SHREE RAMCHANDRA EDUCATION SOCIETY'S

SHREE RAMCHANDRA COLLEGE OF ENGINEERING,

LONIKAND, PUNE – 412 216

DEPARTMENT OF MECHANICAL ENGINEERING

LAB MANUAL

ENGINEERING METALLURGY[EM]

SE (ME) Semester-II

Prepared by

Prof. Ms. Adake B. S. (Assistant Professor)

List of Experiments (S.P.UNIPUNE SYLLABUS)

Notes : 1) Practicals 1 & 8 are Compulsory.

2) From 2 to 7, any four should be conducted.

3) From 9 to 12 any Two should be conducted.

Sr. No	Name of Experiments
1	Study & Demonstration of Specimen Preparation for microscopic examination.
2	Study of Optical Metallurgical microscope.
3	Study and Drawing of Microstructure of Steels of various compositions.
4	Study and Drawing of Microstructure of Cast Irons.
5	Study and Drawing of Microstructure of Non Ferrous Metals.
6	Heat treatment of Plain Carbon Steel and determination of relative hardness.
7	Study and Drawing of Microstructure of Heat Affected Zone in Welding.
8	Jominy End Quench Test for hardenability.
9	Impact Test
10	Vickers Hardness Test.
11	Brinell & Poldi Hardness Test.
12	Magnetic Particle & Dye Penetrant Test.

	SHREE RAMCHANDRA COLLEGE OF ENGG. LONIKAND	LABORATORY MANUAL
	PRACTICAL EXPERIMENT INSTRUCTION SHEET	
	EXPERIMENT TITLE: STUDY AND DEMONSTRATION OF SAMPLE PREPARATION TECHNIQUES USED IN MICROSCOPIC EXAMINATION.	
DEPARTMENT OF MECHANICAL ENGINEERING		
EXPERIMENT NO. : SRCOE/MECH/SE/EM/	SEMESTER : IV(SE)	PAGE:

Title- Study and demonstration of sample preparation techniques used in microscopic examination.

Objectives-

1. Familiarization with the procedure for preparation of material specimen for microscopic examination.
2. Familiarization with the compound optical microscopic and metallographic.
3. Examination of surface characteristics of engineering materials.
4. Grain size determination of metals.
5. To study structural characteristics or constitution of metal or alloy in relation to its physical and mechanical properties.

Introduction-

There are two examination methods-

1. Macroscopy
2. Microscopy

In maroscopy the examination of structural characteristic or chemical characteristic of metal or an alloy is done by unaided eye or with aid of low power microscope or binocular usually under 10X.

In microscopy similar examination is done with prepared metal specimens, employing magnifications with optical microscope of from 100X to as high as 200X. Apart from observation of micro structural details in a metal or alloy, other defects such as grain boundaries, twins, precipitates can be observed readily in microscopic examination.

The preparation of metallurgical specimen generally can e divided into series of stages sectioning/sampling, mounting, grinding, polishing & etching.

Procedure of Test

1] Sectioning / Sampling-

The choice of sample for microscopic study may be very important. If a failure is to be investigated the sampling should be chosen as close as possible to the area of the failure & should be compared with one taken from the normal section. If the material is soft, such as non ferrous metals or alloy & non heat treated steels, the section is obtained by manual hack sawing /power saw. If the material is hard, the section may be obtained by use of an abrasive cut off wheels. This wheel is thin disk of suitable cutting abrasive rotating at high speed. The specimen should be kept cool during the cutting operation.

2] **Rough Grinding** –

Whenever possible the specimen should be of a size & shape that is convenient to handle. A soft sample may be made flat by slowly moving it up to & back across the surface of a flat smooth file. The soft hard may be rough ground on a belt sander with specimen kept cool by frequent dipping in water during the grinding operation. In all grinding & polishing operation, the specimen should be moved perpendicular to the existing scratches this will facilitate, recognition of stage when the deeper scratches are replaced by shallower one characteristic of the finer abrasives. The rough grinding is continued until the surface is flat & free from wire brushes & all scratches due to hacksaw or cutoff wheel are no longer visible.

