SVR ENGINEERING COLLEGE

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

OFFERING DIPLOMA, B.TECH, M.TECH, MBA COURSES

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

DEPARTMENT OF

MECHANICAL ENGINEERING

MATERIAL SCIENCE & ENGG. LAB MANUAL

SUBJECT CODE: 19A03303P

NAME	: ______________________________
ROLL NO	: ______________________________
CLASS/SEM	: ______________________________
ACADEMIC YEAR	: 2020-21

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JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY ANANTAPUR

B.Tech – II-I Sem **L T P C**
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19A03303P MATERIAL SCIENCE & ENGINEERING LAB

Course Objectives:

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

List of Experiments:

1. Study of microstructure of pure metals – Iron, copper and aluminum.
2. Study of microstructure of low carbon steel, mild steel and high carbon steel.
3. Study of microstructure of cast irons.
4. Study of microstructure of non-ferrous alloys – aluminum, copper, titanium, nickel and their alloys.
5. Study hardenability of steels by Jominy End Quench Test.
6. Study of microstructure of heat treated steels.
7. Find hardness of various untreated and treated steels.
8. Study of microstructure of ceramics, polymeric materials.
9. Study of microstructure of super alloy and nano-materials.
10. Find the hardness of ceramics, super alloys, nano-materials and polymeric materials (one sample on each)

Course Outcomes:

The student is able to

- Identify various microstructures of ferrous and non-ferrous metals and alloys. (L3)
- Visualize grains and grain boundaries. (L3)
- Importance of hardening of steels. (L2)
- Evaluate hardness of treated and untreated steels. (L4)

DO’s

1. Students must always wear uniform and shoes before entering the lab.
2. Proper code of conduct and ethics must be followed in the lab.
3. Windows & doors to be kept open for proper ventilation and air circulation.
4. Note down the specifications of the experimental setup before performing the experiment.
5. Check for the electrical connections and inform if any discrepancy found to the attention of lecturer/lab instructor.
6. Perform the experiment under the supervision/guidance of a lecturer/ lab instructor only.
7. After the observations are noted down switch off the electricalconnections.
8. In case of fire use fire extinguisher/throw the sand provided in the lab.
9. In case of any physical injuries or emergencies use first aid box provided.
10. Any unsafe conditions prevailing in the lab can be brought to the notice of the lab in charge.

DONT’s

1. Do not operate any experimental setup to its maximum value.
2. Do not touch/ handle the experimental setups/Test Rigs without their prior knowledge,
3. Never overcrowd the experimental setup/Test Rig, Leave sufficient space for the person to operate the equipment’s.
4. Never rest your hands on the equipment or on the display board, because it has fragile measurement devices like thermometers, manometers, etc.

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 **DATE:**

PREPARATION & STUDY OF MICROSTRUCTURE OF PURE METALS LIKE IRON, COPPER & ALUMINUM

AIM:

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

APPARATUS:

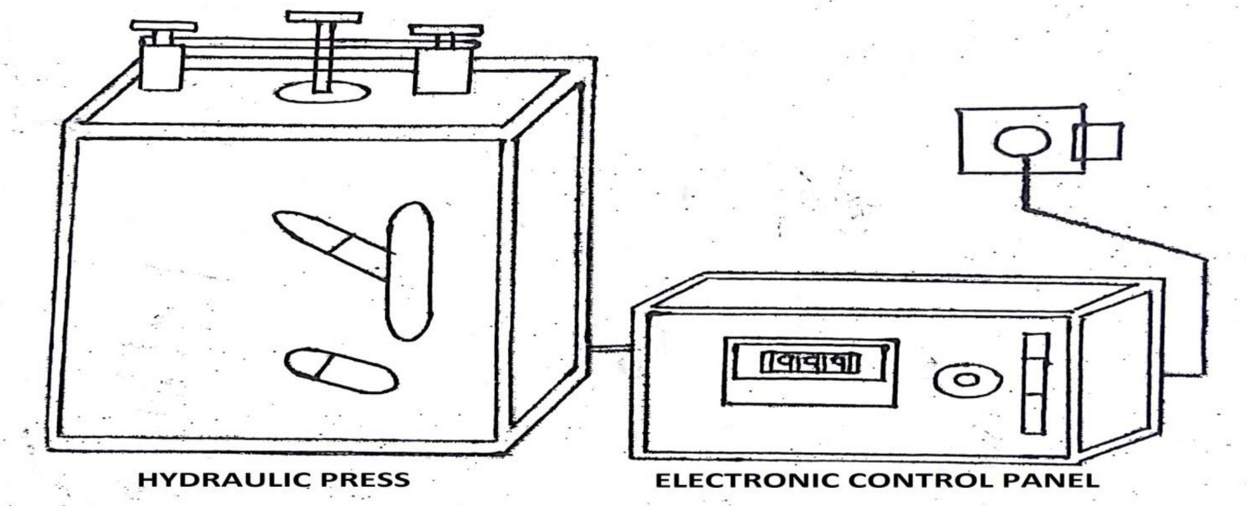
- Mounting Press
- Thermosetting Powder (Bakelite Powder)
- Specimens
- Belt Grinder
- Emery Papers (80,120,240,400,600)
- Alumina Paste (Grade-1, 2 & 3)
- Disc Polishing Machines
- Suitable Etching Agents
- Air Blower
- Metallurgical Microscope

DESCRIPTION:

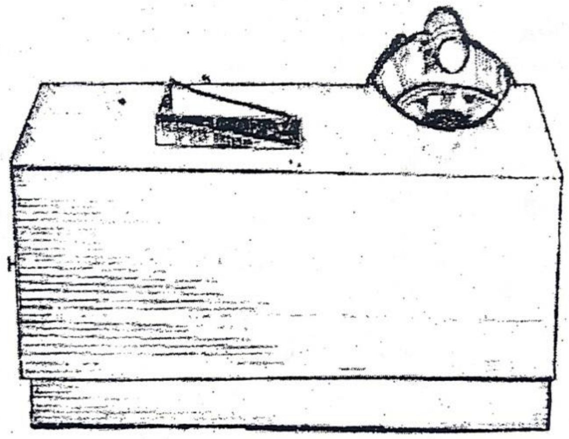
Iron is an allotropic material which means that exists in more than one type of lattice structure depending upon temperature. The percentage of carbon in the iron is 0.8.pure iron is soft and malleable. Depending upon the percentage of carbon it is classified as steels and cast irons.

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.



SPECIMEN MOUNTING PRESS



BELT GRINDING MACHINE

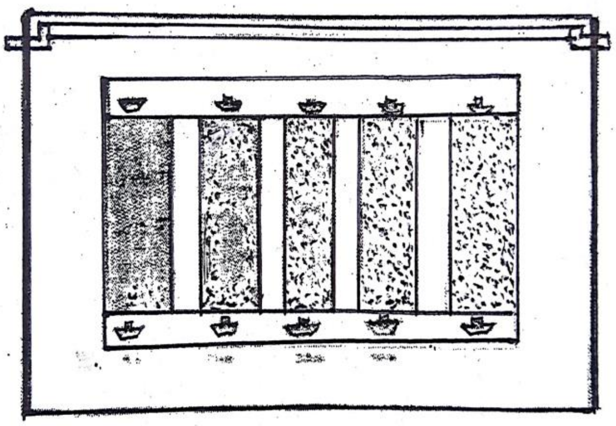
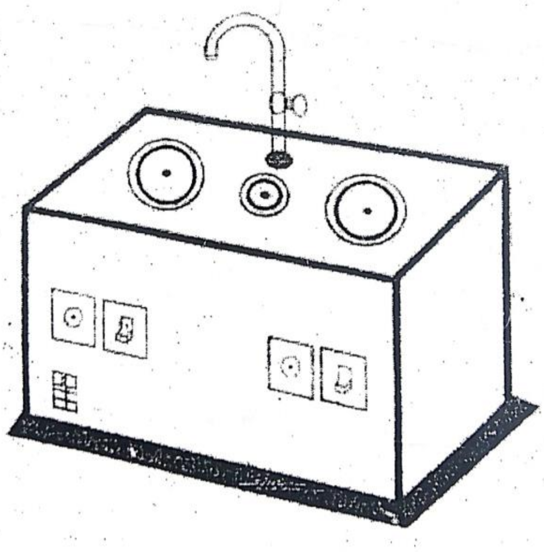


PLATE POLISHING MACHINE



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-2 **DATE:**

STUDY OF MICROSTRUCTURES OF LOW CARBON STEELS, MEDIUM CARBON STEELS AND HIGH CARBON STEELS

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 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

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:

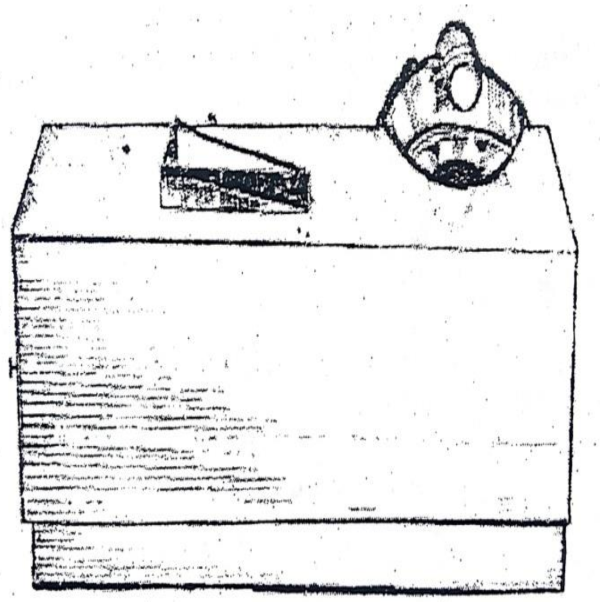
- The material is soft and ductile.
- It is easily weldable.
- It is cold workable.
- The tensile strength varies between 390 to 550 N/ mm^2.
- The Brinell hardness number varies from115 to 140.
- The application includes making steel wire, sheets, rivets, screws, pipe, chain and Struct
  ural parts.

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

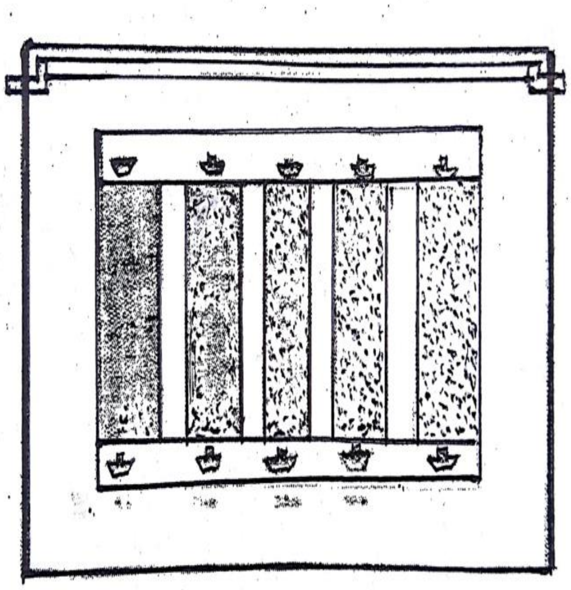
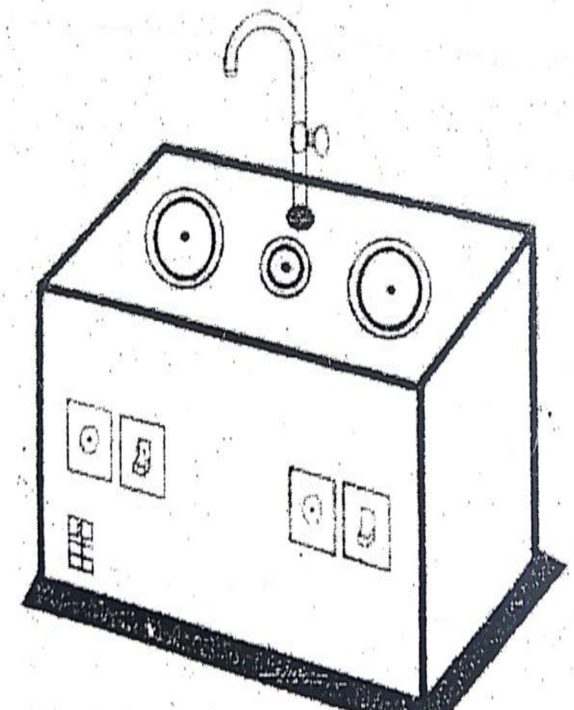
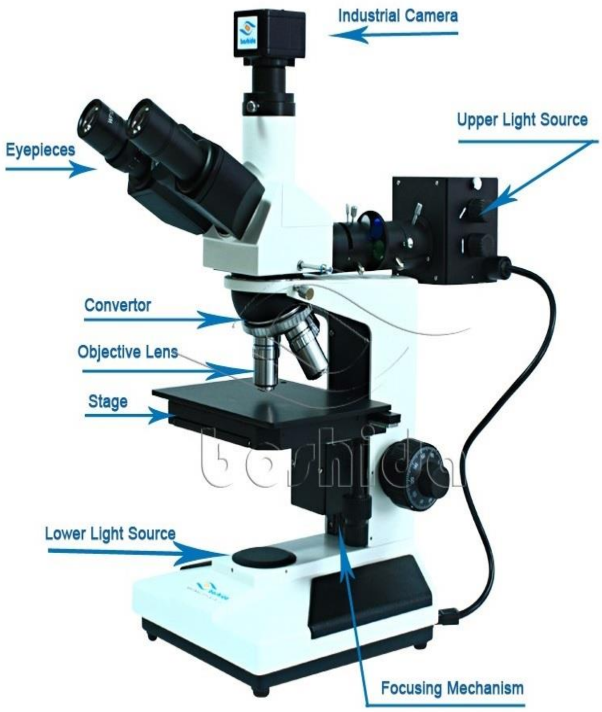


PLATE POLISHING MACHINE



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:

EXPERIMENT-3 **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%.
-

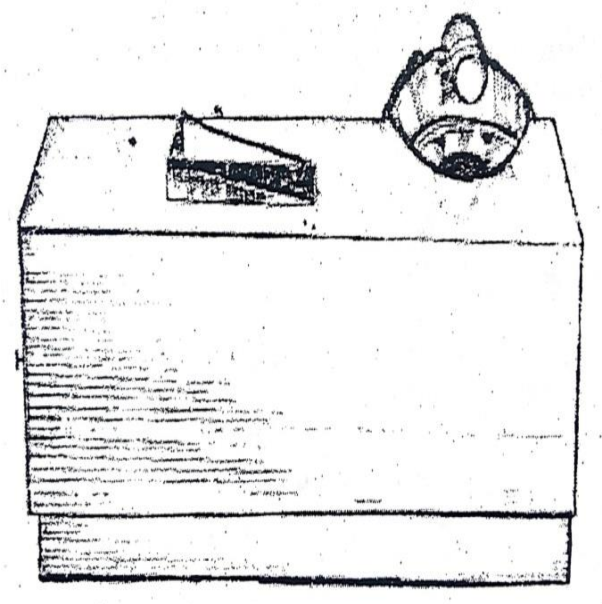
NODULAR CAST IRON: (SPHEROIDAL GRAPHITE CAST IRON)

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

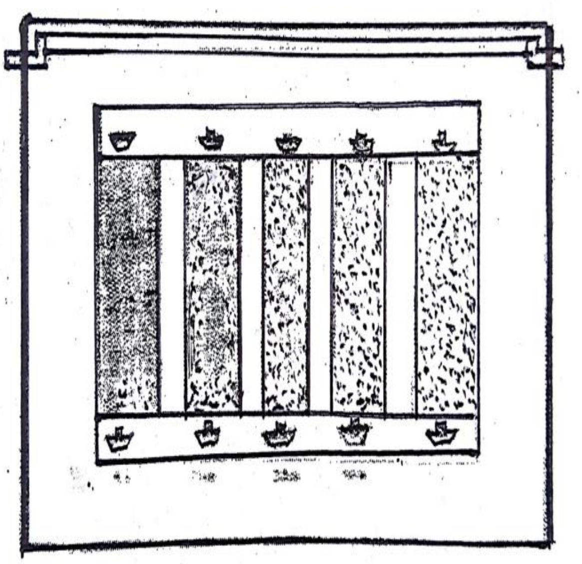
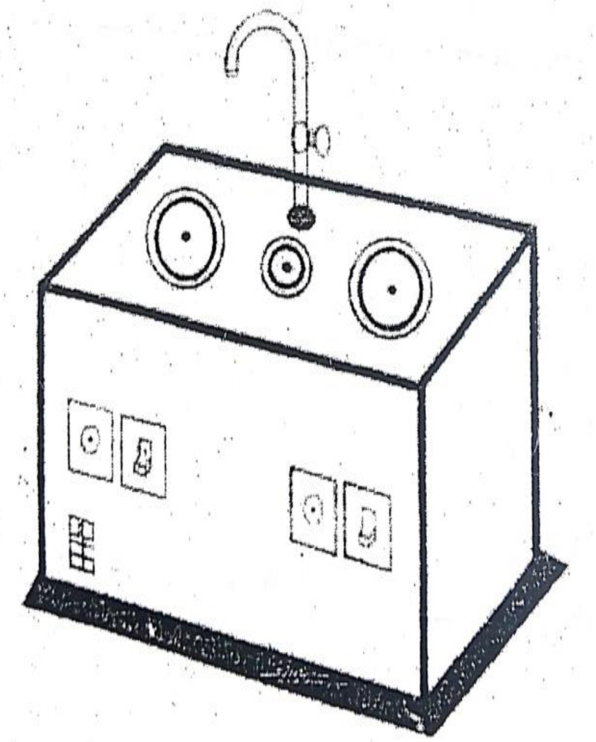
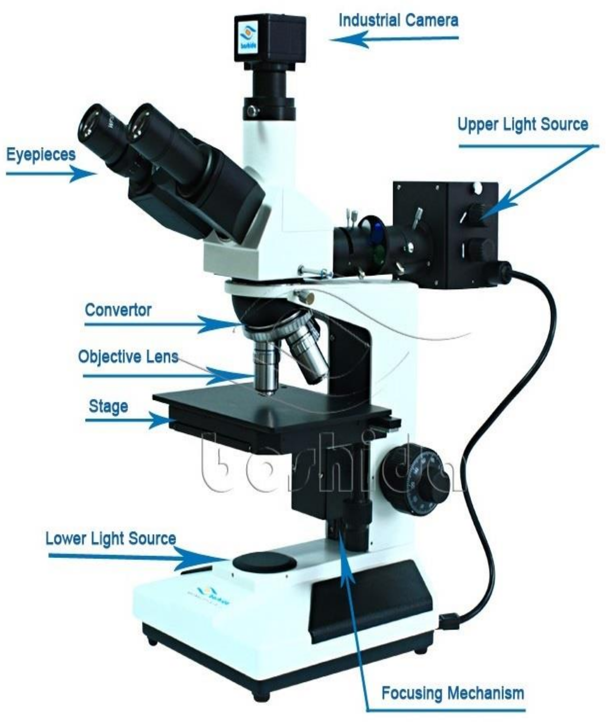


PLATE POLISHING MACHINE



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

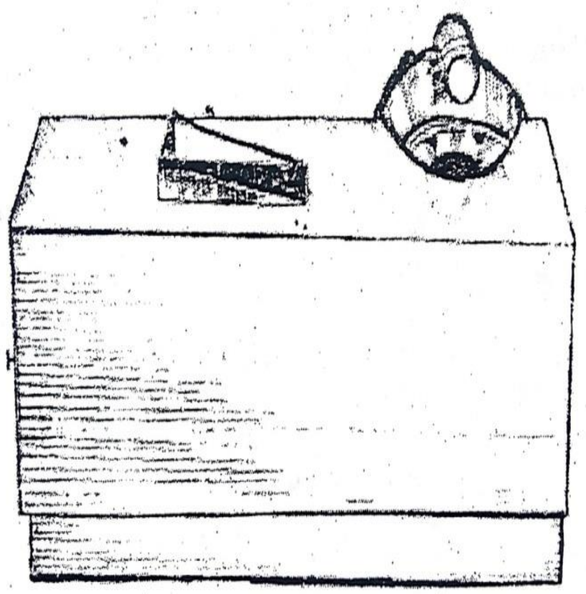
THEORY:

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 equi axied 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

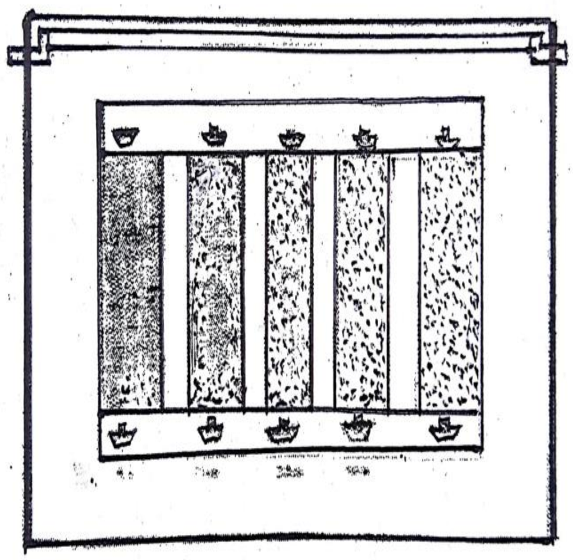
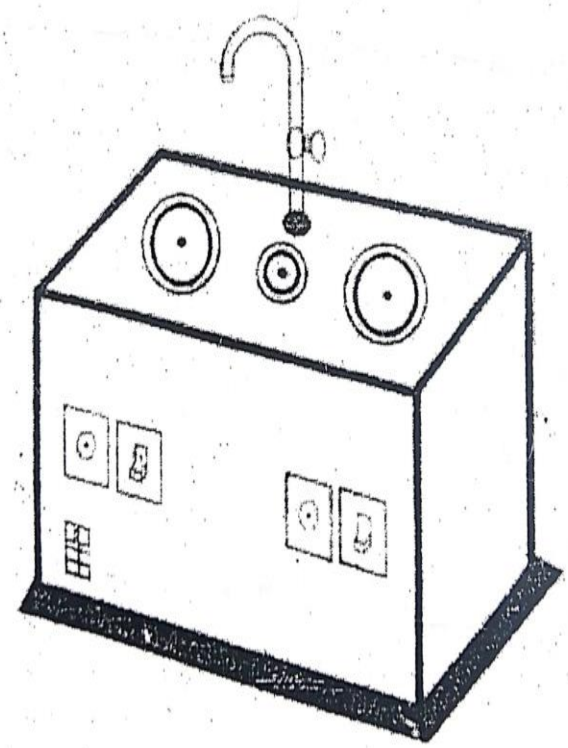
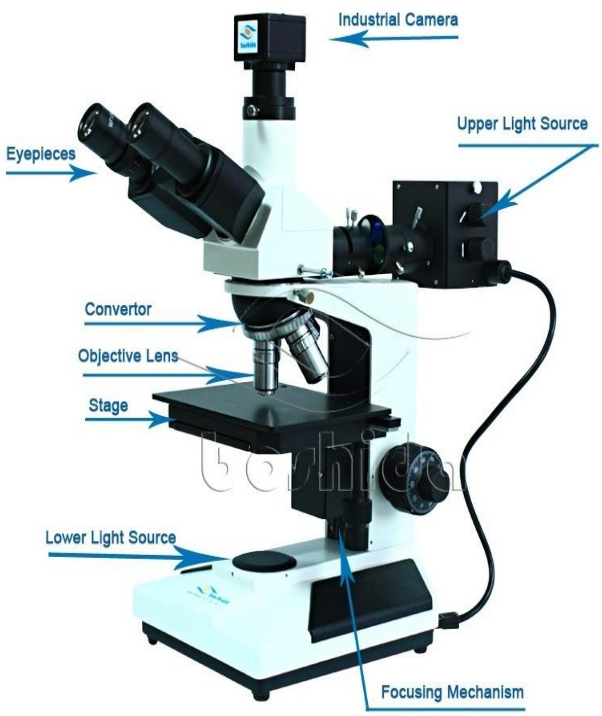


PLATE POLISHING MACHINE



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:**

STUDY 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:

- Heat treatment furnace – Muffle furnace
- Jominy end quench apparatus,
- Test specimen,
- Rockwell test setup

PROCEDURE:

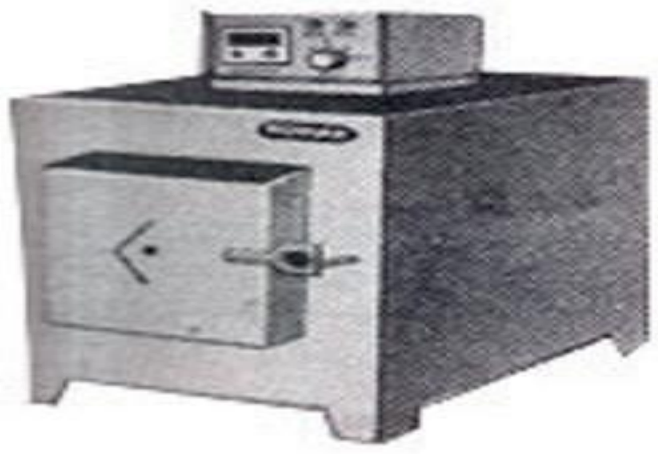
The various steps involved in evaluating the hardenability test for a given specimen are

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

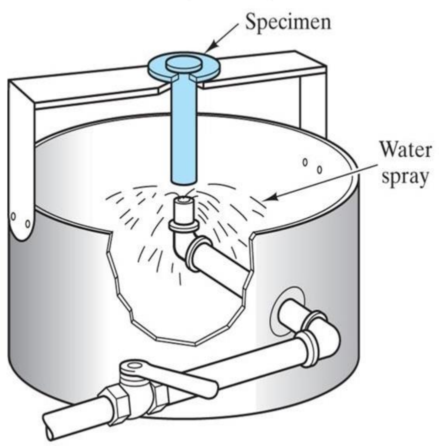
1) DETERMINATION OF HARDNESS NO.BY ROCKWELL HARDNESS TEST

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 from slight surface imperfections.

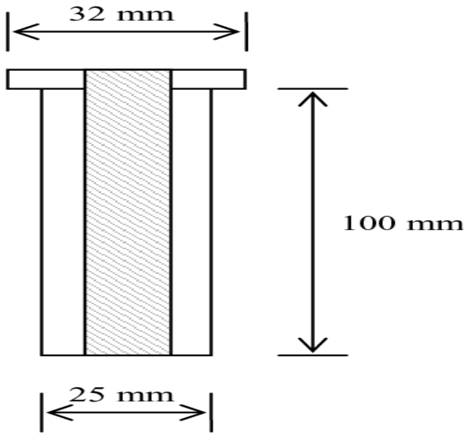
The specimen is placed on a suitable anvil on the upper end of the elevation screw. A minor load of 10 kg is applied by raising the anvil by using elevation screw. Then apply the major load by using the leaver. After applying the load for a period of 20 sec, remove the load by turning the lever. Note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

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

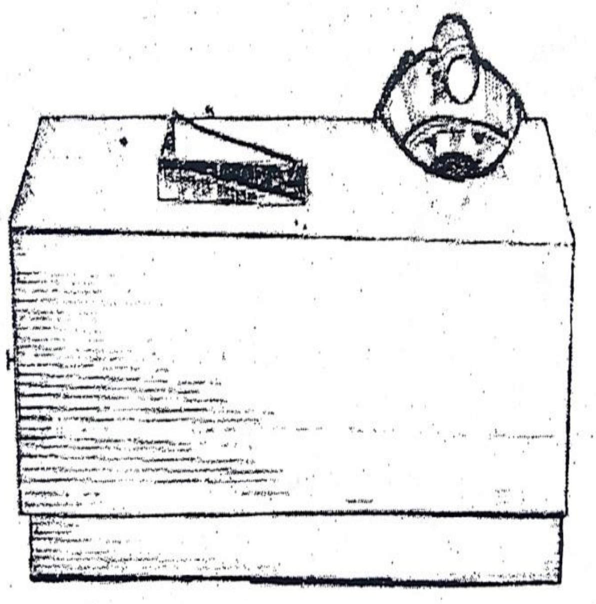
THEORY:

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

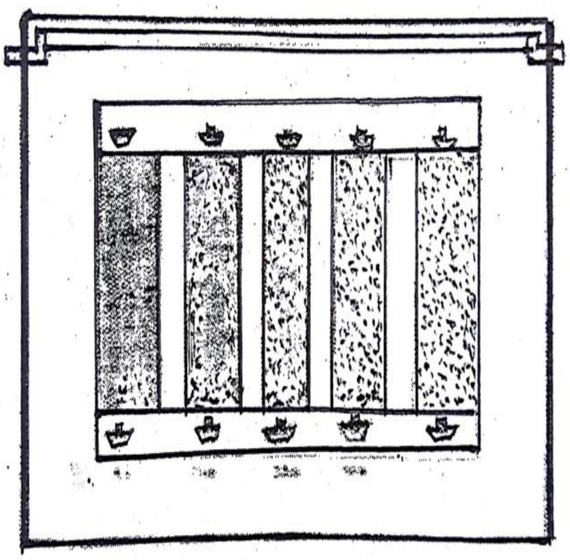
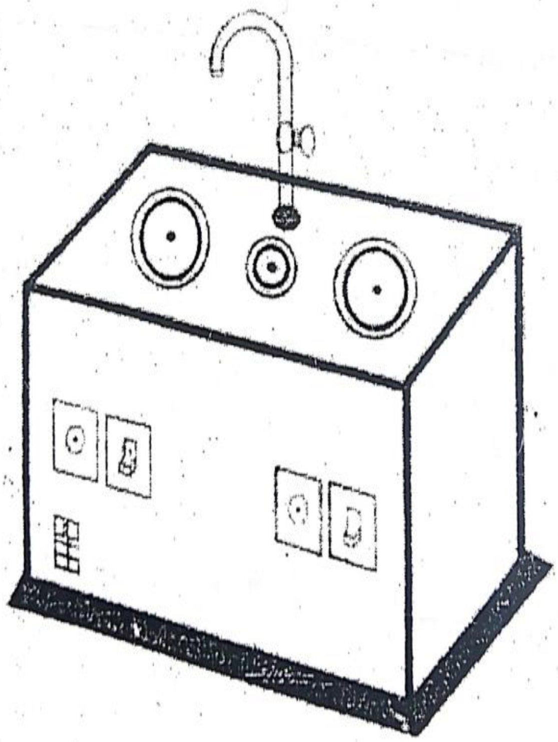
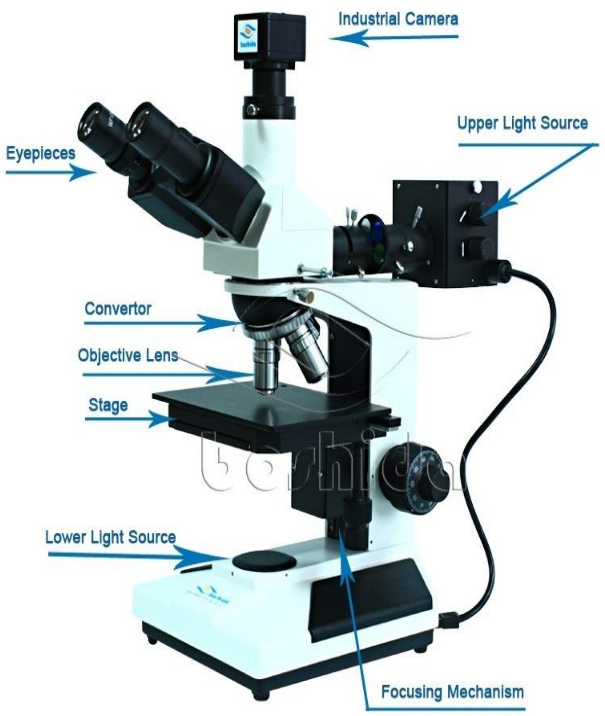


PLATE POLISHING MACHINE



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:**

FIND THE HARDNESS OF THE VARIOUS TREATED AND UNTREATED STEELS

AIM:

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

APPARATUS:

- 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

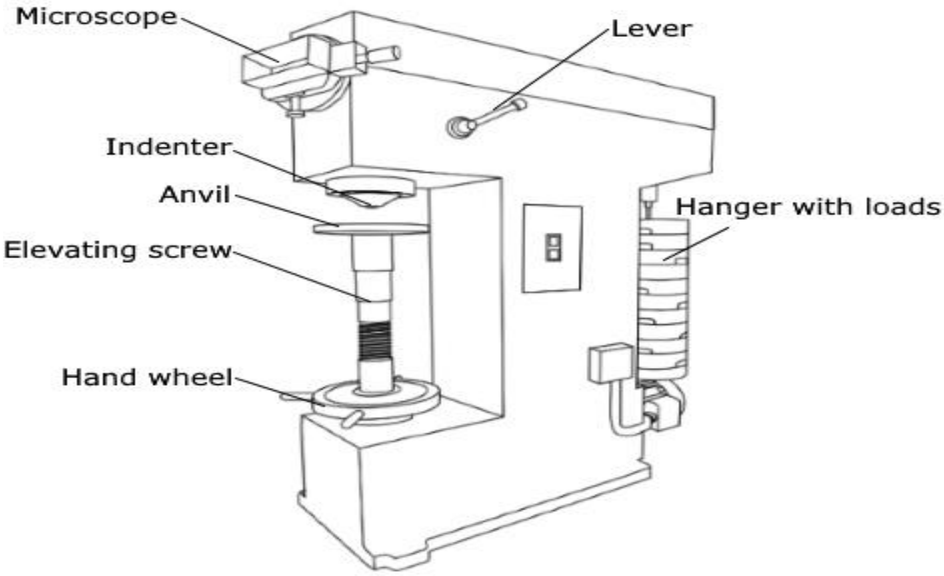
$$\frac{(D - \sqrt{(D^2 - d^2)}}{2}$$

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

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

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.



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

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:**

CREEP TESTING OF MATERIALS

Aim:

To study the constant load creep behavior of lead at room temperature.

Requirements: Lead sample, Screw gauge, Vernier calliper

Principle:

Crystalline materials may undergo plastic deformation by (i) slip, (ii) twinning, (iii) diffusion assisted atomic migration and (iv) grain boundary sliding. Among these methods, mechanisms of plastic deformation by diffusion assisted atomic migration and grain boundary sliding occur at high temperature [$T/T_{MP} > 0.4$] where T_{MP} is the melting point of the material. The other two mechanisms, i.e. the slip and the twinning may occur at low as well as room temperatures. The two high-temperature deformation mechanisms are time-dependent. Therefore, if a material is loaded at high temperature, even if below its yield strength, it will deform and accumulate strain with respect of time. The high-temperature time-dependent deformation of a material occurring at constant stress is called *creep*. Creep occurs in materials due to an increased high-temperature mobility of atoms (by diffusion) as well as that of dislocations (by mechanism of climb). The creep test measures the dimensional changes that occur due to the applied load at an elevated temperature. Creep behavior of a material is the most important consideration for choosing it for high temperature application.

Creep Curve:

Creep properties of a material are generally determined by means of a test in which a constant uniaxial load or stress is applied to the specimen, which is maintained at high temperature, and the resulting strain is recorded as a function of time. Typical shape of a creep curve is shown in Fig.1. When the load is applied, an instantaneous strain develops in the material and gives rise to the strain $_0$ at time $t = 0$. The material initially deforms at a very rapid rate (d/dt), but as time proceeds the rate of deformation progressively decreases and becomes constant. This regime of deformation is referred to as the first-stage of creep or the *primary creep.* In the second-stage of creep, generally referred to as the *secondary creep* or the *steady-state creep,* the strain rate remains constant for a long time. Although considerable deformation can occur under the steady- state creep conditions, the strain rate eventually begins to accelerate with time and the material enters the *third-stage* or the *tertiary creep*. Deformation then proceeds at an ever-faster rate until the material can no longer support the applied stress and fracture occurs. The material thus shows the minimum creep rate, d/dt, in the steady-state regime. This minimum creep rate is considered as the engineering design parameter in selecting a material for high-temperature applications.

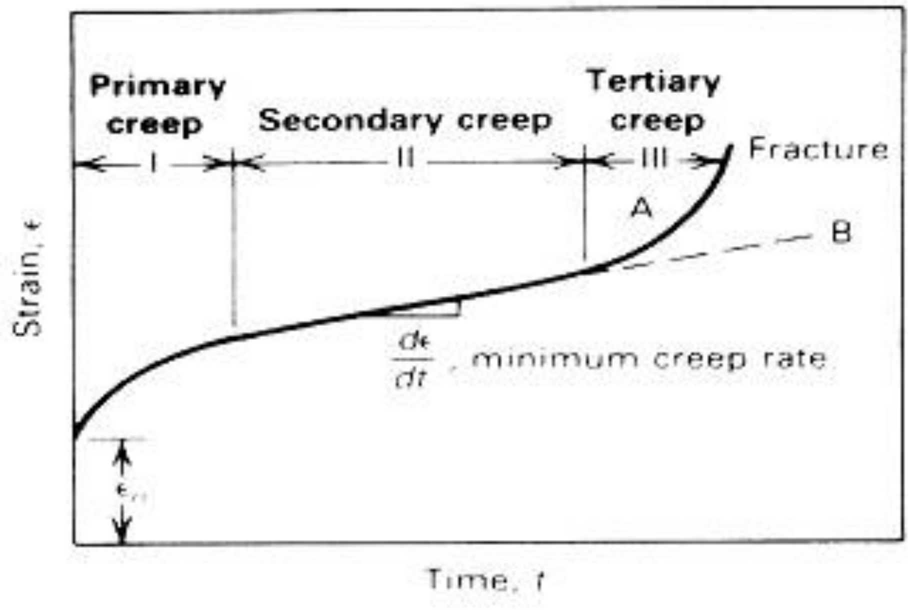


Fig. 1 Schematic illustration of Creep-curve shapes

Variations in the shape of the creep curve are caused by (a) extrinsic parameters such as changes in test temperature and the stress applied [Fig. 2] and (b) intrinsic material parameters such as (i) strain hardening/softening processes (recovery /recrystallization/ precipitate coarsening etc. and (ii) internal damage processes (cavitation and cracking).

As shown in Fig. 2, higher temperatures and stresses reduce the extent of the primary creep and practically eliminate the second stage, with the result that the creep rate accelerates almost from the beginning of the loading. In contrast with the decrease in temperature and/or the stress, the first two stages become clearly defined.

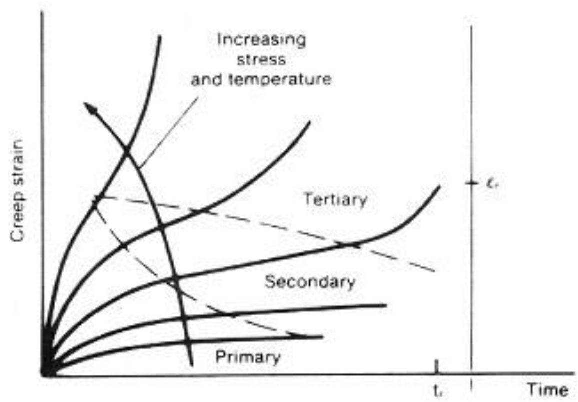


Fig 2 Creep curves obtained at different temperatures and/or stress

Equipment:

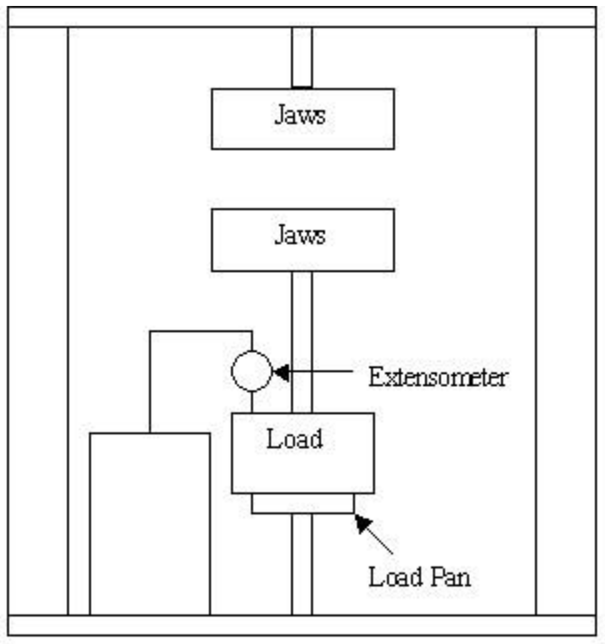


Fig. 3 Schematic of the Creep testing Machine

Important Parameter and Equation:

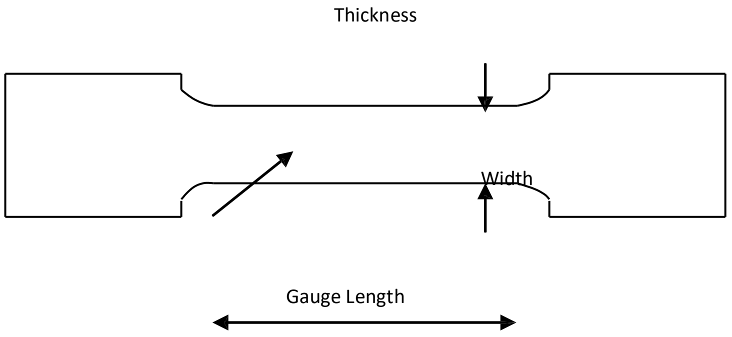


Fig. 4 Lead Sample

Engineering Stress (N/mm^2) = Load (in Kg)*9.81(m/sec^2)/ (thickness (m)*width (m))

Strain () = Elongation (mm)/Gauge Length (mm)

One full rotation of the big dial of extensometer= single step movement in small dial = 1mm

Experimental Procedure:

1. Mark the sample for the reduced gauge length (uniform width)
2. Measure the dimensions (gauge length and width by Vernier caliper and thickness by screw gauge) of the given lead sample

3. Fix the ends of the sample up to mark in the jaws of the machine
4. Support the load pan from bottom till the first reading
5. Put the specified load on the load on load pan
6. Adjust the extensometer position on the load such that needle on small and big dial is at “0” position.
7. Slowly remove the bottom support from the load pan and start take readings till sample breaks,

   of the big dial after every 10 second. Add 100 when small dial needle moves a single step
8. Convert dial readings into extension (mm)

Report:

1. Write sample readings and calculate stress
2. Plot strain *vs* time
3. Calculate the creep rate as a function of time and identify the various stages of creep
4. Report the minimum creep rate at each stage

Result:

Conclusion: