MATERIALS AND MECHANICS OF SOLIDS LABORATORY

LAB MANUAL

Course Code	:	AMEB14
Regulations	:	IARE-R18
Class	:	B. Tech. IV Semester
Branch	:	MECH
Academic Year	:	2019 - 2020

Prepared By

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Department of Mechanical Engineering

INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal – 500 043, Hyderabad

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Department of Mechanical Engineering

Vision
The Department of Mechanical Engineering envisions value based education, research and development in the areas of Manufacturing and Computer Aided Engineering as an advanced centre for Mechanical Engineering, producing graduates of world-class competence to face the challenges of global market with confidence, creating effective interface with various organizations.

Mission
The mission of the Mechanical Engineering Department is to prepare effective and responsible engineers for global requirements by providing quality education & to improve pedagogical methods employed in delivering the academic programs to the needs of the industry and changing world by conducting basic and applied research and to generate intellectual property.

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Department of Mechanical Engineering

Program Outcomes	
PO1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO2	**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.
PO3	**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.
PO4	**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.
PO5	**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.
PO6	**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.
PO7	**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.
PO8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO9	**Individual and team work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO10	**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.
PO11	**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.
PO12	**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	
PSO1	**Professional Skills:** To produce engineering professional capable of synthesizing and analyzing mechanical systems including allied engineering streams.
PSO2	**Modelling and Simulation Practices:** An ability to adopt and integrate current technologies in the design and manufacturing domain to enhance the employability.
PSO3	**Successful Career and Entrepreneurship:** To build the nation, by imparting technological inputs and managerial skills to become Technocrats.

METALLURGY AND MECHANICS OF SOLIDS LABORATORY									
IV Semester: ME									
Course Code	Category	Hours / Week			Credits	Maximum Marks			
AMEB14	Core	L	T	P	C	CIA	SEE		Total
		-	-	3	2	30	70		100
Contact Classes: Nil	Tutorial Classes: Nil	Practical Classes: 32				Total Classes: 32			

OBJECTIVES:

The course will enable the students to:

I. Determination of mechanical properties of different materials.
II. Establish the constitutive relations in metals using destructive methods.
III. Understand the behavior of members during twisting and transverse loading.
IV. Familiarize with standard test specimens.
V. Prepare samples for investigating micro structure of different materials.

LIST OF EXPERIMENTS

Week-1 MICROSTRUCTURE OF PURE METALS

Preparation and study of the micro Structure of pure metals like iron, cu and al.

Week-2 MICROSTRUCTURE OF STEELS

Preparation and study of the microstructure of mild steels, low carbon steels, high–C steels.

Week-3 MICROSTRUCTURE OF CAST IRON

Study of the micro structures of cast irons.

Week-4 MICROSTRUCTURE OF NON FERROUS ALLOYS

Study of the micro structures of non-ferrous alloys.

Week-5 MICROSTRUCTURE OF HEAT TREATED STEELS

Study of the micro structures of heat treated steels.

Week-6 HARDENABILITY OF STEELS

Hardenability of steels by jominy end quench test.

Week-7 HARDNESS OF STEELS

To find out the hardness of various treated and untreated steels.

Week-8 TENSION TEST

To Find % of elongation and young’s modulus of a material.

Week-9 TORSION TEST

To find the torsional rigidity of a material.

Week-10 HARDNESS TEST

a) Brinell’s hardness test.

b) Rockwell hardness test.

WeeK-11 SPRING TEST

Testing on compressive and elongation springs.

Week-12 COMPRESSION TEST

Compression test on springs	
Week-13	**IMPACT TEST**
a) Charpy. b) Izod test.	
Week-14	**SHEAR TEST**
Punch shear test on aluminium sheet.	

Text Books:

1. Sidney H Avner, "Introduction to Physical Metallurgy", McGraw Hill Education, 2nd Edition, 2008.
2. William, Callister, "Material Science and Engineering", Wiley, 9th Edition, 2014.
3. V Raghavan, "Elements of Material Science", PHI Learning Company Pvt Ltd, 6th Edition, 2015.
4. Er.Amandeep Singh Wadhva, "Engineering Materials and Metallurgy", Laxmi Publications, 1st Edition, 2008.
5. Traugott Fisher, "Material Science", 1st Edition, Academic Press Elsevier, 2013.

Web References:

1. http://www.iare.ac.in

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Certificate

This is to certify that it is a bonafied record of Practical work done by Sri/Kum. ____ bearing the Roll No. ________________________ of _____________ class ____ branch in the ______________________________ laboratory during the academic year ____________________ under our supervision.

Head of the Department **Lecture In-Charge**

External Examiner **Internal Examiner**

LIST OF EXPERIMENTS

MAPPING OF PROGRAM OUTCOMES & PROGRAM SPECIFIC OUTCOMES

Exp. No	Experiment	Program Outcomes Attained	Program Specific Outcomes Attained
1	Preparation and study of the micro Structure of pure metals like iron, cu and al	PO1,PO2	-
2	Preparation and study of the microstructure of mild steels, low carbon steels, high–C steels.	PO1,PO2	-
3	Study of the micro structures of cast irons.	PO1,PO2	-
4	Study of the micro structures of non-ferrous alloys	PO1,PO2, PO3	-
5	Study of the micro structures of heat treated steels.	PO1,PO2,PO4	-
6	Hardenability of steels by jominy end quench test.	PO1,PO2	-
7	To find out the hardness of various treated and untreated steels.	PO1,PO2	-
8	To Find % of elongation and young's modulus of a material.	PO1,PO2	-
9	To find the torsional rigidity of a material.	PO1,PO2	-
10	To find hardness on Brinell's hardness test and Rockwell hardness test.	PO1,PO2	-
11	Testing on compressive and elongation springs.	PO1,PO2, PO3	-
12	Compression test on springs.	PO1,PO2,PO4	-
13	To find the energy absorbed by the specimen through Charpy and Izod test.	PO1,PO2	-
14	Punch shear test on aluminium sheet.	PO1,PO2	-

STUDY OF METULURGICAL LAB

The science of metallography is essentially the study of the structural characteristics or constitution of a metal or any alloy in relation to its physical and mechanical properties. Microscopic examination involves study of metals either by the unaided eyes or with the aid by a low power microscope. This type of observation reveals some of the important details such as uniformity of structure, presence of defects etc.

Microscopic examination involves study of prepared metal surfaces using higher magnifications. Due to use of higher magnification, it reveals large number of structural details of the metal or alloys under examination. Structural details such as grain size, the size, shape and distribution of secondary phase, non-metallic inclusions and segregations and other heterogeneous conditions are revealed by microscopy. Study of micro structural details also reveals the history of heat treatments given to the metal or alloys.

All of them influence the mechanical properties and deformation behavior of metals. When these and other constitutional features are determined by metallographic examination, it is possible to predict the likely behavior of metals for a particular service condition with reasonable accuracy. Since microscopic examination reveals large number of details. Involves the use of microscopes and is more sophisticated than macroscopic.

Metallurgy is not an independent science, since many of its fundamental concepts are derived from physics, chemistry and crystallography.

Metallurgic field may be divided into two large groups.

1. Process or extractive metallurgy: the science of obtaining metals from their ores, including mining, concentration, extraction and refining metals and alloys.
2. Physical metallurgy: The science concerned with the physical and mechanical characteristics of metals and alloys. This field studies the properties of metals and alloys as affected by three variables.
   a. Chemical composition
   b. Mechanical treatment
   c. Thermal or heat treatment
   d.

STUDY OF EQUIPMENT

List of equipment that are used by metallurgist are:

1. Specimen Cutter Machine:
   This is a cutter machine used to cut the given specimen sample to required size and shape.

2. Dry grinding machine or belt grinding machine
   The surface of the specimen to be examined is made plane using motor driven abrasive belt and the specimen is kept cool by frequent dropping in water during the grinding operation. In all grinding and polishing operations, the specimen should be moved perpendicular to the existing scratches. This will facilitate recognition of the stage when the deeper scratches have been replaced by the shallower ones.
   Excessive pressure should not be applied on belt grinder, if applied this leads to the formation of deep seated scratches which are difficult to remove. The polishing on dry grinding machine should be continues until the specimen appears to be flat.

3. Glass polishing or Emery paper polishing:
   This is done by using a series of emery papers of grade numbers 1/0, 2/0, 3/0 and 4/0. The emery paper is held and the specimen is slowly moved back and forth with moderate pressure. For polishing of soft metals and some of the heat-treated alloys it is essential to use suitable lubricants.

   Using a lubricant prevents overheating the sample, minimizes smearing of soft metals and also provides a rinsing action to flush away surface removal products so that paper will not become clogged.

ETCHING REAGENT	COMPOSITION		USES	REMARKS
Nitric Acid (nital)	White nitric acid Ethyl or methyl alcohol (95% or absolute) (also amyl alcohol)	1-5 ml 100 ml	In carbon steels: 1. To darken pearlite and give contrast between pearlite colonies. 2. To reveal ferrite boundaries. 3. To differentiate ferrite from martensite.	Etching rate is increased, selectivity decreased, with increasing percentages of HNO3. Reagent 2 (picric acid) usually superior Etching time a few seconds to 1 min.
Picric acid (Picral)	Picric acid Ethyl or methyl alcohol (95% or absolute)	4g 100ml	For all grades of carbon steels: annealed, normalized, quenched, and tempered, spheroidized, austempered. For all low-alloy steels attached by this reagent by this reagent	More dilute solutions occasionally useful. Does not reveal ferrite grain boundaries as readily as natal Etching time a few seconds to 1 min. or more
Ferric chloride and hydrochloric acid	Ferric chloride Hydrochloric acid Water	5g 50ml 100ml	Structure of austenitic nickel and stainless steels	
Ammonium hydroxide & Hydrogen peroxide	Ammonium hydroxide Water Hydrogen peroxide	5 Parts 5 Parts 2-5 Parts	Generally used for copper and many of its alloys	Peroxide content varies directly with copper content of alloy to be etched immersion or swabbing for about 1 min. fresh peroxide for good results
Ammonium persulfate	Ammonium persulphate Water	10g 90ml	Copper, Brass, Bronze, Nickel, Silver, Alumminium bronze	Use either cold or boiling; immersion immersion with gentle agitation
Palmerton reagent	Chromic oxide Sodium sulphate Water	200g 15g 1000 ml	Generally reagent for zinc and its alloys	
Ammonium molybdate	Molybdic acid *85% Ammonium hydroxide (sp gr 0.9) Water Filter and add to nitric acid (sp gr 0.9)	100gr 240 ml 60ml	Rapid etch for lead and its alloys: very suitable for removing thick layer of worked metal	Alternately swab specimen and wash is running water
Hydrofluoric acid	Hydrofluoric acid (conc) H_2O	0.5ml 99.5ml	Generally microscopic for aluminum and its alloys	Swab with soft cotton for 15 s

METALLURGICAL LAB PRACTICE

Aim: To study about the metallurgical lab practice.

Theory: Metallography consists of the microscopic study of the structural characteristics of metal or an alloy. The microscopes by far the most important tool of the metallurgist from both the scientific and technical stand points. It is possible to determine grain size and the size, shape and distribution of various phases and inclusions which have a great effect on the mechanical properties of the metal. The microstructure will reveal the mechanical and thermal treatment of the metal and

It may be possible. out predict it's expected behavior under a given set of conditions.

Tools Used In Lab Practice:

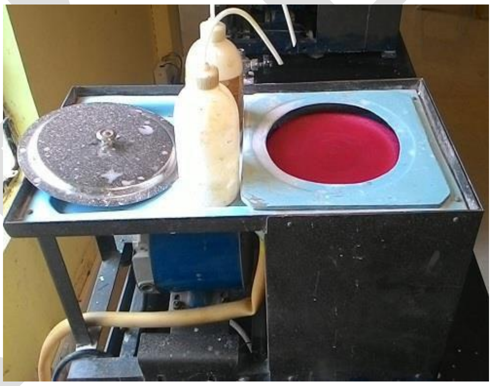
1) **Geomet Cut-Off Machine:** Fig(1) The specimen is cut into a small piece in order to facilitate easy mounting. The specimen is held in between two jaws in the job-vice firmly and is cut using a circular blade connected to a pump. The circular blade is fixed inside the machine in a vertical position and is lowered on to the horizontally held sample by means of a handle. To avoid excess heating up of the blade and the sample, a recalculated (coolant (water with small amount of oil) is applied over the cutting area through a pipe placed near the blade.