3] **Intermediate Polishing** –

After the previous processes the specimen is polishing on a series of emery paper containing successively finer abrasive (Si-C) . The first paper is usually no. 1 than 1/ 0, 2/0, 3/0, & finally 4/0.. The intermediate polishing operation using emery paper is usually done dry. However in certain case such as preparation of soft material , Silicon Carbide has greater removal rate & as it is resin bonded , can be used with a lubricant , which prevents overshooting of the sample, minimizes shearing of soft metals & also provides a rising action to flush away surface removal product so the paper won't be clogged.

4] **Fine polishing** –

The time consumed & the success of fine polishing depends largely on the case that we exercised during the previous polishing processes. The final approximation to the flat , scratch free surface is obtained by the use of a wet rotating wheel covered with a special cloth that is charged by carefully sized abrasive particles. A wide range of abrasive is available for final polishing, while many will do a satisfying job, these appear to be presence of gamma form of aluminum-oxides (Al_2O_3), for ferrous & copper based materials & Cerium oxide for Aluminum, Magnesium & their alloys, other final polishing abrasives often used are diamond , chromium oxide & magnesium oxide etc. A choice of proper polishing cloth depends upon the particular material being polished & the purpose of metallographic study. Many cloths are available of varying lap or pile, from those having no pile, such as silk, to those of intermediate pile such as broad cloth, billiard cloth, canvas cloth & finally to a deep pile such as velvet synthetic clothes are also available for general purpose of which two under the trival names of gamal & micro cloth are most widely used

5] **Etching** –

The purpose of etching is to make the many structural characteristics of the metal or alloy visible. The process should be such that the various parts of the microstructure may be clearly differentiated. This is to subject the polished surface to chemical action. In the alloys composed of two or more shapes. The competent are revealed during etching by a preferential attack of one or more of the constituents by the reagent because of difference in chemical composition of the phases. In uniform single phase alloy contact is obtained and the grain boundaries are made visible because of difference in the rate at which various grains are attacked by the reagent This difference in the rate of attack by reagent which is mainly associated with angle of the different grain structure section to the plane Of the polished surface. Because of chemical attack of the chemical reagent the grain boundary appears as valleys in the polished surface light from the microscope hitting the side of these valleys will be reflected but of the microscope making the grain boundaries appears dark lines. The section of the appropriate etching reagent is determined by metal or alloys & the specific structure desired for viewing.

Etching Reagent	**Composition**	**Use**
Nitric Acid	White nitric acid '1 to 5 ml ethyl or methyl alcohol'100 ml(95% absolute)	Carbon steels and cast iron
Picric acid	Picric acid '49 ethyl or methyl alcohol'	Carbon steels
Ferric chloride and hydrochloric	Ferric chloride and hydrochloric acid 50 ml water 100 ml	Structure of austenitic nickels stainless steel
Ammonium hydroxide and hydrogen	Ammonium hydroxide 90 parts water 5 parts hydrogen peroxide 2 to 5 parts	Copper and its alloys
Palmerton reagent	Chromic oxide 200 gm sodium sulphate 15 gm water 100 ml	Zinc and its alloys
Ammonium molybdenum	Molybdic acid 100 gm ammonium hydro 140ml water 240 ml, filters add to nitric acid S.P.gr. 60 ml	Lead and its alloys
Hydrofluoric acid	Hydrofluoric acid 0.5 ml	Aluminium and its alloy

Table No.1 Etching Reagent composition and use

Result And Conclusion:-

Correct sample techniques if followed properly, will only reveal the microstructure of a metallic specimen. Otherwise it will be most difficult to distinguish between different phase in the microstructure, the fine scratches on meta surface and grain boundaries etc.

	SHREE RAMCHANDRA COLLEGE OF ENGG. LONIKAND	LABORATORY MANUAL
	PRACTICAL EXPERIMENT INSTRUCTION SHEET	
	EXPERIMENT TITLE: Study of Optical Metallurgical microscope.	
DEPARTMENT OF MECHANICAL ENGINEERING		
EXPERIMENT NO. : SRCOE/MECH/SE/EM/	SEMESTER : IV(SE)	PAGE:

Aim: - To study the complete working operation of Metallurgical Microscope

Objectives:-

1. Familiarization with the different components of metallurgical components.
2. Familiarization with compound optical microscope and metallographic.
3. To study magnification system and how to increase in magnification.

Introduction: -

The metallurgical microscope is the most important tool of the metallurgist. It consist an objective and an eye-piece. Its primary function is to reveal the details of the object. The clarity and the extent to which the details are revealed depends on the degree to which these optical systems are created.

Principle: -

A horizontal beam of light from the light source is reflected by means of a plane glass reflector downwards through the microscope objective on the surface of the specimen some of these incident light reflected from the specimen surface will be magnified and passing through the plane glass reflector and magnified again by upper lens system of the eye-piece.

Constructional Details: - The table type microscopes are consist of

1. Stage:- A flat movable table supporting specimen. This can be moved up or

down by knobs.

2. Tubes :- The vertically movable tube containing eyepiece, objective and plane reflector. The tube length varies from 160 mm to 250 mm.
3. Rough & fine focus Adjustments - The limbs of microscope carry the coarse & fine adjustments to facilitate the
4. Objective – The body tube carries revolving nose piece carrying the three objectives.This enables quick change of the objective which helps for a quick resolving the structure of metal, the magnification of lenses is enlarged on focal length of the lens used

The important properties of an objective are-

1) Magnifying Power
2) Resolving Power.

It is the property by which an objective shows distinctly represented two small adjacent bonds in the structure of the object. This is usually expressed as number of lines per mm that can be separated which depends on the numerical operator, the wavelength of the light used. Resolution is particularly important during the microscopy of the micro constituents of metals consisting of fine lamination with core resolution which appears as one uniform area, where as an objective with higher numerical appearance reveals deeper nature of the structure.

Total magnification of microscope may be calculated as

M= L*E/ F

Where, L- The distance from back of objective to eyepiece.

E- Magnification of Eye piece.

F- The focal length of objective.

Eyepiece - It is named, as it is near to the eye. It is made up of various Powers such as _ 5, _ 10, _ 15 etc.

Uses –

The metallurgical microscope is useful in quality control department in Industries to observe & study

1) Differential phases 2) Porosity or defects.

All these have a great effect on mechanical properties of material.

List of Modern Microscopes –

i) Watson Royal Microscope.

ii) Van Lanes Hock Microscope.

iii) Glass led Microscope.

iv)Baker series Microscope.

v) Leitr Microscope.

Conclusion-

Proper selection of magnification is very much essential because –

a. To travel inclusions in steel low magnification is used.
b. To travel grain size, grain structure, twin boundaries etc. medium magnification is used.
c. To travel particular e.g. coarse perlite, fine martensite, bainite,.. etc. high magnification is necessary.

Therefore proper study of metallurgical microscope is necessary.

	SHREE RAMCHANDRA COLLEGE OF ENGG. LONIKAND	LABORATORY MANUAL
	PRACTICAL EXPERIMENT INSTRUCTION SHEET	
	EXPERIMENT TITLE: STUDY AND DRAWING OF MICROSTRUCTURES OF STEELS WITH THE HELP OF METALLURGICAL MICROSCOPE.	
DEPARTMENT OF MECHANICAL ENGINEERING		
EXPERIMENT NO. : SRCOE/MECH/SE/EM/	SEMESTER : IV(SE)	PAGE:

Aim: - Study and drawing of microstructures of Steels with the help of metallurgical microscope.

Objectives-

1. Familiarization with the different microstructures of steel.
2. Familiarization with different phase present in the steels.
3. Familiarization with different operations of metallurgical microscope.

The general microstructure shows majority of ferrite phase and small portion of pearlite phase. The **low carbon steels** are not hardnable by quenching and tempering as carbon content is less than 0.30 percent

Mechanical properties of **medium carbon steel** Can be increased by heat treatment. To improve treating capabilities alloying elements like Cr, Ni, Mo. etc are used.

The microstructure of a typical **high carbon steels** Showing a matrix of pearlite and some grain Boundary cementic.

Temper martensite are used for spring materials rope wires, screw Drivers, hammers, wrenches, band saws.

Microstructure of single phase austenite [400X] **Microstructure of bainite [800X]**

Specimen-

A) Specimen :- Mild steel

Composition:-

Mechanical treatment:-

Heat treatment:-

Magnification:-

Etchant:-

Remark:-

B) Specimen :- Eutectoid steel

Composition:-

Mechanical treatment:-

Heat treatment:-

Magnification:-

Etchant:-

Remark:-

C) Specimen :- Hypereutectoid steel

Composition:-

Mechanical treatment:-

Heat treatment:-

Magnification:-

Etchant:-

Remark:-

D) Specimen :- Hypoeutectoid steel

Composition:-

Mechanical treatment:-

Heat treatment:-

Magnification:-

Etchant:-

Remark:-

- **Explain Terms:-**

Austenite

Bainite

Cementite

Ferrite

Martensite

Pearlite

Tempered Martensite

Conclusion:-

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	PRACTICAL EXPERIMENT INSTRUCTION SHEET	
	EXPERIMENT TITLE: STUDY AND DRAWING OF MICROSTRUCTURE OF CAST IRONS.	
DEPARTMENT OF MECHANICAL ENGINEERING		
EXPERIMENT NO. : SRCOE/MECH/SE/EM/	SEMESTER : IV(SE)	PAGE:

Aim: - Study and drawing of microstructures of cast iron with the help of metallurgical microscope.

Objectives-

1. Familiarization with the different microstructures of cast iron.
2. Familiarization with different phase present in the cast irons.
3. Familiarization with different operations of metallurgical microscope.

a. Gray Cast iron

It has a graphitic microstructure. It is named after the gray color of the fracture. It forms due to presence of graphite flakes and ferrite flakes. It is most commonly use material on the basis of its weight.

Specimen :- Gray cast iron

Composition:-

Mechanical treatment:-

Heat treatment:-

Magnification:-

Etchant:-

Remark:-

b. Nodular Cast iron :-

The photo micrograph shows the rounded shapes of the graphite nodules at 100X.These shapes are common in ductile iron or nodular cast iron

Specimen :- Nodular cast iron

Composition:-

Mechanical treatment:-

Heat treatment:-

Magnification:-

Etchant:-

Remark:-

c. White Cast iron

There typical microstructure on fast cooling from the liquid state consists of dendrites of transformed austenite in a white interdendritic network of cementite in contains a relatively large amount of cementite as a continuous interdendritic network

Specimen :- White cast iron

Composition:-

Mechanical treatment:-

Heat treatment:-

Magnification:-

Etchant:-

Remark:-

4. **Malleable Cast Iron:-**

The purpose of malleabiliazation is to convert all the combined carbon white iron into irregular nodules of temper carbon& ferrite.

Specimen :- Malleable cast iron

Composition:-

Mechanical treatment:-

Heat treatment:-

Magnification:-

Etchant:-

Remark:-

Conclusion:-

	SHREE RAMCHANDRA COLLEGE OF ENGG. LONIKAND	LABORATORY MANUAL
	PRACTICAL EXPERIMENT INSTRUCTION SHEET	
	EXPERIMENT TITLE: STUDY EFFECT OF WELDING PROCESS ON THE BASE METAL IN THE FORM OF HEAT AFFECTED ZONE, AND TO STUDY MICROSTRUCTURE OF IT.	
DEPARTMENT OF MECHANICAL ENGINEERING		
EXPERIMENT NO. : SRCOE/MECH/SE/EM/	SEMESTER : IV(SE)	PAGE:

Aim: - To study effect of welding process on the base metal in the form of heat affected zone, and to study microstructure of it.

Objectives-

4. Investigate the effect of HAZ on steel.
5. To study effect of HAZ on hardness of steel
6. Examine microstructures of HAZ.

Introduction: -

Non Heat Treatable	zone	Temperature	Heat Treatable
A- Weld metal, As cast structure of base and filler metal	A	1200 1000	A Weld Zone
B- Fusion Zone, Where partial melting of base metal occurs	B	1000 900	B- Fusion Zone
C- Anneal Zone, Where base metal is fully recrystallized, full soft	C	800 700	C- solid solution zone where alloy elements are poured in solution and cooled to retain solid state
D- Partial anneal zone, where base alloy is recovered and partially softened	D	400	Partially annealed overage zone where heat has caused

			precipitation and coalescence of particles of soluble
E- Unaffected	E	300 200 100 R.T.	Unaffected

- Various techniques are adopted to manufacture varieties of products. Welding technique is one of them since high temperatures are necessary during welding.
- A weld will exhibit a coarse crystal structure in contrast to the parent metal around it which is generally in wrought condition. It affects the grain size of crystal structure.
- A weld produced by fusion method will show an as cast type of structure.
- Coring, segregation and like may also be present giving rise to incrystalline weakness. The HAZ will encompass those parts of work pieces which have been heated in excess of recrystallization temperature long enough for recrystallisation takes place.
- In arc welding of steel HAZ extends for very few millimeters. But in oxyacetylene and electro slag welding it may be wider.

Three separate sections may be present in HAZ:

1. The part of zone in which the temperature exceeds the upper critical Temperature (A_3) will undergo complete transformation to austenite and the temperature gradient within the zone will result in variation in this austenite grain size.
2. The region in which temperature reached was between upper critical (A_3) and the lower critical (A_1 or 723^0 C) will transform only partially. Pearlite will transform to austenite containing 0.8% carbon and then begin to absorb primary ferrite as the temperature exceeds 723^0 C.
3. In that section of the heat affected zone where the temperature exceeds that of recrystallisation the original cold worked structure of the plate will tend to recrystallized without undergoing any phase change.

Procedure:-

1. Study different welded components one by one. At first from micro examination point of view and then by macro examination point of view.
2. In macro examination type of weld process used.
3. Check whether welding has any defect such as cracks, pores, blow holes, slag, inclusion, incomplete penetration.
4. In micro examination specimen is cut across the complete welding zone and then portion of base metal is also taken foe complete examination.
5. The test specimen should follow all the steps of sample preparation, and then observed under metallurgical microscope
6. However complex structural changes takes place within HAZ ,through microscope it will show different structure

Result and Discussion-

- In microscopic examination it is clearly seen that how different zones are created in the weld, such as fusion zone, recrystallized and grain growth zone, partially melted zone.
- The hardness increase in the HAZ as compared to the fusion base metal.

	SHREE RAMCHANDRA COLLEGE OF ENGG. LONIKAND	**LABORATORY MANUAL**
	PRACTICAL EXPERIMENT INSTRUCTION SHEET	
	EXPERIMENT TITLE: JOMINY END QUENCH TEST	
DEPARTMENT OF MECHANICAL ENGINEERING		
EXPERIMENT NO. : SRCOE/MECH/SE/EM/	**SEMESTER : IV(SE)**	**PAGE:**

Aim: - Determination of Harden ability of steel by Jominy end Quench Test.

Objectives-

1. Obtain hardenability curves for given sample.
2. Observe the effect of carbon content and alloying
3. To study hardness as a function of quench rate and investigate the harden ability of particular steel.

Introduction: -

When a piece of steel of any appreciable size is heated to its austenization temperature & then quenched, the cooling rates during quenching vary across the cross section. The cooling rate at the surface & the center are not same. The difference in their rate increases with rise in severity of quenches or decreases in the speed of heat absorption. At the centre of the cross section, the cooling rate is slowest. This may give rise to the formation of pearlite. The relatively permanent & most common method of determining the hard ability of steel is the Quench test. This is also called as **'Jominy End Quench Test'.**

Determination of Harden ability:-.

When a appreciable size is heated to the austenization temperature and then quenched, the cooling rates varies across the surface. The cooling rate at the center and surface are not the same. The difference in these rates increases with the rise in severity of quench and decreases with speed of heat absorption. At the center of cross section, the cooling rate is slowest. This may give rise to the formation of pearlite. Marten site may be formed on surface and hence gradient of hardness exist from the surface to centre. Since each grade of steel has its own transformation, hardness across cross section. Harden ability of steel is measure of this depth. Properly it may be designed as the susceptibility of steel to harden ability of steel is measured of this depth and distribution of hardness across the cross section. It is not related to maximum hardness and the term hardness and harden ability term should be clearly distinguished.

The maximum hardness depends upon carbon content in the steel. It can be achieved by fulfilling the following conditions

i) All the carbon is solution of austenite.

ii) Critical cooling rate is achieved

iii) No retained austenite is present after quenching.

Harden ability on other hand depends upon the addition of alloy element and grain size of austenite. Besides the coolant used for quenching, the size of the specimen and criteria used for assessment of harden ability also affects the law of harden ability.

If drastic cooling is carried out, martensite can form at the centre of cross section of steel because the cooling rate at the centre may be exceeded the critical cooling rate and the drastic quenching may give rise to other under effects such as warping and cracking of steel is reflecting by its quenching ability to harden throughout its cross-section . While avoiding quenching and deep hardened steel in low hardening steel depth of hardening steel is uniform throughout the cross-section.

Procedure-

1. In this test, the steel bar of 1 inch diameter & 4 inch long is heated to proper austinization temperature.
2. After being soak for sufficient time the specimen is quickly placed in a fixture as shown in figure.
3. A water jet is opened quickly. Water comes out at a constant pressure through the orifice of ½ inch diameter.
4. The distance between orifice and bottom of steel is 0.5 inch. The temperature of water is kept around 240 C (R.T).

5. A stream of water strikes at lower end of specimen. The end is quenched and is continued to about 20 min. to cool.

Figure shows the typical Jominy curve for a no. of AISI steel. Jominy curved is strictly valid only for a given heat of particular steel, because other is in tolerance range. In chemical composition which allows the appropriate range of hardness. Figure shows the harden ability for AIST 4145-H steel. Harden ability occurs for all steel will lies within the range, for many commercial grades of steel. Harden ability limits of specimen standards have been adopted by the society of automotive Engineering's (SAE). These limits are termed as Harden ability Bands.

Observation Table -

Sr. No.	Distance from quench End	Hardness Value	Remark

Result And Discussion-

	SHREE RAMCHANDRA COLLEGE OF ENGG. LONIKAND	LABORATORY MANUAL
	PRACTICAL EXPERIMENT INSTRUCTION SHEET	
	EXPERIMENT TITLE: IMPACT TEST	
DEPARTMENT OF MECHANICAL ENGINEERING		
EXPERIMENT NO. : SRCOE/MECH/SE/EM/	SEMESTER : IV(SE)	PAGE:

Aim:- To conduct charpy V- notch impact test & determine impact strength of steel & alloys

Objectives:-

1. Familiarization with methods of toughness measurement with impact test.
2. Determine effects of carbon content alloying element & cold works on energy absorption capability of steel
3. Observe the effect of temperature on energy absorption capability of steel

Introduction:-

1. In general toughness is associated with high and good ductility.
2. Strength of ductility alone does not significantly improve toughness.
3. e.g. stronger steel is less ductile, capability to absorb energy is lower at an impact load without failure.
4. A metal with high strength or good ductility does not necessarily shows good toughness.
5. Brittle materials have small area under stress- strain curve & as result little energy is Absorbed during impact failure.
6. Although two standardised tests the charpy & izod were designed but charpy V- notch impact testing are more common in practice.

Procedure:-

1. Calibrate the tester to account for beal.... friction & aerodynamic drag of pendulum testing without specimen and adjusting the pointer to indicate zero toughness.
2. Raise & hold the pendulum at selected upper position.
3. Set pointer to zero.
4. Place a specimen in tester. The notch should be on the side of specimen farthest from the striking edge of pendulum fall to rupture.
5. Let the pendulum fall to rupture the specimen

6. & observe the indicated energy value.
7. Note fracture energy directly from dial observe the appearance of fracture surface of specimen

Observation Table:-

For Charpy Test

Sr. No.	Metal	Notch	Impact value	Remarks
1.				
2.				

For Izod Test

Sr. No.	Metal	Notch	Impact value	Remarks
1.				
2.				

Calculation:-

Impact Energy of Pendulum=

Impact velocity=

For Aluminium-

for Copper-

Result & Discussion:-

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	PRACTICAL EXPERIMENT INSTRUCTION SHEET	
	EXPERIMENT TITLE: BRINELL HARDNESS TEST & POLDI HARDNESS TEST	
DEPARTMENT OF MECHANICAL ENGINEERING		
EXPERIMENT NO. : SRCOE/MECH/SE/EM/	SEMESTER : IV(SE)	PAGE:

Aim:- To determine hardness value by using Brinell hardness test & Poldi hardness test.

Objectives:-

1. To introduce principal of indentation hardness testing.
2. To learn about different methods of hardness measurement
3. To learn about correlations among different hardness measurements
4. To acquire experience if using various types of hardness testers.
5. To understand relation between hardness no. and properties of material.

Introduction

Hardness is the property of a material that enables it to resist plastic deformation, usually by penetration. Hardness of materials has probably long been assessed by resistance to scratching or cutting. The usual method to achieve a hardness value is to measure the depth or area of an indentation left by an indenter of a specific shape, with a specific force applied for a specific time. There are three principal standard test methods for expressing the relationship between hardness and the size of the impression, these being Brinell, Vickers, and Rockwell. For practical and calibration reasons, each of these methods is divided into a range of scales, defined by a combination of applied load and indenter geometry.

Brinell Hardness Test:-

1. The Brinell hardness test method consists of indenting the test material with a 10 mm diameter hardened steel or carbide ball subjected to a load of 3000 kg. For softer materials the load can be reduced to 1500 kg or 500 kg to avoid excessive indentation.

The full load is normally applied for 10 to 15 seconds in the case of iron and steel and for at least 30 seconds in the case of other metals.

2. The diameter of the indentation left in the test material is measured with a low powered microscope. The Brinell harness number is calculated by dividing the load applied by the surface area of the indentation.
3. The diameter of the impression is the average of two readings at right angles and the use of a Brinell hardness number table can simplify the determination of the Brinell hardness. A well structured Brinell hardness number reveals the test conditions, and looks like this, "75 HB 10/500/30" which means that a Brinell Hardness of 75 was obtained using a 10mm diameter hardened steel with a 500 kilogram load applied for a period of 30 seconds.
4. On tests of extremely hard metals a tungsten carbide ball is substituted for the steel ball. Compared to the other hardness test methods, the Brinell ball makes the deepest and widest indentation, so the test averages the hardness over a wider amount of material, which will more accurately account for multiple grain structures and any irregularities in the uniformity of the material.
5. This method is the best for achieving the bulk or macro-hardness of a material, particularly those materials with heterogeneous structures.

Procedure:-

- The face of the specimen is lightly grind and rubbed with fine emery paper if required.
- Select the proper test table based o the size and shape of the specimen and place it on main screw or elevating screw
- Select the diameter of the indenter as 10mm or 5 mm based on the thickness of the specimen and place it I the corresponding ball holder and fix the ball holder.
- Place the required weights on the weight hanger based on the type of material of the specimen and diameter of the indenter
- Check and keep the operating level in horizontal position

- Place the specimen securely on testing table
- Turn the hand wheel in clock wise direction so that the specimen touches the ball indenter
- Lift the operating lever fro the horizontal position upwards slightly, after which it rotates automatically.
- Wait for 10 to 15 sec after lever becomes stand still.
- Bring the lever back to horizontal position
- Turn back the hand wheel and remove the specimen
- Measure the diameter of impression of indentation by Brinell microscope and find the Brinell hardness number.
- Repeat the above procedure for three to four times

Formulae

h= depth of indentation

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

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

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

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 o which the brinell impression is to be made should be sufficiently smooth and clean.

Observation Table:-

Sr. No.	Specimen	Dia. of indentation in mm	Load applied in kg	Dia. of indenter	BHN

Result And Discussion:-

POLDI HARNESS TEST:-

It works on same principal as that of Brinell & is simplified version of Brinell hardness testing machine.

Apparatus:-

- Instrument is small in size & consists of a hollow tube.
- At the bottom end of the tube steel ball of 10 mm diameter is fitted.
- Above this ball slot is provided for inserting a steel bar of known hardness.
- This is called ‘standard bar’ & it’s hardness is printed on bar.

Method:-

1. Standard bar is inserted in slot of instrument this ball touches ball as well as plunger.
2. Entire assembly is held with the left hand over the specimen surface of which hardness is to be measured. A hammer is given the right hand on the top of the plunger.
3. Due to the above blow two impressions are obtained simultaneously one on the specimen other on the standard bar.
4. The diameters of impressions are measures by using magnifiscope. Magnifiscope is a small instrument which magnifies the image to about 10 times and has a calibrated grid in its eyepiece

Formulae:-

$$BHN._{sp} = \frac{2P}{\Pi D (D- \sqrt{(D^2 - d_{sp}^2)})}$$

$$BHN._{std} = \frac{2P}{\Pi D (D- \sqrt{(D^2 - d_{std}^2)})}$$

$$BHN._{sp} = \frac{(D- \sqrt{(D^2 - d_{std}^2)})}{(D- \sqrt{(D^2 - d_{sp}^2)})} \times BHN._{std}$$

Observation Table:-

Sr. No.	Specimen	Dia. of indentation in mm	Dia. of indentation on specimen in mm	Dia. of indentation on std. bar in mm	Hardness Value

Result And Discussion: