MICROSCOPE

AL-ALLOYS:

Aluminum alloy contains silicon up to 12 %. Aluminum- silicon is also called as silumin. There are two types of aluminum silicon alloys, they are:

LM-6:

It contains above 12% silicon due to its higher corrosion resistance and fluidity. It is used in water cooled marine tools for pump parts.

LM-13

It contains silicon up to 12.5%, Ni 2.5%, ca 1% and Mg 12%. This shows good forgability and low coefficient of thermal expansion. It is used in automobile pistons.

BEARING METAL:

Bearing metal has high compressive strength and high wear resistance, high fatigue strength and better thermal conductivity for heat dissipation, corrosion resistance and good machinability. They have hard and soft phases. Most widely used bearing metal is a Babbitt metal. They are called as low melting bearing alloy. Lead based ad tin based Babbitt contain Antimony as most popular this group.

PROCEDURE:

1. Polish the specimen by using (1/0, 2/0, 3/0, 4/0,) grade emery papers.
2. Subject the given specimen to mirror like finish by using disc polishing machine and with suitable abrasive.
3. clean the specimen with alcohol and wash it under the stream of flowing water
4. After washing the specimen is dried. After drying apply the suitable etching agent for 30 to 50 sec.
5. After etching wash the specimen under stream of flowing water.
6. Dry the specimen with the help air drier.
7. Place the specimen for metallurgical studies.
8. Draw the microstructure and analyze the properties

PRECAUTIONS:

1) Polishing should be slow, smooth and flat
2) Uniform pressure is applied throughout the polishing
3) Proper Care should be Taken While Etching.
4) Wash Your Hands Thoroughly After Experiment.

RESULT:

CONCLUSION:

EXPERIMENT- 5 **DATE:**

HARDENABILITY OF STEELS BY JOMINY END QUENCH TEST

AIM:

To evaluate the hardenability of the low carbon steel or medium carbon steel by Jominy end quench test method.

APPARATUS:

- HeatTreatment furnace – Muffle furnace
- Jominy end quench apparatus,
- TestSpecimen,
- RockwellTest setup

PROCEDURE:

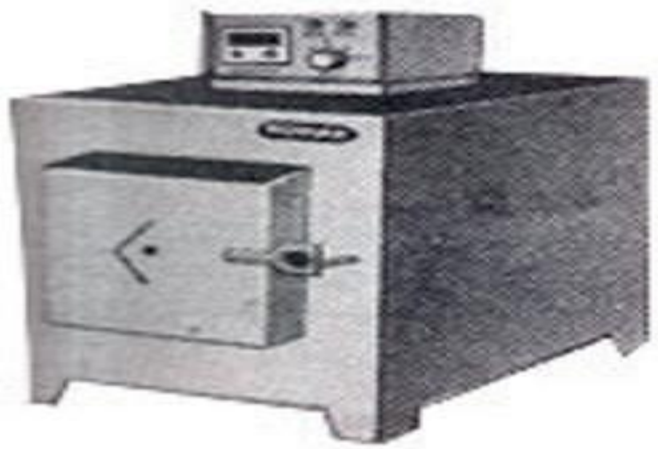
The various steps involved in evaluating the hardenability test for a given specimen are

1) Determination of hardness no. by Rockwell hardness test
2) Heat treatment in the furnace
3) Quenching the specimen in Jominy end quench apparatus

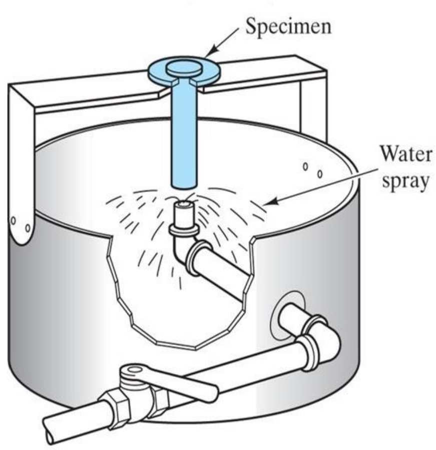
1) DETERMINATION OF HARDNESS NO.BY ROCKWELL HARDNESS TEST

The method of determining the hardness consists of measuring the depth of a diamond cone penetrant that was forced into a metal by applying primary and secondary loads. This method of measuring hardness significant because errors due to mechanical defects on the system such as backlash are eliminated ad as well as errors resulting fromslight surface imperfections.

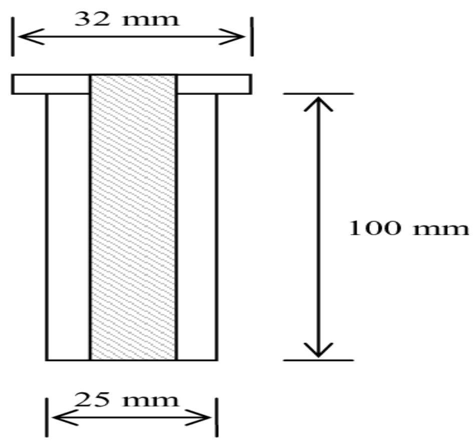
The specimen is placed on a suitable anvil on the upper end of the elevation screw. A minor load of 10 kg is applied by raising the anvil by using elevation screw. Then apply the major load by using the leaver. After applying the load for a period of 20 sec, remove the load by turning the lever. Note downthe reading on the Rockwell scale.



MUFFLE FURNACE



JOMINY END QUENCH TEST APPARATUS



JOMINY QUENCH TEST SPECIMEN

ROCKWELL HARDNESS TESTER

2) HEAT TREATMENT IN THE FURNACE

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)

Take the specimen, place it in the furnace and supply the power. Wait till the temperature reaches to the austenising temperature. Heat the specimen at the austenising temperature until it is completely transformed in to Austenite.

3)QUENCHING THE SPECIMENIN JOMINY END QUENCH APPARATUS

Remove the specimen fromthe furnace with the help of tongs and gloves and place it in the Jomny end quench apparatus and allow the jet of water to strike one end of the specimen. When the specimen reaches to the room temperature remove it from the apparatus and find the Rockwell hardness at 0.5cms along the length of the specimen. Plot the graph between the hardness and distance from the quenched end.

OBSERVATION & TABULAR COLUMN:

S.NO	Specimen material	Indenter	Load (kgf)	Distance from quenched end of the specimen	Rockwell scale (Before Treatment)	Rockwell scale (After Treatment)

PRECAUTIONS:

1. Don't use the hard water while Quenching, as it leads to formation of scales in nozzles and copper conduits.
2. Always use hand gloves, tongs while operating furnace.

RESULT:

CONCLUSION:

EXPERIMENT- 6 **DATE:**

MICROSTRUCTURE OF HEAT TREATED STEELS

AIM:

To identify, draw and to analyze the microstructures of heat treated steel specimens like Stainless steel, High speed steel, Tool steel etc.

APPARATUS:

- Given Specimens
- Belt Grinder
- Emergy Papers (80,120,240,400,600& 1000)
- Alumina Paste (Grade-1, 2 & 3)
- Disc Polishing Machines
- Suitable Etching Agents
- Air Blower
- Metallurgical Microscope

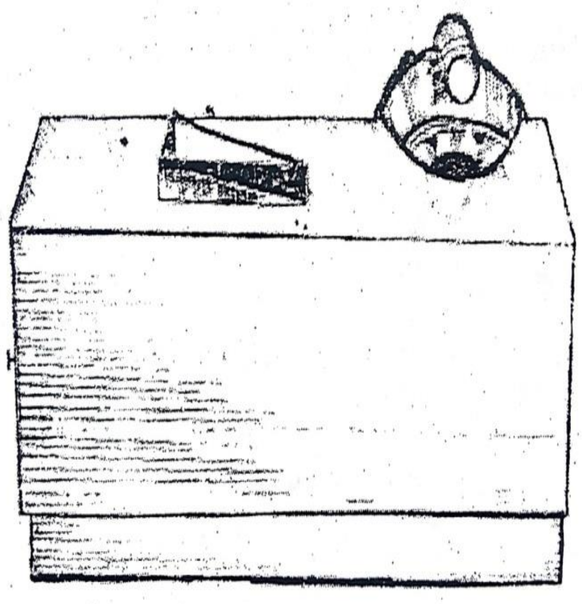
THEORY:

Heat treatment is a process of heating the metal below its melting point and holding it at that temperature for sufficient time and cooling at the desired rate to obtain the required properties. The various heat treatment processes are annealing, normalizing, tempering, hardening, mar tempering, austempering.

The final mechanical properties depend on the microstructure formed due to various heat treatment processes (due to various cooling rates). An annealed specimen was cooled in the furnace or any good heat insulating material; it obtains the coarse grain structure of ferrite and pearlite in case of hypo eutectoid steels and coarse grain structure of ferrite and cementite in case of hyper eutectoid steel. It possesses high ductility.

A normalized specimen was cooled in the presence of air so cooling rate increases, it obtains the fine grain structure of ferrite and pearlite in case of hypo eutectoid steels and fine grain structure of ferrite and cementite in case of hyper eutectoid steel. It possesses high ductility.

A hardened specimen was quenched in oil (in case of alloy steels) or in water (in case of carbon steel).due to faster cooling rate martensite (hard steel) structure was formed.



BELT GRINDING MACHINE

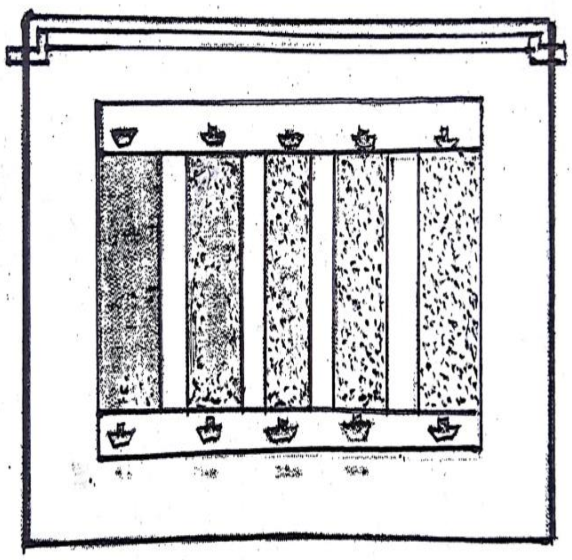
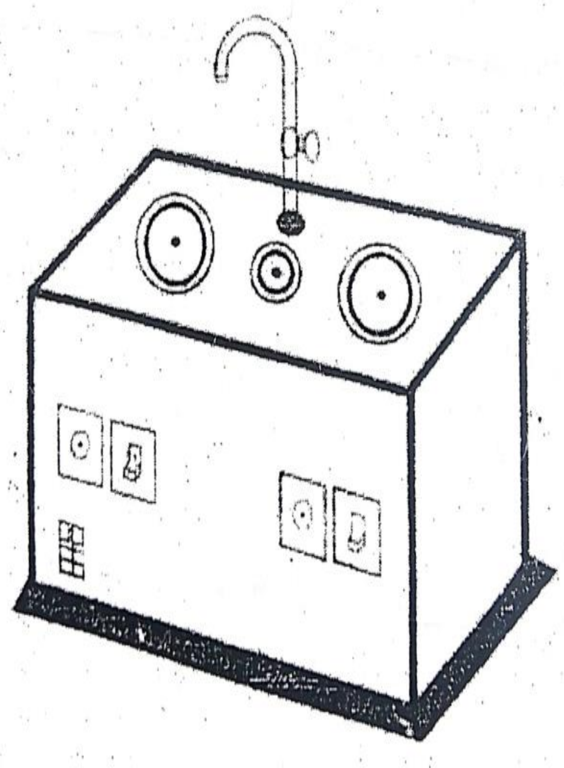
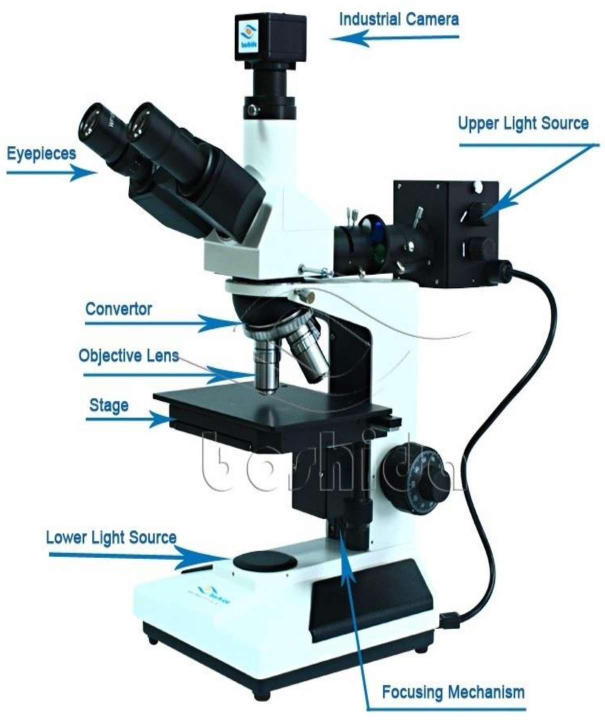


PLATE POLISHING MACHINE



DISC POLISHING MACHINE



METALLURGICAL MICROSCOPE

PROCEDURE:

1. Take the given treated (annealed, normalized, hardened) specimens.
2. Polish the specimen by using (80,120,240,400,600) grade emery papers.
3. Polish the specimen by using (1/0, 2/0, 3/0, 4/0,) grade emery papers.
4. Subject the given specimen to mirror like finish by using disc polishing machine and with suitable abrasive.
5. clean the specimen with alcohol and wash it under the stream of flowing water
6. After washing the specimen is dried. After drying supply the suitable etching agent for 30 to 50 sec.
7. After etching wash the specimen under stream of flowing water.
8. Dry the specimen with the help air drier.
9. Place the specimen for metallurgical studies.
10. Draw the microstructure and analyze the properties

PRECAUTIONS:

1. Polishing should be slow, smooth and flat.
2. Uniform pressure is applied throughout the polishing.
3. Proper Care should be Taken While Etching.
4. Wash Your Hands Thoroughly After Experiment.

RESULT:

CONCLUSION:

EXPERIMENT- 7 **DATE:**

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:

- Given specimens
- Hardness tester
- Indenter

THEORY:

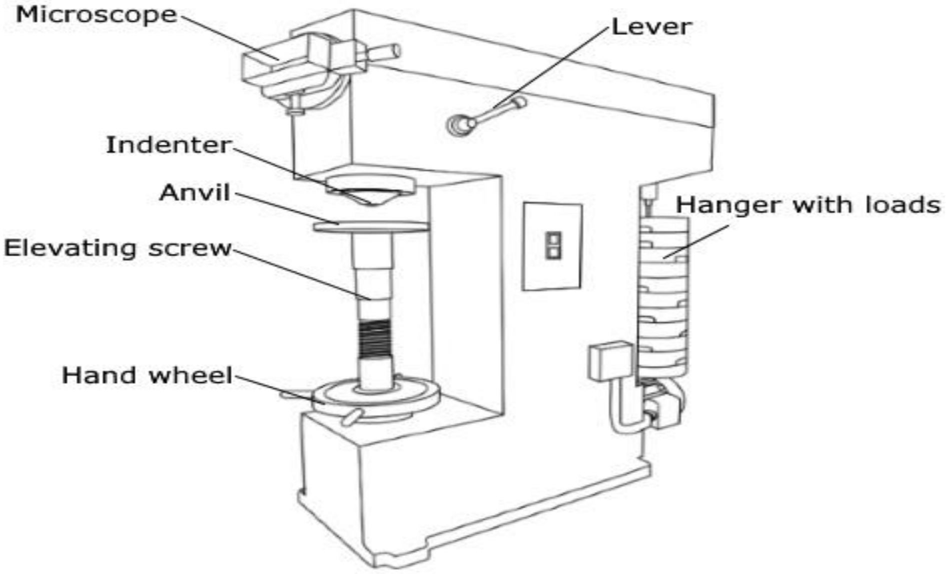
The method of testing introduced by J.A.Brinell in 1900 consisting of indenting the metal with a "d" mm diameter and tempered steel ball subjected to a definite load. Ball of 10 mm, 5 mm,and 2.5 mm are generally used. The load is maintained for a definite period (usually 10 or 15 sec) after which the 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

$$\frac{(D - \sqrt{(D^2 - d^2)}}{2}$$

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

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



BRINNEL HARDNESS TESTER

OBSERVATION AND TABULAR COLUMN

Room temperature:

Material	P/D^2	Dia Of indenter D mm	Applied Load kgf	Diameter of Indentation (d)					Brinell Hardness Number
				1	2	3	4	5	

P/D^2 Ratio for different metals

	Ferrous metals	Nonferrous metals		
	Steel & Iron	Brass	Aluminum	Soft bearing material
P/D^2	30	10	5	2.5

PROCDEDURE:

1. The face of the specimen is lightly grind and rubbed with fine emery paper if required.
2. Select the proper test table based on the size and shape of the specimen and place it on main screw or elevating screw.
3. 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.
4. Place the required weights on the weight hanger based on the type of material of the specimen and diameter of the indenter
5. Check and keep the operating level in horizontal position.
6. Place the specimen securely on testing table
7. Turn the hand wheel in clock wise direction so that the specimen touches the ball Indenter
8. Lift the operating lever for the horizontal position upwards slightly, after which it rotates Automatically.
9. Wait for 10 to 15 sec after lever becomes stand still and bring the lever back to horizontal position.
10. Turn back the hand wheel and remove the specimen.
11. Measure the diameter of impression of indentation by Brinnel microscope and find the Brinnel hardness number.
12. Repeat the above procedure for three to four times

PRECAUTIONS:

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

RESULT:

The Brinnel hardness number of the given material is ---------------

CONCLUSION:

EXPERIMENT- 8 DATE:

Microstructure of ceramics, polymeric materials

Aim:

The primary objective of this study is to gain an understanding of the mechanical properties, and underlying atomic structures that cause the properties, of ceramic materials through application of Modulus of Rupture tests

Requirements:

1. Conduct the 4 MOR tests indicated in the Procedure Section collecting the Load versus Deflection (Stroke) data for each specimen through brittle fracture.

2. Develop a results table that includes the following information for the 4 samples tested: T, L, w, h, Fmax, F1, δ1, F2, δ2, σfs, and Efs.

3. How does the stiffness of the ceramic compare to the stiffness values of the other material types that have been investigated in this course?

4. Obtain the Flexural Strength results of all sections of ME 3701 for the current semester and assemble all of the data into a single table (5 replication/cell).

5. Applying the t-Test to the combined Flexural Strength results of all sections, investigate whether or not there’s a curing temperature effect at a 0.05 Level of Significance:

a.) For the w = 0.50 inch Specimens.

b.) For the w = 1.50 inch Specimens. Discuss the Results. Are the results what you expected? Why or why not?

6. Applying the t-Test to the combined Flexural Strength results of all sections, investigate whether or not there’s a size effect at a 0.05 Level of Significance:

a.) For the Specimens Cured at 110oC.

b.) For the Specimens Cured at 950oC. Discuss the Results. Are the results what you expected? Why or why not?

Lead sample, Screw gauge, Verniercalliper

Principle:

Ceramics are generally composed of Metallic + Non-Metallic Compounds which are primarily Ionically Bonded.

Silicon and Oxygen are Common in Ceramics due to Availability and Cost. Common Structural Ceramics include Silicon Oxides, Nitrides and Carbides which include clay minerals such as

General Ceramic Properties:

Insulative, Refractory, Hard and Brittle.

Advanced Ceramic Applications:

• High-Temperature Engines.

• Tools for Machining Hard Metallics

• Coatings that Require High-Temperature Resistance and Chemical Stability (Enamels).

• Optical uses include: Lasers, Florescent Screens and Iridescent Films. Pottery, tiles, cement and glass.

Brittleness is the Primary Drawback of Ceramics**:** Ceramic Compounds are being developed which exhibit measurable ductility with excellent strength and hardness.

Three General Categories of Ceramics:

1. **Crystalline Ceramics** include Silicates, Oxides and Non-Oxide Compounds which form crystalline solids and are utilized in pottery, bricks and many high-tech industries such as aerospace and electronics.

2. **Glasses** include Silicate and Non-Silicate Compounds which are non-crystalline; Glasses are generally amorphous.

3. **Glass-Ceramics** are composed of crystalline ceramics that are initially formed as glasses and are subsequently crystallized under controlled thermal processing.

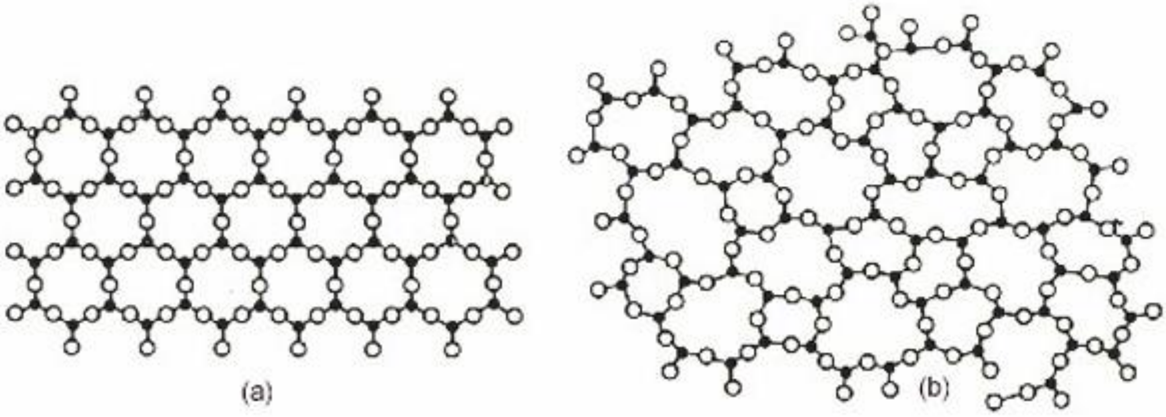


Figure 1 - (a) Crystalline Ceramic Structure, (b) Amorphous Ceramic Structure. [Askeland, 1996]

Crystalline Ceramics Most Crystalline Ceramics are SiOi2 based and are termed Silicates.

Silicate Examples: Pottery, White ware, Bricks, Tile.

Table 1 - Compositions of some Silicate Ceramics. [Shackelford, 1992]

CERAMICS	Sio_2	Al_2o_3	k_2o	Mgo	Cao	others
Silica refractory	96					4
Fireclay refractory	50-70	45-25				5
Mullite refractory	28	72				-
Electrical porcelain	61	32	6			1
Stealite porcelite	64	5		30		1
Portland cement	25	9			64	2

Note that Silicate Ceramics are generally Oxides!

Crystalline Ceramic Formation involves Firing which refers to controlled heating that Dries and Facilitates Ionic Bonding of the Compounds.

Ceramic Strength is highly dependent on Porosity (size and number of voids) which act as crack initiation sites. Crystalline Ceramics are influenced by the Nature of the Component Ions:

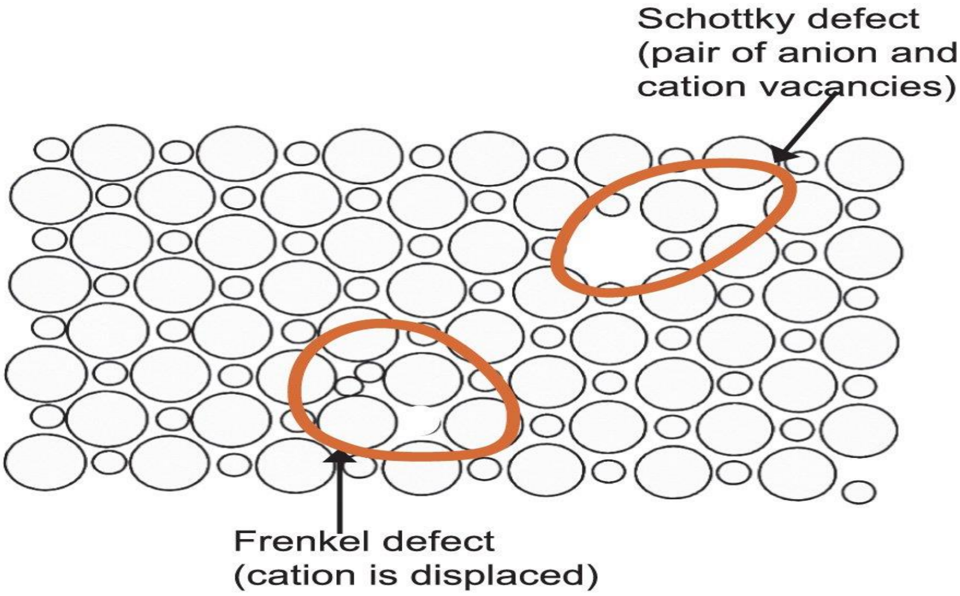
• Crystals must be Electrically Balanced thus Compositions must be balanced!

• Relative Ion Size generally determines the Crystalline Structures that form.

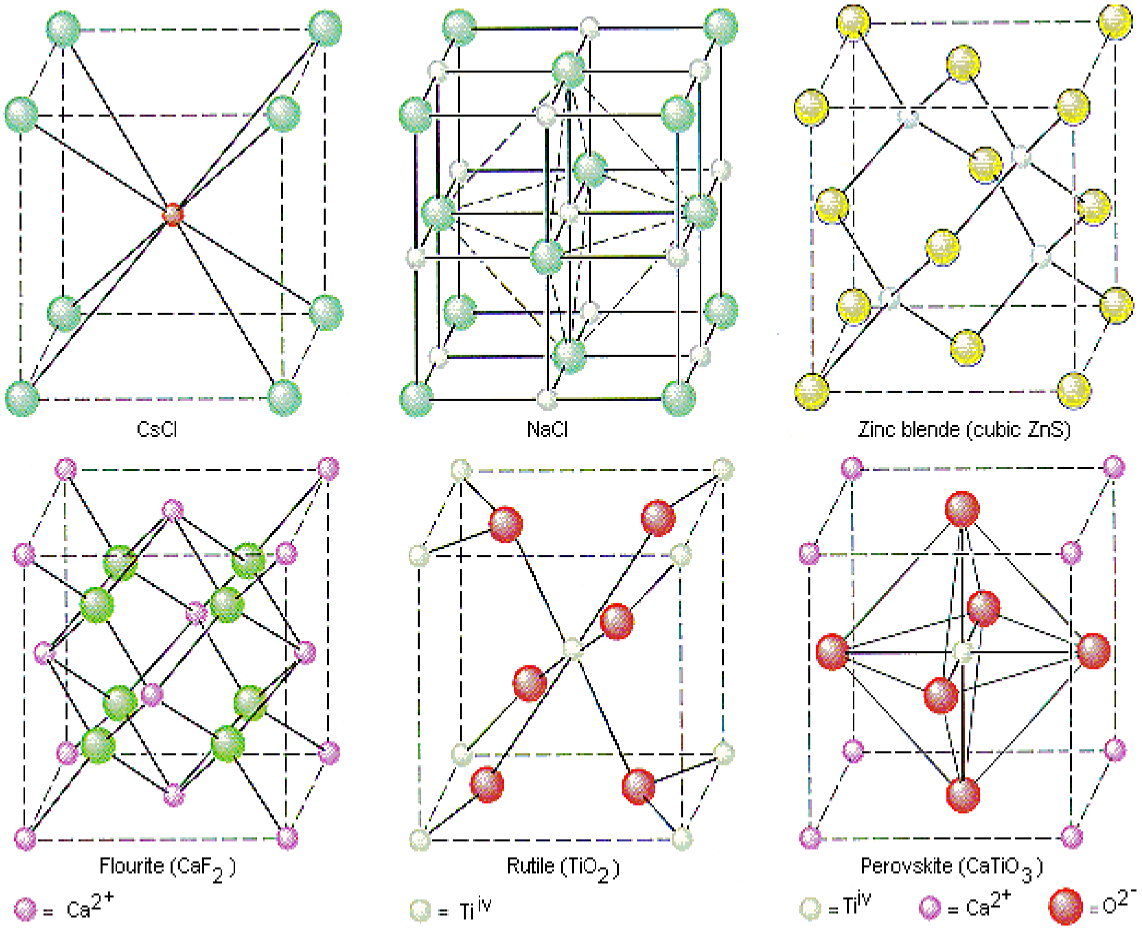
Due to Electrical Balancing restrictions, Crystalline Imperfections occur in Pairs:

• Schottky Defects - Vacancy Pair (Cation & Anion)

• Frenkel Defects - Cation Vacancy near a Cation Interstitial



Electrical Balancing Restrictions are also partially responsible for Ceramic Brittleness; Dislocation Movement and Plastic Deformation are minimal.



Pure Oxide Compounds with very small impurity levels, such as BaTiO3, make excellent high-end semiconductors but are relatively expensive.

Non-Oxide Ceramics, such as Silicon Carbide and Boron Nitride, include refractories and abrasives which are developed for heat and wear resistance

Glasses/Amorphous Compounds

Ordinary sand is primarily SiO2 which is utilized to produce window glass.

Most Glasses are produced by the addition of oxides, such as CaO and Na2O, which catalyze the formation of random 3-D networks of SiO2.

Examples of Common Non-Crystalline Ceramics

Vitreous Silica is relatively pure SiO2 which can withstand temperatures up to 1000o C; typically utilized in furnace windows.

E-Glass and S-Glass are thin pultruded fibers utilized in Composites.

Enamel is a ceramic coating applied for Temperature & Corrosion Protection.

Window Glass is a mixture of Oxides; 72% SiO2 with Na2O, CaO, MgO and Al2O3.

Glass Ceramics

Glass Ceramics are a new group of materials which are initially relatively ordinary glassware which is cheap and easy to form.

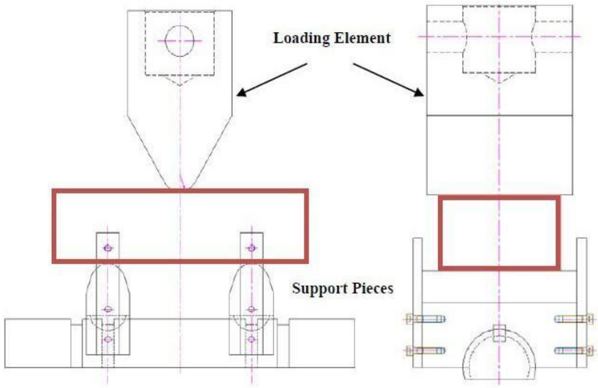
90% of the glassy material can be Crystallized though controlled heat treatment; small-grained, nearly pore-free ceramics form which are Strong and Shock Resistant.

Crystallization is a Nucleation and Growth process; catalysts are added to facilitate the formation of numerous grains.

Bend Test - Modules of Rupture

In ductile materials, the stress-strain behavior is found by applying the tensile test (as determined in previous experiments). The curve typically goes through a maximum which is where the tensile strength is located. Failure occurs at a lower stress after necking has reduced the cross-sectional area supporting the load. On the other hand the stress-strain behavior of brittle ceramics is not ascertained by a tensile test. There are many reasons the tensile test is not used:

1. It is difficult to prepare and test specimens having the required geometry
2. It is difficult to grip brittle materials without fracturing them
3. Surface flaws often cause premature failures; and
4. Ceramics fail after only about 0.1% strain thus specimens must be perfectly aligned in order to avoid the presence of bending stresses.



G689-C133 Bend Fixture

Result:

Conclusion:

EXPERIMENT- 9 **DATE:**

Microstructure of super alloy and nano - materials.

AIM: The present experiment is aimed at finding Microstructure of super alloy and nano - materials

Tools required:

Given Specimens

- Belt Grinder
- Emery Papers (80,120,240,400,600& 1000)
- Alumina Paste (Grade-1, 2 & 3)
- Disc Polishing Machines
- Suitable Etching Agents
- Air Blower
- Metallurgical Microscope

Theory

Ni-based single crystal super alloys are used to make blades, which operate in aero engines and land-based gas turbines. There are steady driving forces for improvement of thermal efficiency in these systems, for optimum thermal efficiency (engineering aspect), optimum use of fossil resources (environmental aspect) and for long component lives in expensive engineering systems (engineering, safety and environmental aspects). This represents the technological driving force for research on super alloy single crystals, which is strongly supported by industry and funding agencies in all leading industrial nations of the world. Single crystal (SX) Ni-based super alloys have γ/γ'-microstructures, where the ordered γ'-phase (L12-structure) forms cuboidal particles (average cube edge length: close to 0.5 µm) with a volume fraction of 70 %. The γ'-cubes are separated by thin γ channels (average channel width: close to 100 nm).

Procedure:

1. Polish the specimen by using belt grinding machine.
2. Polish the specimen by using (80,120,240,400,600& 1000) grade emery papers.
3. Polish the specimen by using (1/0, 2/0, 3/0, 4/0,) grade emery papers.
4. Subject the given specimen to mirror like finish by using disc polishing machine and with suitable abrasive.
5. Clean the specimen with alcohol and wash it under the stream of flowing water.
6. After washing the specimen is dried.
7. After drying, apply the suitable etching agent for 30 to 60 sec.
8. After etching wash the specimen under the stream of flowing water.
9. Dry the specimen with the help of air blower.
10. Place the specimen under the microscope for metallurgical studies.

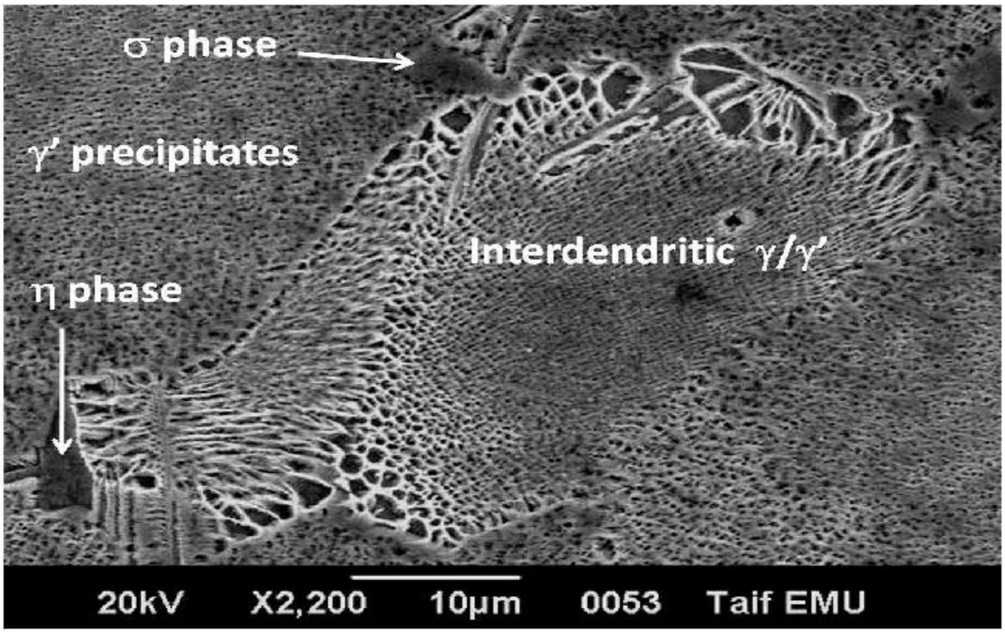
11. Draw the micro structure and identify the material for the given specimen.

Microstructure of super alloys:

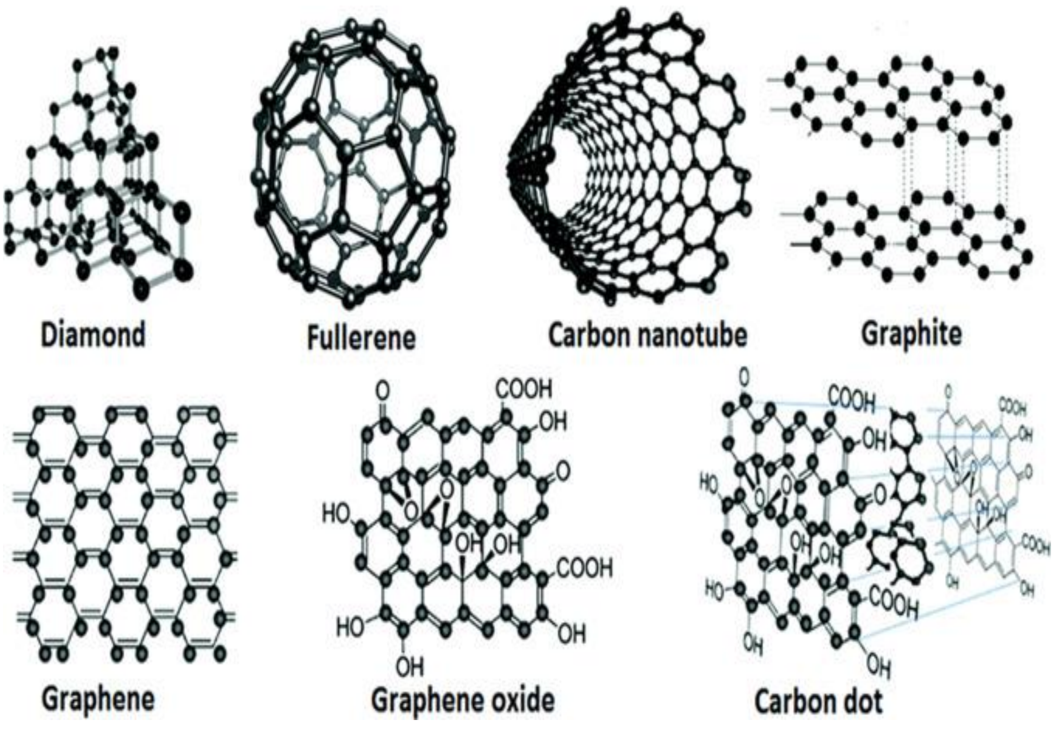
In pure Ni_3Al phase atoms of aluminum are placed at the vertices of the cubic cell and form the sublattice A. Atoms of nickel are located at centers of the faces and form the sub lattice B. The phase is not strictly stoichiometric. There may exist an excess of vacancies in one of the sub lattices, which leads to deviations from stoichiometry. Sub lattices A and B of the γ'-phase can solute a considerable proportion of other elements. The alloying elements are dissolved in the γ-phase as well. The γ'-phase hardens the alloy through an unusual mechanism called the yield strength anomaly. Dislocations dissociate in the γ'-phase, leading to the formation of an anti-phase boundary. At elevated temperature, the free energy associated with the anti-phase boundary (APB) is considerably reduced if it lies on a particular plane, which by coincidence is not a permitted slip plane. One set of partial dislocations bounding the APB cross-slips so that the APB lies on the low-energy plane, and, since this low-energy plane is not a permitted slip plane, the dissociated dislocation is now effectively locked. By this mechanism, the yield strength of γ'-phase Ni_3Al actually *increases* with temperature up to about 1000 °C, giving super alloys their currently unrivaled high-temperature strength.

Initial material selection for blade applications in gas turbine engines included alloys like the Nimonic series alloys in the 1940s. The early Nimonic series incorporated γ' $Ni_3(Al,Ti)$ precipitates in a γ matrix, as well as various metal-carbon carbides (e.g. $Cr_{23}C_6$) at the grain boundaries[29] for additional grain boundary strength. Turbine blade components were forged until vacuum induction casting technologies were introduced in the 1950s.[3][*page needed*] This process significantly improved cleanliness, reduced defects, and increased the strength and temperature capability of the material.

Modern superalloys were developed in the 1980s. The first generation superalloys incorporated increased aluminium, titanium, tantalum, and niobium content in order to increase the γ' volume fraction in these alloys. Examples of first generation superalloys include: PWA1480, René N4 and SRR99. Additionally, the volume fraction of the γ' precipitates increased to about 50–70% with the advent of single crystal, or monocrystal, solidification techniques (see Bridgman technique) for superalloys that enable grain boundaries to be entirely eliminated from a casting. Because the material contained no grain boundaries, carbides were unnecessary as grain boundary strengthens and were thus eliminated.



Microstructure of nano materials:



Nano materials synthesis and processing:

Nanostructure materials have attracted a great deal of attention because their physical, chemical, electronic and magnetic properties show dramatic change from higher dimensional counterparts and depends on their shape and size.

• Many techniques have been developed to synthesize and fabricate nanostructure materials with controlled shape, size, dimensionality and structure.

• The performance of materials depends on their properties.

The properties in tern depend on the atomic structure, composition, microstructure, defects and interfaces which are controlled by thermodynamics and kinetics of the synthesis.

Classification of Techniques for synthesis of Nanomaterials

There are two general approaches for the synthesis of nanomaterials as shown in Figure 2:

a) Top- down approach b) Bottom–up approach.

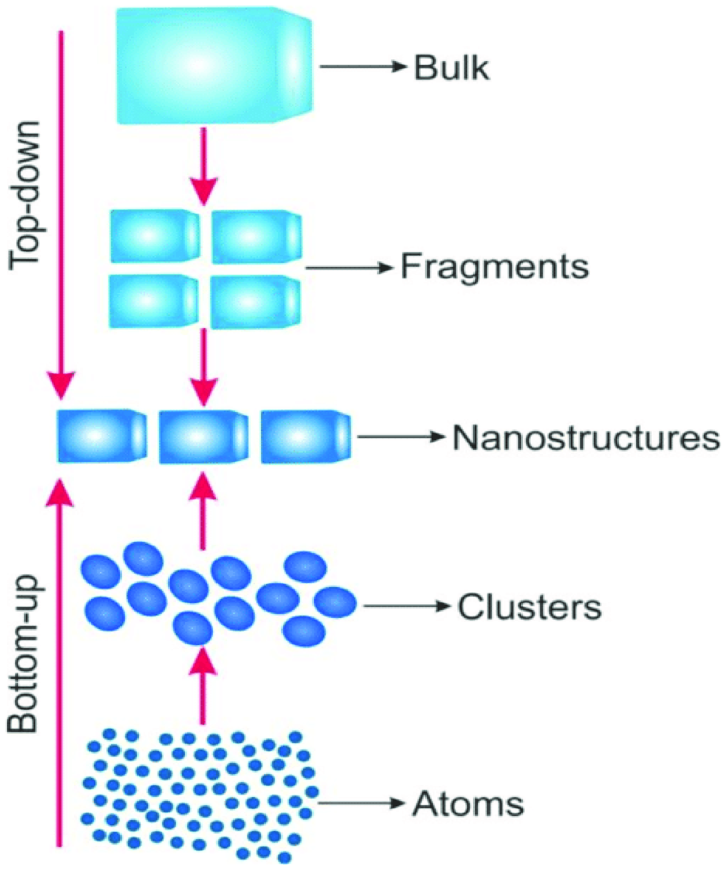
(A)Top- down approach

Top down approach structures or particles. Top involves the breaking down of the bulk material into nanosized down synthesis techniques are extension of those that have been used for producing micron sized particles.

Top down approaches are inherently simpler and depend either on removal or division of bulk material or on miniaturization of bulk fabrication processes to produce the desired structure with appropriate properties.

The biggest problem with the top for example, nanowires down approach is the imperfection of surface structure.

Made by lithography are not smooth and may contain a lot of impurities and structural defects on its surface. Examples of such techniques are high milling, electron beam lithography, atomic force manipulation, gas spray, etc.



(B) Bottom-up approach

✓ The alternative approach, which has the potential of creating less waste and hence the more economical, is the 'bottom- up'.

✓ Bottom-up approach refers to the buildup of a material from the bottom: atom-by-atom, molecule-by-molecule, or cluster-by cluster.

✓ Many of these techniques are still under development or are just beginning to be used for commercial production of nanopowders.

✓ Oraganometallic chemical route, revere-micelle route, sol-gel synthesis, colloidal precipitation, hydrothermal synthesis, template assisted sol-gel, electro deposition etc, are some of the well-known bottom–up techniques reported for the preparation of luminescent nanoparticals.

Procedure:

12. Polish the specimen by using belt grinding machine.
13. Polish the specimen by using (80,120,240,400,600& 1000) grade emery papers.
14. Polish the specimen by using (1/0, 2/0, 3/0, 4/0,) grade emery papers.
15. Subject the given specimen to mirror like finish by using disc polishing machine and with suitable abrasive.
16. Clean the specimen with alcohol and wash it under the stream of flowing water.
17. After washing the specimen is dried.
18. After drying, apply the suitable etching agent for 30 to 60 sec.
19. After etching wash the specimen under the stream of flowing water.
20. Dry the specimen with the help of air blower.
21. Place the specimen under the microscope for metallurgical studies.
22. Draw the micro structure and identify the material for the given specimen.

Result:

Conclusion:

EXPERIMENT- 10 **DATE:**

Hardness of ceramics, super alloys, nano-materials and polymeric Materials (one sample on each)

AIM: To determine the Rockwell Hardness of a given test specimen

APPARATUS: Rockwell Hardness testing machine, Test specimen.

THEORY:

HARDNESS-It is defined as the resistance of a metal to plastic deformation against Indentation, scratching, abrasion of cutting. The hardness of a material by this Rockwell hardness test method is measured by the depth of Penetration of the indenter. The depth of Penetration is inversely proportional to the hardness. Both ball or diamond cone types of indenters are used in this test. There are three scales on the machine for taking hardness readings. Scale "A" with load 60 kgf or 588.4 N and diamond indenter is used for performing tests on thin steel and shallow case hardened steel. Scale "B" with load 100 kgf or 980.7 N and 1.588 mm dia ball indenter is used for performing tests on soft steel, malleable iron, copper and aluminum alloys. First minor load is applied to over come the film thickness on the metal surface. Minor load also eliminates errors in the depth of measurements due to spring of the machine frame or setting down of the specimen and table attachments. The Rockwell hardness is derived from the measurement of the depth of the impression

EP = Depth of penetration due to Minor load of 98.07 N.

Ea = Increase in depth of penetration due to Major load.

E = Permanent increase of depth of indentation under minor load at 98.07 N even after removal of Major load.

IV. PROCEDURE:

1. Select the load by rotating the Knob and fix the suitable indenter.

2. Clean the test-piece and place n the special anvil or work table of the machine.

3. Turn the capstan wheel to elevate the test specimen into contact with the indenter point.

4. Further turn the wheel for three rotations forcing the test specimen against the indenter. This will ensure that the Minor load of 98.07 N has been applied

5. Set the pointer on the Scale dial at the appropriate position.

6. Push the lever to apply the Major load. A Dash Pot provided in the loading mechanism to ensure that the load is applied gradually.

7. As soon as the pointer comes to rest pull the handle in the reverse direction slowly. This releases the Major, but not Minor load. The pointer will now rotate in the reverse direction.

8. The Rockwell hardness can be read off the scale dial, on the appropriate scale, after the pointer comes to rest.

OBSERVATIONS:

Material of test piece =

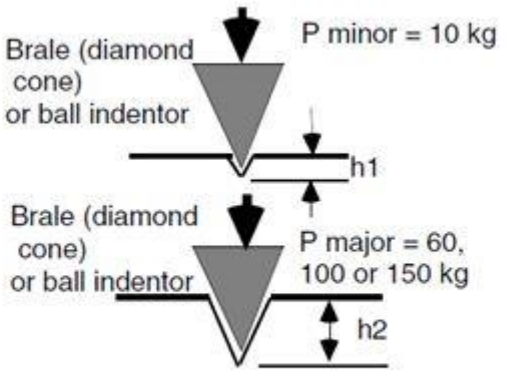
Thickness of test piece =

Hardness Scale used =

Minor Load =

Major Load =

Test No.	**1**	**2**	**3**	**4**
Hard ness value				



Rockwell Scale (X =)	Indentor	Pmajor (kg)
A	Brale (diamond)	60
B	1/16" ball	100
C	Brale (diamond)	150
D	Brale (diamond)	100
E	1/8" ball	100
F	1/8" ball	60
M	1/4" ball	100
R	1/2" ball	60

$$HRX = R_X = M - \frac{(h_2 - h_1)}{0.002}$$

M = 100 for A, C, and D scales

M = 130 for B, E, M, R, etc. scales

Figure 1. Rockwell Principle

Result:

Conclusion:

PRECAUTIONS:

1. For testing cylindrical test specimen, use V-type platform.

2. Calibrate the machine occasionally using standard test blocks.

3. For thin metal prices place another sufficiently thick metal piece between the test specimen and the platform to avoid any damage which may likely occur to the platform.

4. After applying Major load, wait for sometime to allow the needle to come to rest. The waiting time vary from 2 to 8 seconds.

5. The surface of the test piece should be smooth and even and free from oxide scale and foreign matter.

6. Test specimen should not be subjected to any heating or cold working.

7. The thickness of test piece or of the layer under test should be at least 8 times the permanent increase of depth of “E”.

8. The distance between the centers of two adjacent indentations should be at least 4 indentations to the edge of the test piece should be at least 2.5 times the diameter of the indentation.

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