Fig(1) fig(2)

2) **Geomet Mounting Press:** fig(2) specimens that are small or awkwardly shaped should be mounted to facilitate easy handling during metallography. The specimen to be mounted is placed on the bottom die surface and 2 spoons of Bakelite powder is poured over it. Then the upper die is brought down to complete the die setup. Then the temperature is set a 120^0C, i.e. the curing temperature of Bakelite and the hydraulic pressure is released to compact the powder between the two dies. Pressure is to be applied once again at 90^0C to remove possible air gaps. Once 120^0C is reached, power is to be turned off after minutes. The sample is ejected out of the die and let to cool. The other mountin materials generally used are Lucite and araldite, but these do not need a mountin machine as they set at room temperature itself.

3) **Geomet Belt Grinding:** Fig(3) The sample surface after mouting is rather uneven. Therefore the sample is polished on Belt grinder in one single direction to mae the surface flat enough for further polishing. The machine consists of a belt sander of grit 18, which moves circularly over a pair of rolls, and when the specimen is kept on it, the belt grinder removes the surface irregularities.

Fig(3)



fig(4)

4) **Sand Paper Polishing:** Belt grinding is followed by polishing on sand papers of grade 180, 220, 320, 400, 600, numbered in the order of decreasing abrasive particle (SiC) size. Starting with 180 paper, polishing is done in a direction perpendicular to those of the scratches made by belt grinder. After 180 grades, polishing is done on subsequent sand paper changing the direction by 90^0 every time the paper is changed.

5) **Emery Paper Polishing:** The sample is then polishing on emery papers (1/0, 2/0,3/0,4/0) following the same procedure as for sand papers.

6) **Geomet Disc Polishing:** fig(4) Fine polishing is done on Geomet variable speed tabletop single disc polishing machine. The machine consists of brass topped A1 disc of 8” ϕ over which a Micrcloth 240 (Billiard or Slyveth cloth) is fastened firmly. Then the cloth is charged with alumina suspension in distilled water (1:5). Sample is polished on the disc rotating at slow speed. Once a mirror like surface is obtained the sample is cleaned with distilled water.

7) **Etching:** fig(5) On completion of polishing the sample is dabbed with the appropriate ethant. Etchant is a combination of chemicals that attacks the various phases and regions of a microstructure to a different extent, thus making them distinctly visible under the microscope. Phases attacked to a greater extent will appear darker than those lightly attacked as they will reflect light to a greater extent. This is called etching contrast. For example, grain boundaries being regions of instability and of high free energy, will be

fig(5)

attacked to a larger extent and will appear dark. Similarly, in a multi-phase structure, each phase will appear differently depending on its etching properties. However, even in a single-phase structure, some of the grain will appear dark. This is due to the orientation difference between various grains. Some of the etchants and their uses are given below.

Etchant	Composition	Materials Etched
Nital	4% HNO_3 + 96% C_2H_5OH	All steels (except stainless steels)
$FeCl_3$	$FeCl_3$ + HCl + Water	Brass
Aqua Regia	60% HCl + 20% HNO_3 +20% H_2O	Stainless steel
HF	2% HF + 98% H_2O	AL & its alloys
Kellars Reagent	1% HF + 1.5% HCl + 2.5% HNO_3+95% H_2O	Duralumin
H_2O_2	5% H_2O_2+5% NH_3OH+90% H_2O	Cu, Brass, Bronze

8) **Sample Leveler:** The etched sample is held onto on to a glass plate with a piece of clay and is leveled with the sample leveler. Bottom surface of the punch should not be in direct contact with the metal piece, therefore a clean white paper is to be placed on the top of the sample.

9) **Observing Under Microscope:** fig(6) Then the microstructure is studied under microscope, then the picture of the microstructure is transferred on to the computer screen through a CCD camera and saved.

fig(6)

Precautions:

1. While cutting the sample, excess down feed force should not be applied on the cutting wheel and that the sample gets sufficient amount of coolant.
2. Before and after mounting clean the die walls only with a soft cloth or cotton so as to not damage the surface and use a thin smear of lubricant (grease).
3. Do not apply pressure while belt grinding, paper polishing or fine polishing the specimen.
4. Before and after disc polishing wash the sample neatly under running water.
5. After use the disc polisher must be cleaned carefully to avoid contamination of grit.
6. Over-etching or insufficient etching must be avoided.

Result:

The general procedure of metallurgy lab practice has been studied and follow

STUDY OF CRYSTAL STRUCTURE

Aim:

To study various crystals structures.

Theory:

Matter exist usually in solid or fluid (liquid, gas) state. According to modern concept matter classification is specified as condensed state and gaseous state. Solids and liquids come under condensed state. Any material whose position of constituent particles is fixed can be regarded as solids.

Solids are characterized by incompressibility, rigidity and mechanical strength. This indicates that the molecules, atoms or ions that make up as solid is closely packed. Thus in solids we will have a well ordered molecular, atomic or ionic arrangement.

In general solids can be classified into:

1). Crystalline-particles are orderly arranged (long range order).
2). Amorphous-particles are randomly oriented.

If the atoms or molecules are uniquely arranged in crystalline solid or liquid we call it as a crystal structure. A crystal posses long range order and symmetry. The main property of crystal structure is its periodicity. This periodicity is due to the arrangement of atoms/molecules in the lattice points. The crystal structure as a whole can be considered as the repetition of unit cell. For a given crystal structure the shape of unit cell is same but varies from crystal to crystal.

X-ray diffraction studies reveal that the constituent particles (molecules, atoms or ions) are arranged in a definite pattern in the crystal. To get the diffraction pattern the wavelength of light used must be comparable with the atomic spacing.

Lattice

A crystal structure is formed only when the group of atoms is arranged identically at the lattice point. The group of atoms or molecules is called a basis. Lattice point is actually an imaginary concept.

In other way, we can say that,

Lattice + Basis=crystal structure

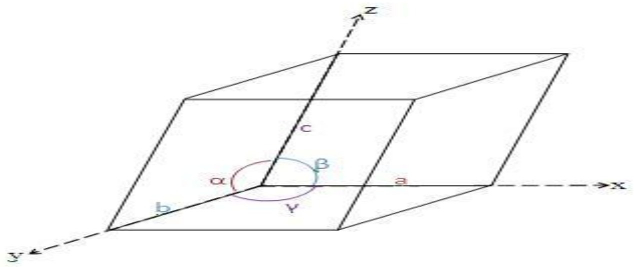
Line joining any two points is a translation in lattice. Two non-collinear translation leads to a plane lattice and three non coplanar translation leads to a space lattice.

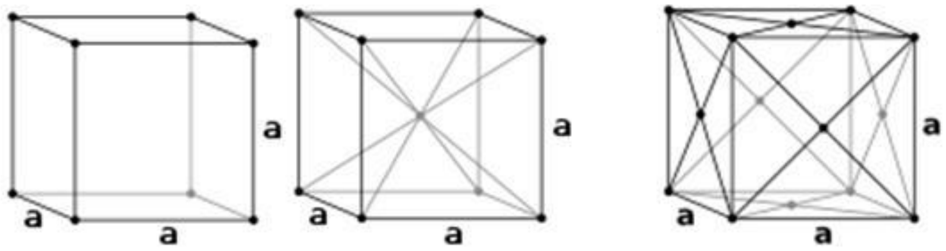
Unit cell

Unit cell can be considered as the building block of a crystal. It has the same symmetry as the entire crystal. When we arrange the unit cell in 3D, we get the bulk crystal. In other words it can be described as the smallest volume which when repeated in all direction gives the crystal. The three edges a, b, c along the axis and angle between them α, β and γ is termed as lattice parameters. In 3D it is better to consider a parallelepiped as unit cell.

Unit cell can be of primitive as well as non primitive type. A primitive cell is a minimum volume unit cell and has only one lattice point in it and the latter contains more than one.

In the given figure below, simple cube is a primitive cell. No.of atoms per unit cell is one for it. The rest two is non primitive. No.of atoms per unit cell is 2 and 4 respectively.



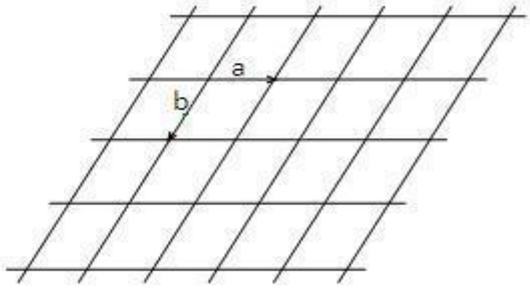


Simple cubic (P) Body- centred cubic (I) Face centered cubic (F)

<u>Bravais Lattice in Two dimension-Plane lattice</u>

In general, number of lattices obtained is unlimited since there is no restriction to the length a, b of the lattice translations and on angle φ between them. Such a lattice for arbitrary a, b and φ is known as oblique lattice. This oblique lattice is invariant under rotation of 2π/n (with n=1 and 2). It can also be made invariant under rotation of 2π/n with n=3, 4 and 6.

For a=b and $\varphi=90^0$, we get square lattice
$a\neq b$ and $\varphi=90^0$, rectangular
a=b and $\varphi=\varphi^0$, rhombus
a=b and $\varphi=60^0$, hexagonal



<u>Bravais Lattice in Three dimension-Space lattice</u>

Based on the lattice parameters a, b, c, α, β and γ and applying the restrictions as above, only 14 types of lattices are possible in three dimensions. One general (triclinic) and thirteen special. Only seven different systems of axis are found to be sufficient to represent all Bravais lattice. This fourteen space lattice is divided into seven crystal systems.

<u>Atomic packing Fraction (APF)</u>

Atomic packing fraction mainly gives us an idea about the arrangement of atoms/ions in solids. It will give the efficiency with which the available space is being filled by atoms.

Packing fraction is defined as the ratio of volume of atoms occupying the unit cell to the volume of unit cell.

<u>Examples:</u>

1. **Simple Cubic**

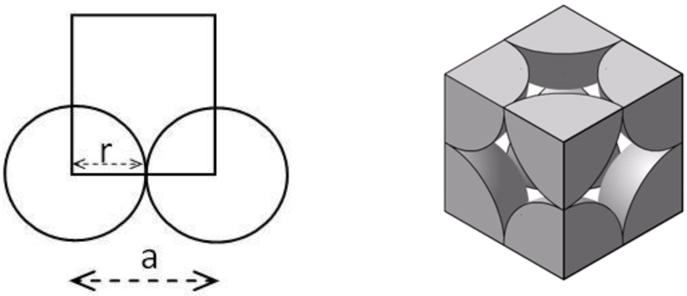
Consider a cube of side 'a' .Atoms of radius ‘r’ is placed at the corner. So that length of cube a=2r.

Volume of atoms in unit cell $= \frac{1*4\pi r^3}{3}$

In a simple cubic structure, the atoms occupies at the eight corners. An atom at the corner is equally shared by 8 unit cells. So the contribution of one atom to a unit cell is 1/8. Therefore the no. of atoms per unit cell is (1/8)*8(corner atoms) =1.

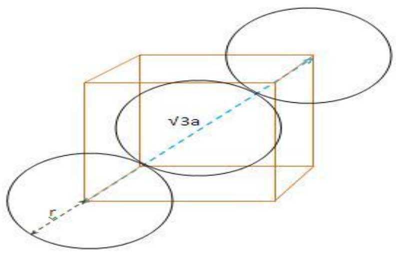
Volume of unit cell= $a^3 = (2r)^3 = 8r^3$

$$APF = \frac{\frac{4}{3}\pi r^3}{8r^3} = \frac{\pi}{6} = 52\%$$



Simple Cubic

2. **Body centered Cube**



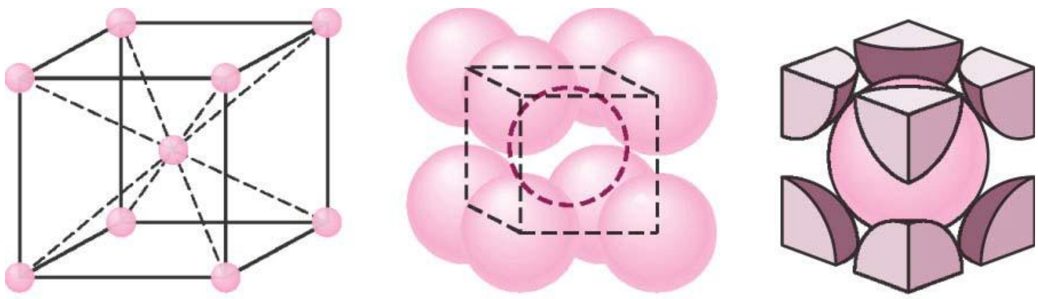
Consider a cube of side ‘a’, and atoms of radius ‘r’ are placed at corners and at the body centre.
Length of body diagonal, √3a=4r.

Volume of atoms in unit cell $= \frac{2*4\pi r^3}{3} = \frac{8\pi r^3}{3}$

In a body centered cube, there will be one atom at the centre along with 8 corner atoms. This corner atom is shared by 8 unit cell and the atom at the centre is not a shared one. Therefore no. of atoms per unit cell= (1/8)*8(corner atoms)+1(body centre)=2.

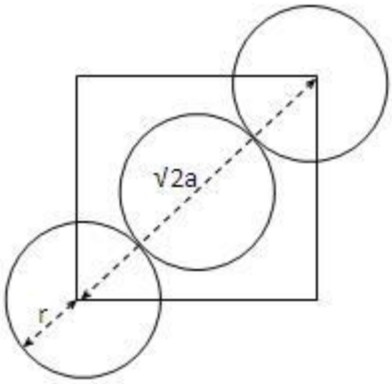
Volume of unit cell $= a^3 = (\frac{4r}{\sqrt{3}})^3$

$$APF = \frac{\frac{8\pi r^3}{3}}{\frac{64r^3}{(3\sqrt{3})}} = \frac{\sqrt{3}\,\pi}{8} = 68\%$$



(a) (b) (c)

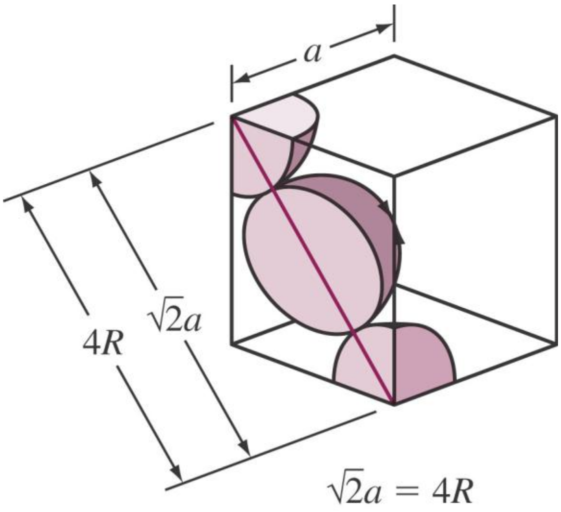
3. Face centered Cube:

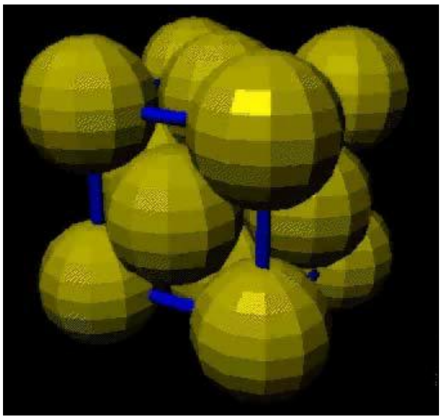


Consider a cube of length ‘a’ and atoms of radius ’r’ are placed at the corners as well as at the face centre. Length of face diagonal √2a=4r.

Volume of unit cell $= \frac{4*4}{3}\pi r^3 = \frac{16}{3}\pi r^3$

In a face centered cube, each face possess one atom along with 8 corner atoms. The atoms at the faces are equally shared by two unit cell. Corner atoms by 8 unit cells. So the no. of atoms per unit cell is=(1/8)*8(corner atoms)+(1/2)*6(atoms at face)=4.





Face centered Cube

Volume of unit cell $= a^3 = (\frac{4r}{\sqrt{2}})^3$

$$APF = \frac{\frac{16}{3}\pi r^3}{(\frac{4r}{\sqrt{2}})^3} = \frac{\pi}{3\sqrt{2}} = 74\%$$

EXPERIMENT – 1

PREPARATION AND STUDY OF THE MICRO STRUCTURE OF PURE METALS

1.1 MICROSTRUCTURE OF ALUMINUM

Aim: To Study The Microstructure of The Given Specimen.

Apparatus:

- Cutoff machine
- Mounting press
- Disc polisher
- Belt polisher
- Sand (180, 220, 320, 400, 600)
- emery paper (1/0, 2/0, 3/0, 4/0)
- Microscope
- Etchant
- Magnification
- Specimen

Sample:

Etchants:

Magnification:

Theory:

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

Aluminium is remarkable for the metal's low density and for its ability to resist corrosion due to the phenomenon of passivation. Structural components made from aluminium and its alloys are vital to the aerospace industry and are important in other areas of transportation and structural materials. The most useful compounds of aluminium, at least on a weight basis, are the oxides and sulfates.

Applications:

- Transportation (automobiles, aircraft, trucks, railway cars, marine vessels, bicycles, etc.) as sheet, tube, castings, etc.
- Packaging (cans, foil, frame of etc.)
- Construction (windows, doors, siding, building wire, etc.).
- A wide range of household items, from cooking utensils to baseball bats, watches.
- Street lighting poles, sailing ship masts, walking poles, etc.

Outer shells of consumer electronics, also cases for equipment e.g. photographic equipment, Mac Book Pro's casing

- ➢ Electrical transmission lines for power distribution
- ➢ Super purity aluminium (SPA, 99.980% to 99.999% Al), used in electronics and CDs, and also in wires/cabling.
- ➢ Heat sinks for electronic appliances such as transistors and CPUs.
- ➢ Powdered aluminium is used in paint, and in pyrotechnics such as solid rocket fuels and thermite.
- ➢ Aluminium reacts with hydrochloric acid or with sodium hydroxide to produce hydrogen gas.
- ➢ Aluminium is used to make food containers, because of its resistance to corrosion.
- ➢ Aluminium with magnesium [alloy] is used to make body of aircraft.
- ➢ Aluminium with other metals, used to make railway tracks.
- ➢ Aluminium is used to make cooking utensils, because it is resistant to corrosion, and light-weight.

Procedure:

1. Cut the specimen into required shape by using cutoff machine.
2. Mount the specimen in mounting press by adding 2 spoons of Bakelite powder.
3. Polish the specimen on belt polisher to make the surface even.
4. Then polish the specimen again by using sand and emery papers.
5. After polishing the specimen is again polish on the belt polisher by adding 2-3 drops of water.
6. Observe the micro-structure of specimen under microscope and note it down.
7. Apply approximate etchant to the specimen.
8. Observe the micro scope structure and note it down.

Precautions:

i. Wear tight overalls and shoe for safety.

ii. Be wear about mounting press and the time of etching process.

iii. Don’t touch the specimen when it is so hot and use tongs for hold it.

vi. Be away at the time of belt polishing and disc polishing.

Result:

EXPERIMENT – 1.2

MICROSTRUCTURE OF COPPER

Aim: To Study The Microstructure of The Given Specimen.

Apparatus:

- Cutoff machine
- Mounting press
- Bakelite
- Belt polisher, Disc polisher
- Sand (180, 220, 320, 400, 600), Emery paper (1/0, 2/0, 3/0, 4/0)
- Microscope
- Etchant
- Specimen

Sample:

Etchants:

Magnification:

Theory:

Copper is a chemical element with symbol Cu (from Latin: cuprum) and atomic number 29. It is a ductile metal with very high thermal and electrical conductivity. Pure copper is soft and malleable; a freshly exposed surface has a reddish-orange color. It is used as a conductor of heat and electricity, a building material, and a constituent of various metal alloys.

The metal and its alloys have been used for thousands of years. In the Roman era, copper was principally mined on Cyprus. Architectural structures built with copper corrode to give green verdigris (or patina). Art prominently features copper, both by itself and as part of pigments.

Applications:

Wire and cable, Electronics and related devices, Electric motors windings, Architecture, Antimicrobial applications, Copper is commonly used in jewelry, and folklore says that copper bracelets relieve arthritis symptoms. Copper is used as the printing plate in etching, engraving and other forms of intaglio (printmaking) printmaking. Copper oxide and carbonate is used in glassmaking and in ceramic glazes to impart green and brown colors.

Procedure:

1. Cut the specimen into required shape by using cutoff machine.
2. Mount the specimen in mounting press by adding 2 spoons of Bakelite powder.
3. Polish the specimen on belt polisher to make the surface even.

4. Then polish the specimen again by using sand and emery papers.

5. After polishing the specimen is again polish on the belt polisher by adding 2-3 drops of water.

6. Observe the micro-structure of specimen under microscope and note it down.

7. Apply approximate etchant to the specimen.

8. Observe the micro scope structure and note it down.

Precautions:

i. Wear tight overalls and shoe for safety.

ii. Be wear about mounting press and the time of etching process.

iii. Don’t touch the specimen when it is so hot and use tongs for hold it.

vi. Be away at the time of belt polishing and disc polishing.

Result:

Experiment 2

2.1 MICROSTRUCTURE OF LOW CARBON STEEL

Aim: To Study The Microstructure of The Given Specimen.

Apparatus:

- Cutoff machine
- Mounting press
- Disc polisher
- Belt polisher
- Sand (180, 220, 320, 400, 600)
- Emery paper (1/0, 2/0, 3/0, 4/0)
- Microscope
- Etchant
- Magnification
- Specimen

Sample:

Etchants:

Magnification:

Theory:

Carbon steel is steel in which the main interstitial alloying constituent is carbon in the range of 0.12–2.0%.

Low-carbon steel contains approximately 0.05–0.15% carbon making it malleable and ductile. Mild steel has a relatively low tensile strength, but it is cheap and easy to form; surface hardness can be increased through carburizing.

It is often used when large quantities of steel are needed, for example as structural steel. The density of mild steel is approximately 7.85 g/cm^3 (7850 kg/m^3 or 0.284 lb/in^3) and the Young's modulus is 210 GPa (30,000,000 psi).

Applications:

Low carbon steels offer many applications. Truck bed floors, automobile doors, domestic appliances. The automobile industry employs a considerable amount of this steel for making parts that require simple bending or moderate forming. Truck cab backs, tailgate access covers, floor pans, and bed floors are often made of this steel.

Procedure:

1. Cut the specimen into required shape by using cutoff machine.
2. Mount the specimen in mounting press by adding 2 spoons of Bakelite powder.
3. Polish the specimen on belt polisher to make the surface even.

4. Then polish the specimen again by using sand and emery papers.
5. After polishing the specimen is again polish on the belt polisher by adding 2-3 drops of water.
6. Observe the micro-structure of specimen under microscope and note it down.
7. Apply approximate etchant to the specimen.
8. Observe the micro scope structure and note it down.

Precautions:

i. Wear tight overalls and shoe for safety.

ii. Be wear about mounting press and the time of etching process.

iii. Don’t touch the specimen when it is so hot and use tongs for hold it.

vi. Be away at the time of belt polishing and disc polishing.

Result:

Experiment 2.2
MICROSTRUCTURE OF MEDIUM CARBON STEEL

Aim: To Study The Microstructure of The Given Specimen.

Apparatus:

- Cutoff machine
- Mounting press
- Disc polisher
- Belt polisher
- Sand (180, 220, 320, 400, 600)
- Emery paper (1/0, 2/0, 3/0, 4/0)
- Microscope
- Etchant
- Magnification
- Specimen

Sample:

Etchants:

Magnification:

Theory:

Medium carbon steel is carbon steel that contains between 0.30 and 0.60 percent carbon. It also has a manganese content between 0.6 and 1.65 percent. This type of steel provides a good balance between strength and ductility, and it is common in many types of steel parts.

Additional carbon makes the steel harder but also more brittle, so manufacturing carbon steel requires a balance between hardness and ductility. The most common uses of medium carbon steel are in heavy machinery, such as axles, crankshafts, couplings and gears. Steel with carbon content between 0.4 and 0.6 percent is commonly used in the railroad industry to make axles, rails and wheels.

Applications:

M.C.S used in manufacturing and making of Gears, Pins, Rams, Shafts, Axles, Rolls, Sockets, Spindles, Bolts, Ratchets, Light gears, Guide rods, Hydraulic clamps, Studs, Connecting rods, Crankshafts, Torsion bars etc.

Procedure:

1. Cut the specimen into required shape by using cutoff machine.
2. Mount the specimen in mounting press by adding 2 spoons of Bakelite powder.
3. Polish the specimen on belt polisher to make the surface even.
4. Then polish the specimen again by using sand and emery papers.

5. After polishing the specimen is again polish on the belt polisher by adding 2-3 drops of water.

6. Observe the micro-structure of specimen under microscope and note it down.

7. Apply approximate etchant to the specimen.

8. Observe the micro scope structure and note it down.

Precautions:

i. Wear tight overalls and shoe for safety.

ii. Be wear about mounting press and the time of etching process.

iii. Don’t touch the specimen when it is so hot and use tongs for hold it.

vi. Be away at the time of belt polishing and disc polishing.

Result:

Experiment 2.3
MICROSTRUCTURE OF HIGH CARBON STEEL

Aim: To Study The Microstructure of The Given Specimen.

Apparatus:

- Cutoff machine
- Mounting press
- Disc polisher
- Belt polisher
- Sand (180, 220, 320, 400, 600)
- emery paper (1/0, 2/0, 3/0, 4/0)
- Microscope
- Etchant
- Magnification
- Specimen

Sample:

Etchants:

Magnification:

Theory:

High carbon steel will be any type of steel that contains over 0.8% carbon but less than 2.11% carbon in its composition. The average level of carbon found in this metal usually falls right around the 1.5% mark. High carbon steel has a reputation for being especially hard, but the extra carbon also makes it more brittle than other types of steel. This type of steel is the most likely to fracture when misused.

Applications:

Depending on the specific needs of the person using it, high carbon steel can have many advantages over other options. This type of steel is excellent for making cutting tools or masonry nails. The hardness levels and metal wear resistance of high carbon steel is also rated very highly. High carbon steel is also preferred by many manufacturers who create metal cutting tools or press machinery that must bend and form metal.

High carbon steel remains popular for a wide variety of uses. This type of steel is preferred in the manufacturing of many tools such as drill bits, knives, masonry nails, saws, metal cutting tools, and woodcutting tools.

Procedure:

1. Cut the specimen into required shape by using cutoff machine.

2. Mount the specimen in mounting press by adding 2 spoons of Bakelite powder.

3. Polish the specimen on belt polisher to make the surface even.

4. Then polish the specimen again by using sand and emery papers.

5. After polishing the specimen is again polish on the belt polisher by adding 2-3 drops of water.

6. Observe the micro-structure of specimen under microscope and note it down.

7. Apply approximate etchant to the specimen.

8. Observe the micro scope structure and note it down.

Precautions:

i. Wear tight overalls and shoe for safety.

ii. Be wear about mounting press and the time of etching process.

iii. Don’t touch the specimen when it is so hot and use tongs for hold it.

vi. Be away at the time of belt polishing and disc polishing.

Result:

Experiment 3

3.1 MICROSTRUCTURE OF WROUGHT IRON

Aim: To Study The Microstructure of The Given Specimen.

Apparatus:

- Cutoff machine
- Mounting press
- Disc polisher
- Belt polisher
- Sand (180, 220, 320, 400, 600)
- Emery paper (1/0, 2/0, 3/0, 4/0)
- Microscope
- Etchant
- Magnification
- Specimen

Sample:

Etchants:

Magnification:

Theory:

Wrought iron is an iron alloy with a very low carbon (less than 0.08%) and has fibrous inclusions known as slag up to 2% by weight. Wrought iron is tough, malleable, ductile, corrosion-resistant and easily welded.

Applications:

It is used to make home decor items such as baker's racks, wine racks, pot racks, etageres, table bases, desks, gates, beds, candle holders, curtain rods, bars and bar stools. The vast majority of wrought iron available today is from reclaimed materials. Old bridges and anchor chains dredged from harbors are major sources. The greater corrosion resistance of wrought iron is due to the siliceous impurities (naturally occurring in iron ore), namely ferric silicate. Because of limited availability, the use of wrought iron today is usually reserved for special applications, such as fine carpentry tools and historical restoration for objects of great importance.

Procedure:

1. Cut the specimen into required shape by using cutoff machine.
2. Mount the specimen in mounting press by adding 2 spoons of Bakelite powder.
3. Polish the specimen on belt polisher to make the surface even.
4. Then polish the specimen again by using sand and emery papers.
5. After polishing the specimen is again polish on the belt polisher by adding 2-3 drops of water.
6. Observe the micro-structure of specimen under microscope and note it down.

7. Apply approximate etchant to the specimen.
8. Observe the micro scope structure and note it down.

Precautions:

i. Wear tight overalls and shoe for safety.
ii. Be wear about mounting press and the time of etching process.
iii. Don’t touch the specimen when it is so hot and use tongs for hold it.
vi. Be away at the time of belt polishing and disc polishing.

Result:

Experiment 3.2
MICROSTRUCTURE OF GREY CAST IRON

Aim: To Study The Microstructure of The Given Specimen.

Apparatus:

- Cutoff machine
- Mounting press
- Disc polisher
- Belt polisher
- Sand (180, 220, 320, 400, 600)
- emery paper (1/0, 2/0, 3/0, 4/0)
- Microscope
- Etchant
- Magnification
- Specimen

Sample:

Solution:

Etchants:

Magnification:

Theory:

Gray iron, or grey cast iron, is a type of cast iron that has a graphitic microstructure. It is named after the gray color of the fracture it forms, which is due to the presence of graphite. It is the most common cast iron and the most widely used cast material based on weight.

It is used for housings where the stiffness of the component is more important than its tensile strength, such as internal combustion engine cylinder blocks, pump housings, valve bodies, electrical boxes, and decorative castings. Grey cast iron's high thermal conductivity and specific heat capacity are often exploited to make cast iron cookware and disc brake rotors.

Applications:

Gray iron is a common engineering alloy because of its relatively low cost and good machinability, which results from the graphite lubricating the cut and breaking up the chips. It also has good galling and wear resistance because the graphite flakes self lubricate. The graphite also gives gray iron an excellent damping capacity because it absorbs the energy

Procedure:

1. Cut the specimen into required shape by using cutoff machine.
2. Mount the specimen in mounting press by adding 2 spoons of Bakelite powder.

3. Polish the specimen on belt polisher to make the surface even.

4. Then polish the specimen again by using sand and emery papers.

5. After polishing the specimen is again polish on the belt polisher by adding 2-3 drops of water.

6. Observe the micro-structure of specimen under microscope and note it down.

7. Apply approximate etchant to the specimen.

8. Observe the micro scope structure and note it down.

Precautions:

i. Wear tight overalls and shoe for safety.

ii. Be wear about mounting press and the time of etching process.

iii. Don’t touch the specimen when it is so hot and use tongs for hold it.

vi. Be away at the time of belt polishing and disc polishing.

Result:

Experiment 3.3
MICROSTRUCTURE OF MALLEABLE CAST IRON

Aim: To Study The Microstructure of The Given Specimen.

Apparatus:

- Cutoff machine
- Mounting press
- Disc polisher
- Belt polisher
- Sand (180, 220, 320, 400, 600)
- emery paper(1/10, 2/10, 3/10, 4/10, grade)
- Microscope
- Etchant
- Magnification
- Specimen

Sample:

Solution:

Etchants:

Magnification:

Theory:

Malleable iron is cast as white iron, the structure being Meta stable carbide in a pearlitic matrix. Through an annealing heat treatment, the brittle structure as first cast is transformed into the malleable form. Carbon agglomerates into small roughly spherical aggregates of graphite leaving a matrix of ferrite or pearlite according to the exact heat treatment used. Three basic types of malleable iron are recognized within the casting industry: blackheart malleable iron, white heart malleable iron and pearlitic malleable iron.

Applications:

It is often used for small castings requiring good tensile strength and the ability to flex without breaking (ductility). Uses include electrical fittings, hand tools, pipe fittings, washers, brackets, fence fittings, power line hardware, farm equipment, mining hardware, and machine parts.

Procedure:

1. Cut the specimen into required shape by using cutoff machine.
2. Mount the specimen in mounting press by adding 2 spoons of Bakelite powder.
3. Polish the specimen on belt polisher to make the surface even.
4. Then polish the specimen again by using sand and emery papers.

5. After polishing the specimen is again polish on the belt polisher by adding 2-3 drops of water.

6. Observe the micro-structure of specimen under microscope and note it down.

7. Apply approximate etchant to the specimen.

8. Observe the micro scope structure and note it down.

Precautions:

i. Wear tight overalls and shoe for safety.

ii. Be wear about mounting press and the time of etching process.

iii. Don’t touch the specimen when it is so hot and use tongs for hold it.

vi. Be away at the time of belt polishing and disc polishing.

Result

Experiment 4

STUDY OF THE MICRO STRUCTURES OF NON FERROUS ALLOYS MICROSTRUCTURE OF BRASS

Aim: To Study The Microstructure of The Given Specimen.

Apparatus:

- Cutoff machine
- Mounting press
- Disc polisher
- Belt polisher
- Sand (180, 220, 320, 400, 600)
- emery paper (1/0, 2/0, 3/0, 4/0)
- Microscope
- Etchant
- Magnification
- Specimen

Sample:

Etchants:

Magnification:

Theory:

Brass is an alloy made of copper and zinc; the proportions of zinc and copper can be varied to create a range of brasses with varying properties. It is a substitution alloy: atoms of the two constituents may replace each other within the same crystal structure.

By comparison, bronze is principally an alloy of copper and tin. However, the common term "bronze" may also include arsenic, phosphorus, aluminium, manganese, and silicon. The term is also applied to a variety of brasses, and the distinction is largely historical. Modern practice in museums and archaeology increasingly avoids both terms for historical objects in favor of the all-embracing "copper alloy".

Applications:

Brass is used for decoration for its bright gold-like appearance; for applications where low friction is required such as locks, gears, bearings, doorknobs, ammunition casings and valves; for plumbing and electrical applications; and extensively in brass musical instruments such as horns and bells where a combination of high workability (historically with hand tools) and durability is desired. It is also used in zippers. Brass is often used in situations in which it is important that sparks not be struck, such as in fittings and tools around explosive gases.

Procedure:

1. Cut the specimen into required shape by using cutoff machine.

2. Mount the specimen in mounting press by adding 2 spoons of Bakelite powder.

3. Polish the specimen on belt polisher to make the surface even.

4. Then polish the specimen again by using sand and emery papers.

5. After polishing the specimen is again polish on the belt polisher by adding 2-3 drops of water.

6. Observe the micro-structure of specimen under microscope and note it down.

7. Apply approximate etchant to the specimen.

8. Observe the micro scope structure and note it down.

Precautions:

i. Wear tight overalls and shoe for safety.

ii. Be wear about mounting press and the time of etching process.

iii. Don’t touch the specimen when it is so hot and use tongs for hold it.

vi. Be away at the time of belt polishing and disc polishing.

Result:

Experiment 4.1
MICROSTRUCTURE OF PHOSPHOR BRONZE

Aim: To Study The Microstructure of The Given Specimen.

Apparatus:

- Cutoff machine
- Mounting press
- Disc polisher
- Belt polisher
- Sand (180, 220, 320, 400, 600)
- Emery paper (1/0, 2/0, 3/0, 4/0)
- Microscope
- Etchant
- Magnification
- Specimen

Sample:

Etchants:

Magnification:

Theory:

Phosphor bronze is an alloy of copper with 3.5 to 10% of tin and a significant phosphorus content of up to 1%. The phosphorus is added as deoxidizing agent during melting. These alloys are notable for their toughness, strength, low coefficient of friction, and fine grain. The phosphorus also improves the fluidity of the molten metal and thereby improves the cast ability, and improves mechanical properties by cleaning up the grain boundaries.

Procedure:

1. Cut the specimen into required shape by using cutoff machine.
2. Mount the specimen in mounting press by adding 2 spoons of Bakelite powder.
3. Polish the specimen on belt polisher to make the surface even.
4. Then polish the specimen again by using sand and emery papers.
5. After polishing the specimen is again polish on the belt polisher by adding 2-3 drops of water.
6. Observe the micro-structure of specimen under microscope and note it down.
7. Apply approximate etchant to the specimen.
8. Observe the micro scope structure and note it down.

Precautions:

i. Wear tight overalls and shoe for safety.

ii. Be wear about mounting press and the time of etching process.

iii. Don’t touch the specimen when it is so hot and use tongs for hold it.

vi. Be away at the time of belt polishing and disc polishing.

Result:

Experiment 5

STUDY OF THE MICRO STRUCTURES OF HEAT TREATED STEELS

Aim: To Study The Microstructure of The Given Specimen.

Apparatus:

- Cutoff machine
- Mounting press
- Disc polisher
- Belt polisher
- Sand (180, 220, 320, 400, 600)
- Emery paper (1/0, 2/0, 3/0, 4/0)
- Microscope
- Etchant
- Magnification
- Specimen

Sample:

Etchants:

Magnification:

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, and 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.

Procedure:

1. Cut the specimen into required shape by using cutoff machine.
2. Mount the specimen in mounting press by adding 2 spoons of Bakelite powder.
3. Polish the specimen on belt polisher to make the surface even.
4. Then polish the specimen again by using sand and emery papers.

5. After polishing the specimen is again polish on the belt polisher by adding 2-3 drops of water.

. Observe the micro-structure of specimen under microscope and note it down.

7. Apply approximate etchant to the specimen.

8. Observe the micro scope structure and note it down.

Precautions:

i. Wear tight overalls and shoe for safety.

ii. Be wear about mounting press and the time of etching process.

iii. Don’t touch the specimen when it is so hot and use tongs for hold it.

vi. Be away at the time of belt polishing and disc polishing.

v. Polishing should be slow, smooth and flat. Uniform pressure is applied throughout the polishing.

Result:

Experiment 6

HARDENABILITY OF STEELS BY JOMINY END QUENCH TEST

Aim: to estimate the harden ability and hardness variation upon quenching of the given sample

Apparatus:

- Muffle furnace,
- Jominynature,
- Jominy quench,
- Harden ability test apparatus and
- Rockwell hardness tester

Indenter: Diamond

Procedure:

1. Out the given steel bar, the standard sample is to be prepared as per the dimensions shone in figure.
2. The austeniting temperature and time for the given steel is to be determined depending on its chemical composition.
3. The furnace is setup on the required temperature and sample is kept in the furnace
4. The sample is to be kept in furnace of a predetermined time (based on the chemical composition of steel) the it is taken out of the furnce and is kept fixed in the test apparatus.
5. The water flow is directed into the bottom end of the sample. The water flow is adjusted such that it obtain shape of umbrella over bottom of the sample.
6. The quenching is to be continued for approximately 15 min.
7. A flat near about 0.4mm deep is grounded on the specimen.
8. The hardness of the sample can be determined at the various points sterling from the quenched end and the results are tabulated.
9. The graph is plotted with hardness values verses distance from quenched end from the results and graph plotted the depth of the hardness of the given sample can be determined.

Precautions:

i. Wear tight overalls and shoe for safety.

ii. Don’t touch the specimen when it is so hot and use tongs for hold it.

Result:

Experiment 7

HARDNESS OF VARIOUS TREATED AND UNTREATED STEELS

Aim: To Study The Microstructure of The Given Specimen.

Apparatus:

- Cutoff machine
- Mounting press
- Disc polisher
- Belt polisher
- Sand (180, 220, 320, 400, 600)
- Emery paper (1/0, 2/0, 3/0, 4/0)
- Microscope
- Etchant
- Magnification
- Specimen

Sample:

Etchants:

Magnification:

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, and 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.

Procedure:

1. Cut the specimen into required shape by using cutoff machine.
2. Mount the specimen in mounting press by adding 2 spoons of Bakelite powder.
3. Polish the specimen on belt polisher to make the surface even.
4. Then polish the specimen again by using sand and emery papers.

5. After polishing the specimen is again polish on the belt polisher by adding 2-3 drops of water.

. Observe the micro-structure of specimen under microscope and note it down.

7. Apply approximate etchant to the specimen.

8. Observe the micro scope structure and note it down.

Precautions:

i. Wear tight overalls and shoe for safety.

ii. Be wear about mounting press and the time of etching process.

iii. Don’t touch the specimen when it is so hot and use tongs for hold it.

vi. Be away at the time of belt polishing and disc polishing.

v. Polishing should be slow, smooth and flat. Uniform pressure is applied throughout the polishing.

Result:

Experiment- 8

TENSION TEST

AIM: To determine ultimate tensile stress of a metal.
OBJECTIVE: To conduct a tensile test on a mild steel specimen and determine the following:

(i) Limit of proportionality

(ii) Elastic limit

(iii) Yield strength

(iv) Ultimate strength

(v) Young's modulus of elasticity

(vi) Percentage elongation

(vii) Percentage reduction in area.

APPARATUS:

(i) Universal Testing Machine (UTM)

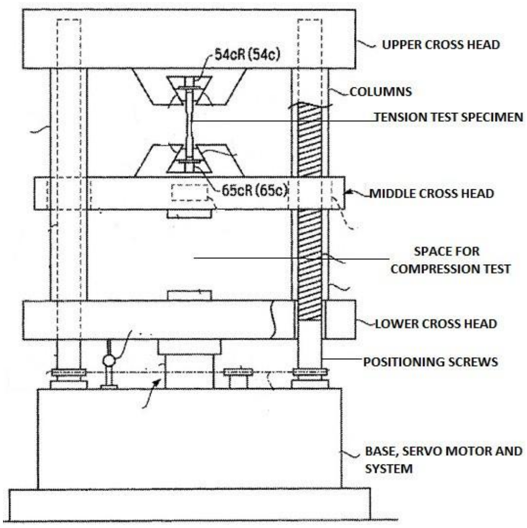
(ii) Mild steel specimens

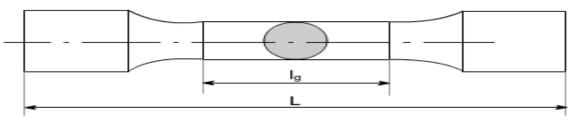
(iii) Graph paper

(iv) Scale

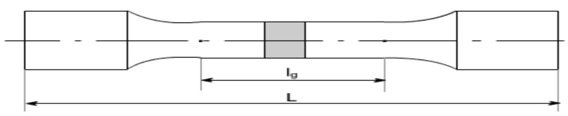
(v) Vernier Caliper

DIAGRAM:





[specimen with circular X-section]



[specimen with rectangular X-section]

THEORY:-

The tensile test is most applied one, of all mechanical tests. In this test ends of test piece are fixed into grips connected to a straining device and to a load measuring device. If the applied load is small enough, the deformation of any solid body is entirely elastic. An elastically deformed solid will return to its original from as soon as load is removed. However, if the load is too large, the material can be deformed permanently. The initial part of the tension curve which is recoverable immediately after unloading is termed. As elastic and the rest of the curve which represents the manner in which solid undergoes plastic deformation is termed plastic. The stress below which the deformations essentJially entirely elastic is known as the yield strength of material. In some material the onset of plastic deformation is denoted by a sudden drop in load indicating both an upper and a lower yield point. However, some materials do not exhibit a sharp yield point. During plastic deformation, at larger extensions strain hardening cannot compensate for the decrease in section and thus the load passes through a maximum and then begins to decrease. This stage the "ultimate strength"' which is defined as the ratio of the load on the specimen to original cross-sectional area, reaches a maximum value. Further loading will eventually cause 'neck' formation and rupture.

PROCEDURE:-

1) Measure the original length and diameter of the specimen. The length may either be length of gauge section which is marked on the specimen with a preset punch or the total length of the specimen.

2. Insert the specimen into grips of the test machine and attach strain-measuring device to it.
3. Begin the load application and record load versus elongation data.
4. Take readings more frequently as yield point is approached.
5. Measure elongation values with the help of dividers and a ruler.
6. Continue the test till Fracture occurs.
7. By joining the two broken halves of the specimen together, measure the final length and diameter of specimen.

DESCRIPTION OF UTM :

It consists of main hydraulic cylinder with robust base inside. The piston which moves up and down. The chain driven by electric motor which is fitted on left hand side. The screw column maintained in the base can be rotated using above arrangement of chain. Each column passes through the main nut which is fitted in the lower cross head. The lower table connected to main piston through a ball & the ball seat is joined to ensure axial loading. There is a connection between lower table and upper head assembly that moves up and down with main piston. The measurement of this assembly is carried out by number of bearings which slides over the columns. The test specimen each fixed in the job is known as 'Jack Job'. To fix up the pecimen tightly, the movement of jack job is achieved helically by handle.

CONTROL PANEL:-

It consists of oil tank having a hydraulic oil level sight glass for checking the oil level. The pump is displacement type piston pump having free plungers those ensure for continuation of high pressure. The pump is fixed to the tank from bottom. The suction & delivery valve are fitted to the pump near tan Electric motor driven the pump is mounted on four studs which is fitted on the right side of the tank. There is an arrangement for loosing or tightening of the valve. The four valves on control panel control the oil stroke in the hydraulic system. The loading system works as described below. The return valve is close, oil delivered by the pump through the flow control valves to the cylinder & the piston goes up. Pressure starts developing & either the specimen breaks or the load having maximum value is controlled with the base dynameters consisting in a cylinder in which the piston reciprocates. The switches have upper and lower push at the control panel for the downward & upward movement of the movable head. The on & off switch provided on the control panel & the pilot lamp shows the transmission of main supply.

METHOD OF TESTING:-

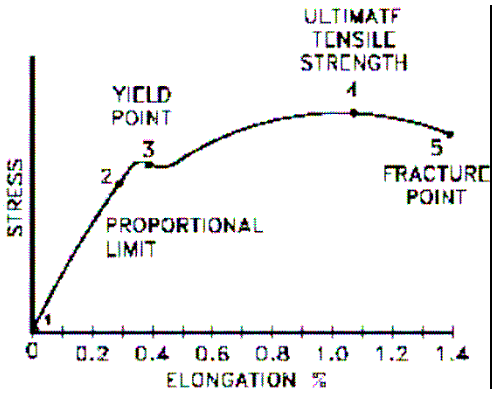
Initial Adjustment: - before testing adjust the pendulum with respect to capacity of the test i.e. 8 Tones; 10 Tones; 20 Tones; 40 Tones etc. For ex: - A specimen of 6 tones capacity gives more accurate result of 10 Tones capacity range instead of 20 Tones capacity range. These ranges of capacity are adjusted on the dial with the help of range selector knob. The control weights of the pendulum are adjusted correctly. The ink should be inserted in pen holder of recording paper around the drum & the testing process is started depending upon the types of tests.

EXTENSOMETER:-

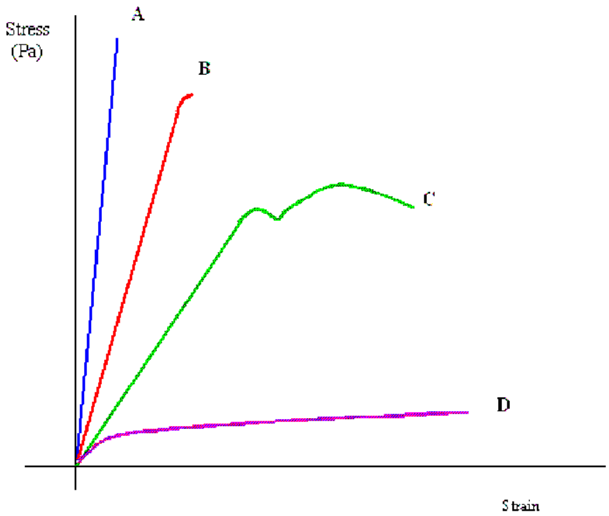
This instrument is an attachment to Universal / Tensile Testing Machines. This measures the elongation of a test place on load for the set gauge length. The least count of measurement being

0.1 mm, and maximum elongation measurement up to 3 mm. This elongation measurement helps in finding out the proof stress at the required percentage elongation.

WORKING OF THE INSTRUMENT:-The required gauge length(between 30to 120) is set by adjusting the upper knife edges (3) A scale (2) is provided for this purpose . Hold the specimen in the upper and lower jaws of Tensile / Universal Testing Machine. Position the extensometer on the specimen. Position upper clamp (4) to press upper knife edges on the specimen. The extensometer will be now fixed to the specimen by spring pressure. Set zero on both the dial gauges by zero adjust screws (7). Start loading the specimen and take the reading of load on the machine at required elongation or the elongation at required load. Force setter accuracies mean of both the dial gauge (8) readings should be taken as elongation. It is very important to note & follow the practice of removing the extensometer from the specimen before the specimen breaks otherwise the instrument will be totally damaged. As a safety, while testing the instrument may be kept hanging from a fixed support by a slightly loose thread.



A) Stress-strain graph of Mild Steel



C) Stress-strain graphs of different materials.

• Curve **A** shows a **brittle** material. This material is also strong because there is little strain for a high stress. The fracture of a brittle material is sudden and catastrophic, with little or no plastic deformation. Brittle materials crack under tension and the stress increases around the cracks. Cracks propagate less under compression.

• Curve **B** is a **strong** material which is not ductile. Steel wires stretch very little, and break suddenly. There can be a lot of elastic strain energy in a steel wire under tension and it will "whiplash" if it breaks. The ends are razor sharp and such a failure is very dangerous indeed.

• Curve **C** is a **ductile** material

• Curve **D** is a **plastic** material. Notice a very large strain for a small stress.The material will not go back to its original length.

OBESERVATIONS:

A) Original dimensions

Gauge Length = ------------

Diameter = ---------

Area = --------------

B) Final Dimensions:

Gauge Length = -------------------

Diameter = -----------------

Area = ------------------------

TABULATION:- (Cross check 'E' with reference table 1.0)

S.No.	Extension (mm)		Load, N		Average Load	Young's Modulus E,
	Left	Right	Left	Right		
1						
2						
3						
4						
5						

i) **Limit of proportion** $= \dfrac{\text{Load at limit of proportionality}}{\text{Original area of cross-section}}$ N/mm^2

ii) **Elastic limit** $= \dfrac{\text{load at elastic limit}}{\text{Original area of c/s}}$ N/mm^2

Yield strength $= \dfrac{\text{Yield load}}{\text{Original area of cross-section}}$ N/mm^2

Ultimate strength $= \dfrac{\text{Maximum tensile load}}{\text{Original area of cross-section}}$

$$\text{Young's modulus} \quad E = \frac{Stress}{Strain} = \frac{F / A}{\Delta L / L}$$

$$\text{Percent elongation} = \frac{\text{final gage length} - \text{initial gage length}}{\text{initial gage length}}$$

$$= \frac{L_x - L_o}{L_o} = \text{inches per inch x } 100$$

Percent reduction of area (RA) =

$$\frac{\text{area of original cross section} - \text{minimum final area}}{\text{area of original cross section}}$$

$$= \frac{A_o - A_{min}}{A_o} = \frac{\text{decrease in area}}{\text{original area}} = \frac{\text{square inches or mm}}{\text{square inches or mm}} \text{ x } 100$$

PRECAUTIONS:-

1. If the strain measuring device is an extensometer it should be removed before necking begins.
2. Measure deflection on scale accurately & carefully.

GRAPH:

1. Stress Vs Strain

RESULT:-

i) Average Breaking Stress =

ii) Ultimate Stress =

iii) Average % Elongation =

iv) Modulus of Elasticity, E =

PRE LAB QUESTIONS

2. Define Hook's law
3. Define elastic and plastic limit of a material.
4. Explain young's modulus?
5. Define gauge length.
6. Define mechanical properties of a materials.
7. Define proof stress.

POST LAB QUESTIONS

1. What is the youngs modulus for steel, aluminium, brass.
2. What is ultimate tensile stress for steel, aluminium.
3. Identify upper & lower yield, proportional limit, fracture point on a σ-ϵ curve.

Experiment- 9

TORSION TEST

Aim: To conduct torsion test on mild steel or cast iron specimen to determine modulus of rigidity.

APPARATUS:

1. A torsion test machine along with angle of twist measuring attachment.
2. Standard specimen of mild steel or cast iron.
3. Steel rule.
4. Vernier caliper or a micrometer.

Torsion testing machine:

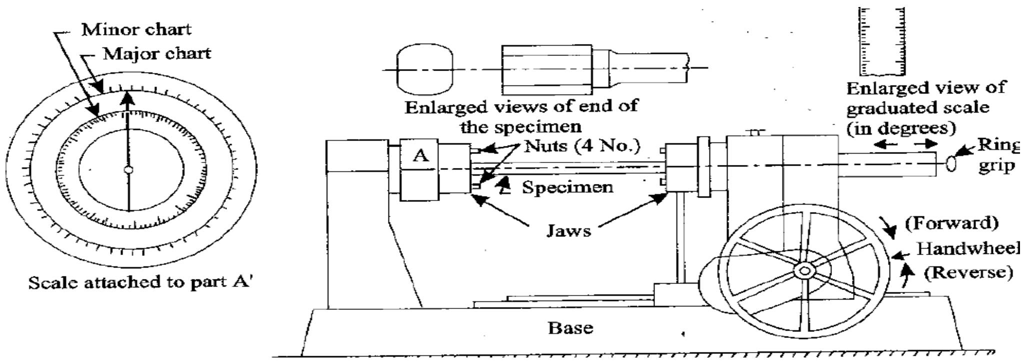
M/C SPECIFICATIONS:

Capacity: Torque Range: 0-10

Kg-m. Model: TTM-10..

SR.No: 2001/1012.

Mfd. By: Macro Testing Machines, Ichalkaranji, M.H, India.



THEORY:

For transmitting power through a rotating shaft it is necessary to apply a turning force. The force is applied tangentially and in the plane of transverse cross section. The torque or twisting moment may be calculated by multiplying two opposite turning moments. It is said to be in pure torsion and it will exhibit the tendency of shearing off at every cross section which is perpendicular to the longitudinal axis.

Torsion equation:

Torsion equation is given by below

$T/J = \tau/R = G\theta/L$

$G = T L/J \theta$ N/mm^2

T= maximum twisting torque (N mm)

J = polar moment of inertia

$(mm^4) = \pi d^4/32$ τ = shear

stress (N/mm^2)

G = modulus of

rigidity (N/mm^2) θ

= angle of twist in

radians

L= length of shaft under torsion (mm)

Assumptions made for getting torsion equation

1. The material of the shaft is uniform throughout.
2. The shaft, circular in section remain circular after loading.
3. Plane sections of shaft normal to its axis before loading remain plane after the torque have been applied.
4. The twist along the length of the shaft is uniform throughout.

5. The distance between any two normal-sections remains the same after the application of torque.

6. Maximum shear stress induced in the shaft due to application of torque does not exceed its elastic limit.

Procedure

1. Select the driving dogs to suit the size of the specimen and clamp it in the machine by adjusting the length of the specimen by means of a sliding spindle.
2. Measure the diameter at about three places and take the average value.
3. Choose the appropriate range by capacity change lever
4. Set the maximum load pointer to zero.
5. Set the protractor to zero for convenience and clamp it by means of knurled screw.
6. Carry out straining by rotating the hand wheel in either direction.
7. Load the machine in suitable increments.
8. Then load out to failure as to cause equal increments of strain reading.
9. Plot a torque- twist (T- θ) graph.

6. Read off co-ordinates of a convenient point from the straight line portion of the torque twist (T- θ) graph and calculate the value of G by using relation.

OBESERVATIONS:-

Gauge length of the specimen, L = ………

Diameter of the specimen, d = ………

Polar moment of inertia, $J = \pi d^4/32$ = ...

TABULATION: (Cross check ‘G’ with reference table 1.0)

Sl. No.	Torque, Kg-cm	Torque, N - mm	Angle of twist		Modulus Rigidity	Average G, N/mm^2
			Degrees	Radians		

PRECAUTIONS:-

1) Measure the dimensions of the specimen carefully
2) Measure the Angle of twist accurately for the corresponding value of Torque.
3) The specimen should be properly to get between the jaws.
4) After breaking specimen stop to m/c.

GRAPH:

1. Torque Vs Angle of Twist

RESULT :-

Thus the torsion test on given mild steel specimen is done and the modulus of rigidity is ------------- N/mm^2

Pre Lab Questions

1. Define torque.
2. Give the expression for torque.
3. Define modulus of rigidity.
4. Give the values of G for different materials.

Post Lab Questions

1. What is angle of twist?
2. Define Polar moment of inertia?

Experiment 10

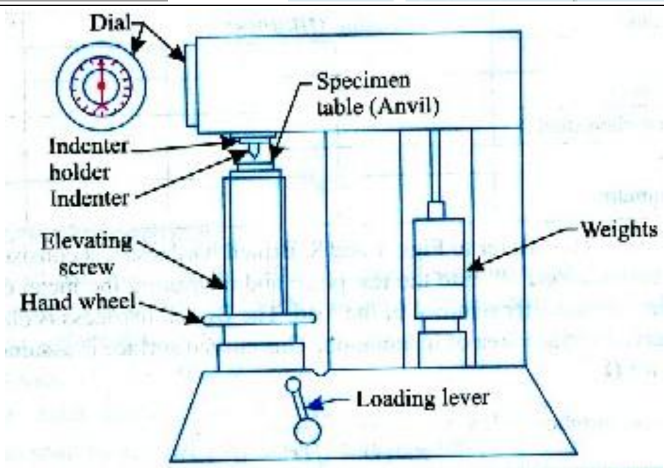
HARDNESS TEST

AIM: - To conduct hardness test on mild steel, carbon steel, brass and aluminum specimens.

APPARATUS:- Hardness tester, soft and hard mild steel specimens, brass, aluminum .

Diagram:

Nomenclature	Specifications
Loads	60,100,150,187.5, 250 (kgf)
Initial Load	10 (kgf)
Max. Test Height	230 (mm)
Depth of Throat	133 (mm)
Max. Depth of elevating screw below base	240 (mm)
Size of Base (approx)	171 x 423 (mm)
Machine Height	635 (mm)
Net weight (Approx)	75 Kg



THEORY: The hardness of a material is resistance to penetration under a localized pressure or resistance to abrasion. Hardness tests provide an accurate, rapid and economical way of determining the resistance of materials to deformation. There are three general types of hardness measurements depending upon the manner in which the test is conducted:

a. Scratch hardness measurement,

b. Rebound hardness measurement

c. Indention hardness measurement.

In scratch hardness method the material are rated on their ability to scratch one another and it is usually used by mineralogists only. In rebound hardness measurement, a standard body is usually dropped on to the material surface and the hardness is measured in terms of the height of its rebound. The general means of judging the hardness is measuring the resistance of a material to indentation. The indenters usually a ball cone or pyramid of a material much harder than that being used. Hardened steel, sintered tungsten carbide or diamond indenters are generally used in indentation tests; a load is applied by pressing the indenter at right angles to the surface being tested. The hardness of the material depends on the resistance which it exerts during a small amount of yielding or plastic. The resistance depends on friction, elasticity, viscosity and the intensity and distribution of plastic strain produced by a given tool during indentation.

10.1 BRINELL’S HARDNESS

AIM :-

To determine the Brinell’s hardness of the given test specimen.

APPARATUS:-

1. Brinell Hardness testing machine,
2. Specimen of mild steel / cast iron/ non ferrous metals
3. Brinell microscope.

THEORY:-

Hardness represents the resistance of material surface to abrasion, scratching and cutting, hardness after gives clear identification of strength. In all hardness testes, a define force is mechanically applied on the test piece for about 15 seconds. The indentor, which transmits the load to the test piece, varies in size and shape for different testes. Common indenters are made of hardened steel or diamond. In Brinell hardness testing, steel balls are

used as indentor. Diameter of the indentor and the applied force depend upon the thickness of the test specimen, because for accurate results, depth of indentation should be less than $1/8^{th}$ of the thickness of the test pieces. According to the thickness of the test piece increase, the diameter of the indentor and force are changed. A hardness test can be conducted on Brinell testing m/c, Rockwell hardness m/c or vicker testing m/c. the specimen may be a cylinder, cube, thick or thin metallic sheet. A Brinell- cum-Rockwell hardness testing m/c along with the specimen is shown in figure. Its specification are as follows:

1. Ability to determine hardness upto 500 HB.
2. Diameter of ball (as indentor) used D = 2.5mm, 5mm, 10mm.
3. Maximum application load = 3000kgf.
4. Method of load application = Lever type
5. Capability of testing the lower hardness range = 1 HB on application of 0.5D2 load.

Indentation Hardness-A number related to the area or to the depth of the impression made by an indenter or fixed geometry under a known fixed load. This method consists of indenting the surface of the metal by a hardened steel ball of specified diameter D mm under a given load F kgf and measuring the average diameter d mm of the impression with the help of Brinell microscope fitted with a scale.

The Brinell hardness is defined, as the quotient of the applied force F divided by the spherical area of the impression.

HB = Load Applied (kgf.)/ Spherical surface area indentation (in mm.)

$$= 2F / \pi D (D - \sqrt{D^2 - d^2}) \text{ kg/mm}^2$$

PROOF:-

For any sphere of diameter "D" the surface area between any two parallel planes with distance "h" between them = ΠD x h

The spherical indentation in the Brinell hardness test is indicated by the portion A-C-B

A = Surface area of potion ACB of spheres = ΠD x CE

But CE = OC-OE

$= D/2 - \sqrt{(OA)^2 - (AE)}^2$

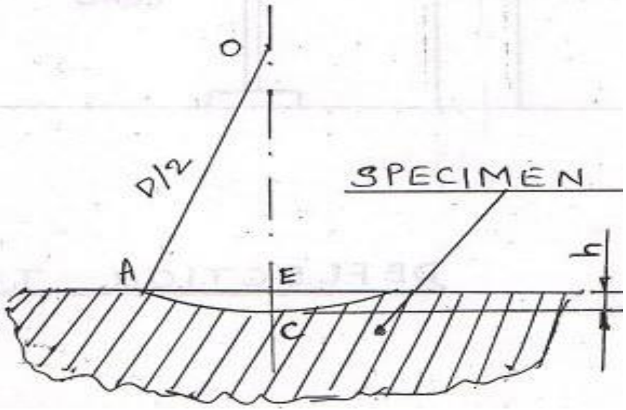
$= D/2 - \sqrt{(D/2)^2 - (d/2)^2}$

$= 1/2(D - \sqrt{(D^2 - d^2)}$

Area(A) = ΠD x CE

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

Hardness =F/A= $2F/_{\pi D}$ $(D - \sqrt{D^2 - d^2})$



PROCEDURE:

1. Select the proper size of the ball and load to suit the material under test.
2. Clean the test specimen to be free from any dirt and defects or blemishes.
3. Mount the test piece surface at right angles to the axis of the ball indenter plunger.
4. Turn the platform so that the ball is lifted up.
5. By shifting the lever applies the load and waits for some time.
6. Release the load by shifting the lever.
7. Take out the specimen and measure the diameter of indentation by means of the Brinell microscope.
8. Repeat the experiments at other positions of the test piece.
9. Calculate the value of HB.

OBSERVATIONS:

Test piece material =

Diameter of the ball, D =

Load section, P/D^2 =

Test load =

TABULATION: (Cross check with reference tables)

S. No.	**Impression Diameter**			**Load Applied, Kg**	**Diameter of Ball, D mm**	**Average HB Kg/mm^2**
	d_1	**d_2**	**$(d_1 + d_2)/2$**			
1						
2						
3						

PRECAUTIONS:-

- The surface of the test piece should be clean.
- The testing machine should be protected throughout the test from shock or vibration.
- The test should be carried out at room temperature.
- The distance of the center of indentation from the edge of test piece should be at least 2.5 times the diameter of the indentation and the distance between the centres of the two adjacent indentations should be at least 4 times the diameter of the indentation.
- The diameter of each indentation should be measured in two directions at right angles and themean value readings used the purpose of determining the hardness number.

RESULT:-

The Brinell hardness number of the specimen is --------

10.2. ROCKWELL HARDNESS TEST

AIM :

To study the Rockwell Hardness testing machine and perform the Rockwell hardness test.

APPARATUS: -

1. Rockwell Hardness testing machine,
2. Specimen of mild steel or other material.

THEORY: -

Hardness represents the resistance of material surface to abrasion, scratching and cutting, hardness after gives clear indication of strength. In all hardness tests, a define force is mechanically applied on the piece, varies in size and shape for different tests. Common indentors are made of hardened steel or diamond. Rockwell hardness tester presents direct reading of hardness number on a dial provided with the m/c. principally this testing is similar to Brinell hardness testing. It differs only in diameter and material of the indentor and the applied force. Although there are many scales having different combinations of load and size of indentor but commonly 'C' scale is used and hardness is presented as HRC. Here the indentor has a diamond cone at the tip and applied force is of 150 kgf. Soft materials are often tested in 'B' scale with a 1.6mm dia. Steel indentor at 60kgf. A hardness test can be conducted can be conducted on Brinell testing m/c, Rockwell hardness m/c or vicker testing m/c. The specimen may be a cylinder, cube, thick or thin metallic sheet. A Brinell-cum- Rocwell hardness testing m/c along with the specimen is shown in figure.

ASTM E 18 - 2000, Standard Test Methods for Rockwell Hardness and Rockwell Superficial Hardness of Metallic Materials.

ISO 6508-1 Metallic Materials - Rockwell hardness test (scales A, B, C, D, E, F, G, H, K, N,
T) - Part 1: Test method, 1999-09-01

ISO 6508-2 Metallic Materials - Rockwell hardness test (scales A, B, C, D, E, F, G, H, K, N,
T) - Part 2: Verification of testing machines, 1999-09-01

ISO 6508-3 Metallic Materials - Rockwell hardness test (scales A, B, C, D, E, F, G, H, K, N,

T) - Part 3: Calibration of reference blocks, 1999-09-01

Rockwell-cum-Brinell's hardness tester

PROCEDURE:-

1. Insert ball of dia. 'D' in ball holder of the m/c.
2. Make the specimen surface clean by removing dust, dirt, oil and grease etc.
3. Make contact between the specimen surface and the ball by rotating the jack adjusting wheel.
4. Push the required button for loading.
5. Pull the load release lever wait for minimum 15 second. The load will automatically apply gradually.
6. Remove the specimen from support table and locate the indentation so made.
7. Repeat the entire operation, 3-times.

OBSERVATIONS:

Material of the specimen =

Thickness of test specimen =

Hardness scale used =

TABULATION: (Cross check with reference tables)

S. No.	Material	Rockwell Scale			Rockwell Number			Average
		Scale	Load	Indent	1	2	3	
1								
2								
3								
4								

PRECAUTIONS:

1. For testing cylindrical test specimens use V-type platform.
2. Calibrate the machine occasionally by 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 some time to allow the needle to come to rest. The waiting time may vary from 2 t0 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 of cold working.
7. The distance between the canters of two adjacent indentation should be at least 4 times the diameter of the indentation and the distance from the center of any indentation to the edge of the test piece should be at least 2.5 times the diameter of the indentation.

RESULT:-

Rockwell hardness of given specimen is --------

Viva Questions:

1. Define Hardness.
2. How the hardness will vary from hardened to unhardened steels.
3. What are the various methods of finding the hardness number of materials.

Experiment – 11

SPRING TEST

AIM: To determine the stiffness and modulus of rigidity of the spring wire.

APPARATUS: -

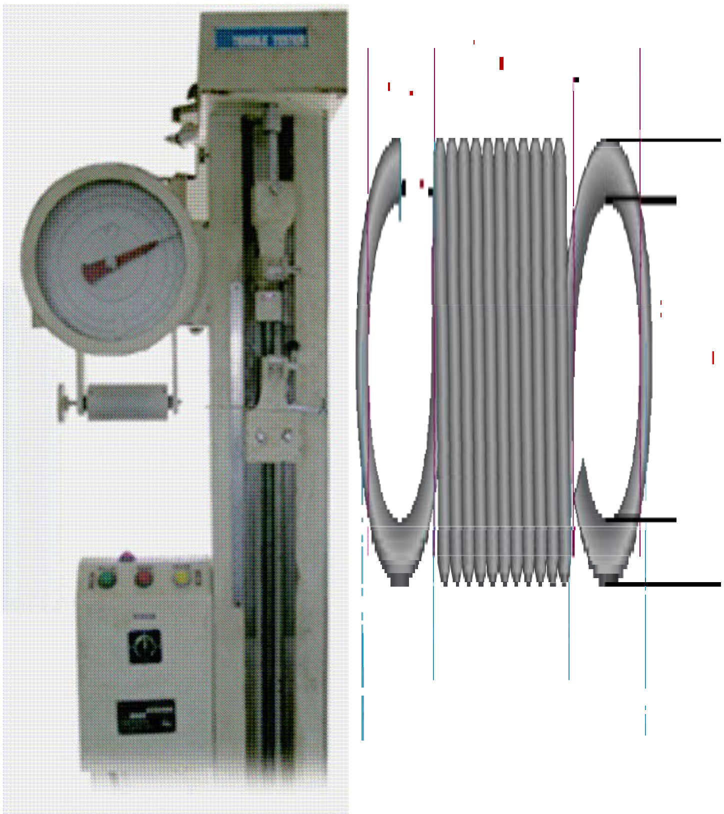
i) Spring testing machine.

ii) A spring

iii) Vernier caliper, Scale.

iv) Micrometer.

DIAGRAM:-



M/C SPECIFICATIONS:

Capacity:

0-250 Kgf.

Model:

MX-250

SR.No:

2001/1001.

Mfd. By: Macro Testing Machines, Ichalkaranji, M.H, India.

THEORY: -

Springs are elastic member which distort under load and regain their original shape when load is removed. They are used in railway carriages, motor cars, scooters, motorcycles, rickshaws, governors etc. According to their uses the springs perform the following Functions:

1) To absorb shock or impact loading as in carriage springs.
2) To store energy as in clock springs.
3) To apply forces to and to control motions as in brakes and clutches.
4) To measure forces as in spring balances.
5) To change the variations characteristic of a member as in flexible mounting of motors.

The spring is usually made of either high carbon steel (0.7 to 1.0%) or medium carbon alloy steels. Phosphor bronze, brass, 18/8 stainless steel and Monel and other metal alloys are used for corrosion resistance spring. Several types of spring are available for different application. Springs may classified as helical springs, leaf springs and flat spring depending upon their shape. They are fabricated of high shear strength materials such as high carbon alloy steels spring form elements of not only mechanical system but also structural system. In several cases it is essential to idealise complex structural systems by suitable spring.

PROCEDURE:

1) Measure the outer diameter (D) and diameter of the spring coil (d) for the given compression spring.
2) Count the number of turns i.e. coils (n) in the given compression specimen.
3) Place the compression spring at the centre of the bottom beam of the spring testing machine.
4) Insert the spring in the spring testing machine and load the spring by a

suitable weight and note the corresponding axial deflection in tension or compression.

5) Note down the initial reading from the scale in the machine.
6) Increase the load and take the corresponding axial deflection readings.
7) Find the actual deflection of the spring for each load by deducting the initial scale reading from the corresponding scale reading.
8) Calculate the modulus of rigidity for each load applied.
9) Plot a curve between load and deflection. The shape of the curve gives the stiffness of the spring.

FORMULA:

Modulus of rigidity, $G = \frac{64WR^3 n}{\delta d^4}$

Where,

i. W = Load in N

ii. R = Mean radius of the spring in mm (D –(d /2))/2

iii. d = Diameter of the spring coil in mm

iv. δ = Deflection of the spring in mm

v. D = Outer diameter of the spring in mm.

OBESERVATIONS:

10) Material of the spring specimen =
11) Least count of micrometer = ……...mm
12) Diameter of the spring wire, d
=………mm (Mean of three readings)
13) Least count of Vernier Caliper = ……...mm
14) Diameter of the spring coil, D =
……...mm (Mean of three readings)
15) Number of turns, n =
16) Initial scale reading = ……...mm

TABULATION:

S.No.	Applied Load		Scale Reading, mm	Actual Deflection,	Modulus of Rigidity, GPa	Stiffness, N/mm
	Kg	N				
1						
2						
3						
4						
5						

GRAPH:

1. **Load Vs Deflection**

PRECAUTIONS:-

1) Dimensions should be measure accurately with the help of Vernier Calipers.
2) Deflection from the scale should be noted carefully and accurately.

RESULT:

The modulus of rigidity of the given spring = ------------------- GPa

The stiffness of the given spring = -------------------N/mm^2

VIVA QUESTIONS:-

1. Define stiffness of a material.
2. Explain various types of springs.
3. How modulus of rigidity of a same material will vary with varying dimensions?

Experiment 12

COMPRESSION TEST ON CONCRETE

AIM:- To perform compression test on UTM.

APPARATUS:-

1. UTM or A compression testing m/c,
2. Cylindrical or cube shaped specimen,
3. Vernier caliper,
4. Liner scale.

DIAGRAM:-

THEORY:-

Bricks are used in construction of either load bearing walls or in portion walls incase of frame structure. In bad bearing walls total weight from slab and upper floor comes directly through brick and then it is transversed to the foundation. In case the bricks are loaded with compressive nature of force on other hand in case of frame structure bricks are used only for construction of portion walls, layers comes directly on the lower layers or wall. In this case bricks are loaded with compressive nature of force. Hence for safely measures before using the bricks in actual practice they have to be tested in laboratory for their compressive strength.

PROCEDURE: -

1. Select some brick with uniform shape and size.
2. Measure its all dimensions. (LxBxH)
3. Now fill the frog of the brick with fine sand. And
4. Place the brick on the lower platform of compression testing machine and lower the spindle till the upper motion of ram is offered by a specimen the oil pressure start increasing the pointer start returning to zero leaving the drug pointer that is maximum reading which can be noted down.

5.1 TABULATION:-(Refer Tables)

S. No.	L x B x H, Cm^3	Area, L x B, Cm^2	Load (P), N	Compressive Strength (P/A), KPa	Avg. Compressive Strength (P/A),
1					
2					
3					
4					
5					

CALCULATION:-

Max. Load at failure
Compressive Strength = -------------------------- Kpa
Loaded area of brick Area

RESULT:- The average compressive strength of new brick sample is found to be ………. **KPa**

PRECAUTIONS:-

1) Measure the dimensions of Brick accurately.
2) Specimen should be placed as for as possible in the of lower plate.
3) The range of the gauge fitted on the machine should not be more than double the breaking load of specimen for reliable results.

Compressive and tensile strength of some common materia

Material	Compression Strength		Tension Strength	
	(psi)	*(kPa)*	*(psi)*	*(kPa)*
Bricks, hard	12000	80000	400	2800
Bricks, light	1000	7000	40	280
Brickwork, common quality	1000	7000	50	350
Brickwork, best quality	2000	14000	300	2100
Granite	19000	130000	700	4800
Limestone	9000	60000	300	2100
Portland Cement, less than one month old	2000	14000	400	2800
Portland Cement, more than one year old	3000	21000	500	3500
Portland Concrete	1000	7000	200	1400
Portland Concrete, more than one year old	2000	14000	400	2800
Sandstone	9000	60000	300	2100
Slate	14000	95000	500	3500
Trap rock	20000	140000	800	5500

Image credit: http://www.engineeringtoolbox.com/compression-tension-strength-d_1352.html

Experiment 13

a) IMPACT TEST (CHARPY)

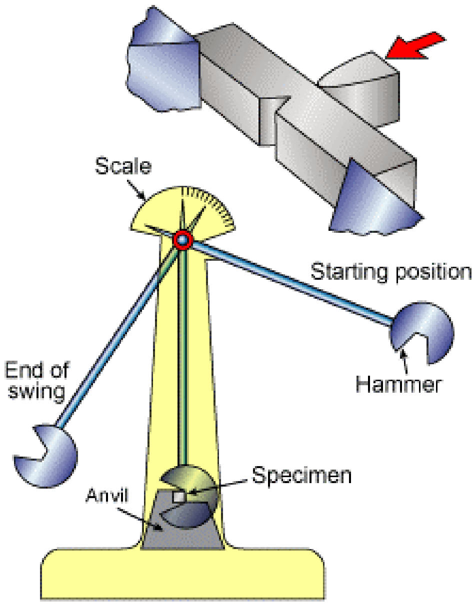
AIM: -To determined impact strength of steel**.**

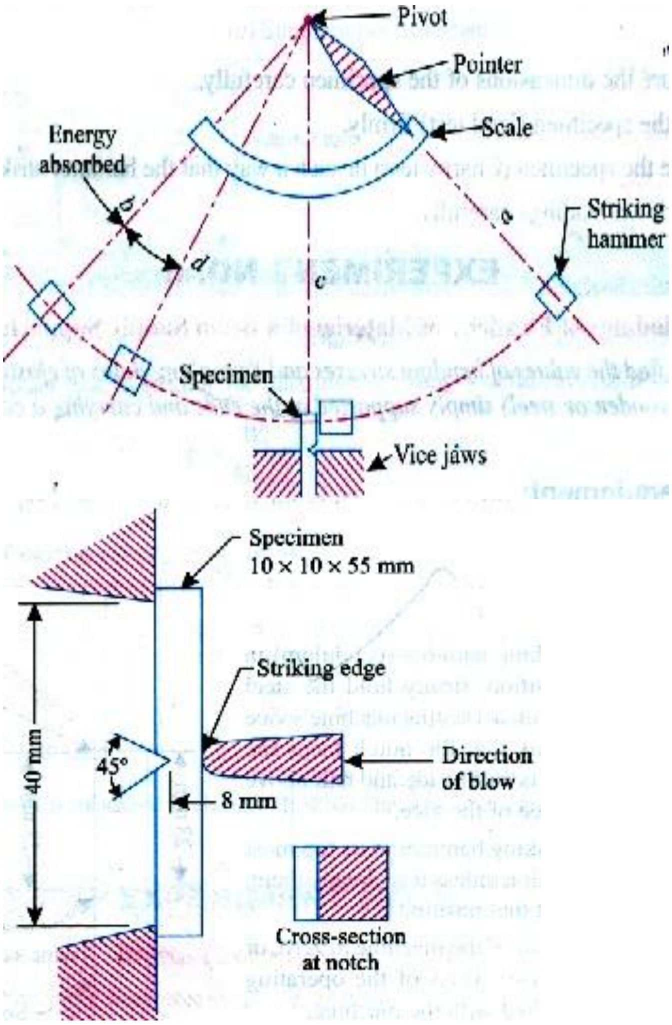
OBJECT: -To Determine the impact strength of steel by (Charpy test)

APPARATUS: -1. Impact testing machine

2. A steel specimen 10 mm x 10 mm X 55mm

DIAGRAM:-





THEORY:-

An impact test signifies toughness of material that is ability of material to absorb energy during plastic deformation. Static tension tests of unmatched specimens do not always reveal the susceptibility of a metal to brittle fracture. This important factor is determined by impact test. Toughness takes into account both the strength and ductility of the material. Several engineering materials have to withstand impact or suddenly applied loads while in service. Impact strengths are generally lower as compared to strengths achieved under slowly applied loads. Of all types of impact tests, the notch bar tests are most extensively used. Therefore, the impact test measures the energy necessary to fracture a standard notch bar by applying an impulse load. The test measures the notch toughness of material under shock loading. Values obtained from these tests are not of much utility to design problems directly and are highly arbitrary. Still it is important to note that it provides a good way of comparing toughness of various materials or toughness of the same material under different condition. This test can also be used to assess the ductile brittle transition temperature of the material occurring due to lowering of temperature.

PROCEDURE:-

(b) Charpy Test

1. With the striking hammer (pendulum) in safe test position, firmly hold the steel specimen in impact testing machines vice in such a way that the notch faces s the hammer and is half inside and half above the top surface of the vice.
2. Bring the striking hammer to its top most striking position unless it is already there, and lock it at that position.
3. Bring indicator of the machine to zero, or follow the instructions of the operating manual supplied with the machine.
4. Release the hammer. It will fall due to gravity and break the specimen through its momentum, the total energy is not absorbed by the specimen. Then it continues to swing. At its topmost height after breaking the specimen, the indicator stops moving, while the pendulum falls back. Note the indicator at that topmost final position.
5. The specimen is placed on supports or anvil so that the blow of hammer is opposite to the notch.

OBESERVATIONS:-

Charpy test

1. Impact value of - Mild Steel ------------N-m
2. Impact value of - Brass ------------N-m
3. Impact value of - Aluminum ------------N-m

RESULT:-

i.The energy absorbed for Mild Steel is found out to be (K)-------------Joules.

ii. The energy absorbed for Brass is found out to be (K)------------ Joules.

iii. . The energy absorbed for Aluminum is found out to be (K) -------------Joules

iv. Impact strength of the specimen, (K/A) = -------------------J/mm^2

PRECAUTIONS:-

1. Measure the dimensions of the specimen carefully.
2. Locate the specimen (Charpy test) in such a way that the hammer, strikes it at the middle.
3. Note down readings carefully.

VIVA QUESTIONS:

1. Define toughness.
2. What is the difference between notched and unnotched specimens?

13.2 IMPACT TEST (IZOD TEST)

AIM: - To Determine the impact strength of steel by Izod impact test

APPARATUS: - 1.Impact testing machine

2. A steel specimen 75 mm X 10mm X 10mm

DIAGRAM:-

M/C SPECIFICATIONS:

Capacity: Energy range: i. Charpy: 0-300 J.

ii. Izod: 0-168 J.

Model:

ITM-300

SR.No:

2001/1016

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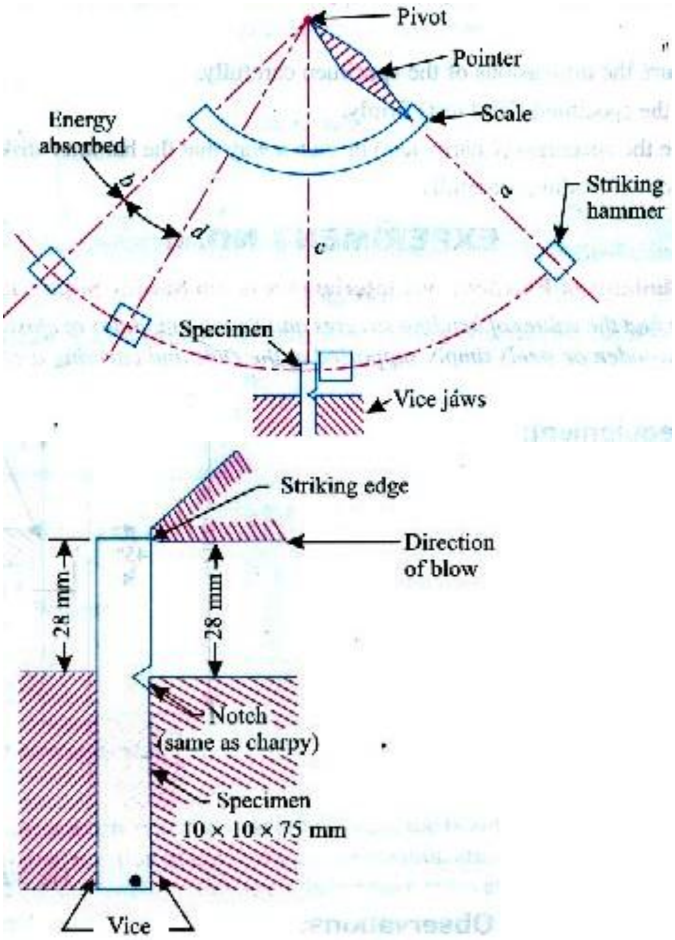
Mfd. By: Macro Testing Machines, Ichalkaranji, M.H, India.



THEORY:-

An impact test signifies toughness of material that is ability of material to absorb energy during plastic deformation. Static tension tests of unnotched specimens do not always reveal the susceptibility of a metal to brittle fracture. This important factor is determined by impact test. Toughness takes into account both the strength and ductility of the material. Several engineering materials have to withstand impact or suddenly applied loads while in service. Impact strengths are generally lower as compared to strengths achieved under slowly applied loads. Of all types of impact tests, the notch bar tests are most extensively used. Therefore, the impact test measures the energy necessary to fracture a standard notch bar by applying an impulse load. The test measures the notch toughness of material under shock loading. Values obtained from these tests are not of much utility to design problems directly and are highly arbitrary. Still it is important to note that it provides a good way of comparing toughness of various materials or toughness of the same material under different condition. This test can also be used to assess the ductile brittle transition temperature of the material occurring due to lowering of temperature.

PROCEDURE:-

(a) lzod test

1. With the striking hammer (pendulum) in safe test position, firmly hold the steel specimen in impact testing machine's vice in such a way that the notch face the hammer and is half inside and half above the top surface of the vice.

2. Bring the striking hammer to its top most striking position unless it is already there, and lock it at that position.

3. Bring indicator of the machine to zero, or follow the instructions of the operating manual supplied with the machine.

4. Release the hammer. It will fall due to gravity and break the specimen through its momentum, the total energy is not absorbed by the specimen. Then it continues to swing. At its topmost height after breaking the specimen, the indicator stops moving, while the pendulum falls back. Note the indicator at that topmost final position.

5. Again bring back the hammer to its idle position and back

OBESERVATIONS:-

Izod Test.

1. Impact value of - Mild Steel ------------N-m
2. Impact value of - Brass ------------N-m
3. Impact value of - Aluminum ------------N-m

PRECAUTIONS:-

1. Measure the dimensions of the specimen carefully.
2. Hold the specimen (lzod test) firmly.
3. Note down readings carefully.

RESULT:-

ii. The energy absorbed for Mild Steel is found out to be (K) ----------------Joules.

iii.The energy absorbed for Brass is found out to be (K) ------------------- Joules.

iv. The energy absorbed for Aluminium is found out to be (K) ------------------ Joules

v. Impact strength of the specimen, (K/A) = -------------------J/mm^2

Experiment 14

SHEAR TEST

AIM: -To find the shear strength of given specimen

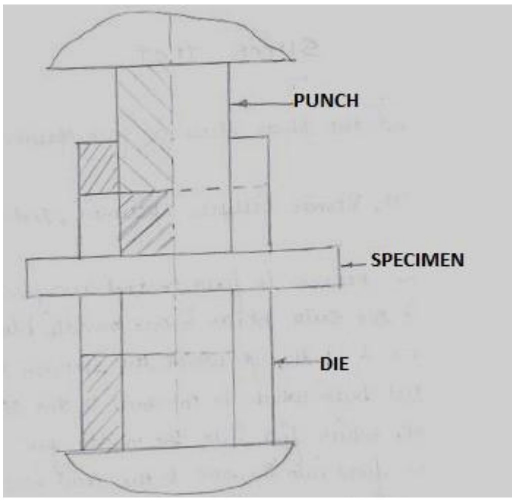
APPARATUS: -

i) Universal testing machine.

ii) Shear test attachment.

iii) Specimens.

DIAGRAM:-



THEORY:-

Place the shear test attachment on the lower table, this attachment consists of cutter. The specimen is inserted in shear test attachment & lift the lower table so that the zero is adjusted, then apply the load such that the specimen breaks in two or three pieces. If the specimen breaks in two pieces then it will be in single shear & if it breaks in three pieces then it will be in double shear.

PROCEDURE:

1. Insert the specimen in position and grip one end of the attachment in the upper portion and one end in the lower portion.
2. Switch on the main switch of universal testing machine machine.
3. The drag indicator in contact with the main indicator.
4. Select the suitable range of loads and space the corresponding weight in the pendulum and balance it if necessary with the help of small balancing weights.

5. Operate (push) buttons for driving the motor to drive the pump.

6. Gradually move the head control level in left-hand direction till the specimen shears.

7. Down the load at which the specimen shears.

8. Stop the machine and remove the specimen

9. Repeat the experiment with other specimens.

OBESERVATIONS:-

Diameter of the Rod, D = ….. mm

Cross-section area of the Rod (in double shear) = 2x

$\pi/4$x d^2 =.. mm^2 Load taken by the Specimen at the

time of failure , W =N Strength of rod against

Shearing = fx2x $\pi/4$x d^2

$f = \mathbf{W / 2.\pi/4.d^2}$ N/mm^2

PRECAUTIONS:-

1. The measuring range should not be changed at any stage during the test.
2. The inner diameter of the hole in the shear stress attachment should be slightly greater than that of the specimen.
3. Measure the diameter of the specimen accurately.

RESULT:

The Shear strength of mild steel specimen is found to be = ……………… N/mm2

VIVA QUESTIONS:

1. Define shear stress.
2. Give the classification of stress.
3. What is the relationship between G and E.