MARRI LAXMAN REDDY
INSTITUTE OF TECHNOLOGY AND MANAGEMENT
(AN AUTONOMOUS INSTITUTION)
(Approved by AICTE, New Delhi & Affiliated to JNTUH, Hyderabad)
Accredited by NBA and NAAC with 'A' Grade & Recognized Under Section2(f) & 12(B)of the UGC act,1956

DEPARTMENT MECHANICAL ENGINEERING

MATERIAL SCIENCE AND MECHANICS OF SOLIDS
LAB MANUAL

SUBJECT NAME	**Material Science and Mechanics of Solids Lab**
SUBJECT CODE	**1930375**
COURSE-BRANCH	**B. Tech - Mechanical Engineering**
YEAR-SEMESTER	**II - I**
ACADEMIC YEAR	**2020-2021**
REGULATION	**MLRS-R19**

MARRI LAXAMAN REDDY

INSTITUTE OF TECHNOLOGY AND MANAGEMENT

MISSION AND VISION OF THE INSTITUTE:

Our Vision:

To establish as an ideal academic institutions in the service of the nation the world and the humanity by graduating talented engineers to be ethically strong globally competent by conducting high quality research, developing breakthrough technologies and disseminating and preserving technical knowledge.

Our Mission:

To fulfill the promised vision through the following strategic characteristics and aspirations:

- Contemporary and rigorous educational experiences that develop the engineers and managers;
- An atmosphere that facilitates personal commitment to the educational success of students in an environment that values diversity and community;
- Prudent and accountable resource management;
- Undergraduate programs that integrate global awareness, communication skills and team building across the curriculum;
- Leadership and service to meet society's needs;
- Education and research partnerships with colleges, universities, and industries to graduate education and training that prepares students for interdisciplinary engineering research and advanced problem solving;
- Highly successful alumni who contribute to the profession in the global society.

Vision and Mission statements of the Department of Mechanical Engineering:

Vision Statement:

"The Mechanical Engineering Department strives immense success in the field of education, research and development by nurturing the budding minds of young engineers inventing sets of new designs and new products which may be envisaged as the modalities to bring about a green future for humanity"

Mission Statement:

1. Equipping the students with manifold technical knowledge to make them efficient and independent thinkers and designers in national and international arena.

2. Encouraging students and faculties to be creative and to develop analytical abilities and efficiency in applying theories into practice, to develop and disseminate new knowledge.

3. Pursuing collaborative work in research and development organizations, industrial enterprises, Research and academic institutions of national and international, to introduce new knowledge and methods in engineering teaching and research in order to orient young minds towards industrial development.

PROGRAM EDUCATIONAL OBJECTIVE

PEO 1: Graduates shall have knowledge and skills to succeed as Mechanical engineer's for their career development.

PEO 2: Graduates will explore in research.

PEO 3: Mechanical Graduates shall have the ability to design products with various interdisciplinary skills

PEO 4: Graduates will serve the society with their professional skills

PROGRAM OUTCOMES

- **A.** Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals and an engineering specialization for the solution of complex engineering problems.
- **B.** Problem Analysis: Identify, formulate, research, review the available literature and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural science and engineering sciences.
- **C.** Design and development of solutions: Design solutions for complex engineering problems and design system components or processes that meet the specific needs with appropriate considerations for public health safety and cultural, societal and environmental considerations.
- **D.** 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.
- **E.** Modern tool usage: Create, select and apply appropriate techniques, resources and modern engineering and IT tools including predictions and modeling to complex engineering activities with an understanding of the limitations.
- **F.** 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 practices.
- **G.** Environment and sustainability: Understand the impact of the professional engineering solutions in society and environmental context and demonstrate the knowledge of and need for sustainable development.
- **H.** Ethics: Apply ethical principles and commitment to professional ethics, responsibilities and norms of the engineering practice.
- **I.** Individual and team work: Function effectively as an individual and as a member or leader in diverse teams and in multi disciplinary settings.
- **J.** Communication: Communicate effectively on complex engineering activities with the engineering community and with the society at large, such as being able to comprehend, write effective reports, design documentation, make effective presentations, give and receive clear instructions.
- **K.** 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.
- **L.** Life – long learning: Recognize the need and have the preparation, ability to engage in independent and life – long learning in the broadest context of technological change.

PROGRAMME SPECIFIC OUTCOMES:

PS01: Students acquire necessary technical skills in mechanical engineering that make them employable graduate.

PSO2: An ability to impart technological inputs towards development of society by becoming an entrepreneur.

COURSE OBJECTIVES:

1. The purpose of this course is to make the students learn the concepts of Metallurgy and Material Science role in all manufacturing processes which convert raw materials into useful products adapted to human needs.
2. Students will be able to understand basic concepts of stress, strain and their relations based on linear elasticity. Material behaviors due to different types of loading will be discussed.
3. Students will be able to understand and know how to calculate stresses and deformation of a bar due to an axial loading under uniform and non-uniform conditions.
4. Students will understand how to develop shear-moment diagrams of a beam and find the maximum moment/shear and their locations.
5. Students will understand how to calculate normal and shear stresses on any crosssection of a beam. Different cross-sections (including I-beam) will be discussed.

COURSE OUTCOMES:

ME 376.1	Provide fundamental knowledge based on associated materials properties.
ME 376.2	Provide fundamental knowledge based on selection and application.
ME 376.3	Students would acquire and develop skills for careers in material related industries.
ME 376.4	Analyze the behavior of the solid bodies subjected to various types of loading.
ME 376.5	Analyze and interpret laboratory data relating to behavior of structures and the materials.
ME376.6	Apply knowledge of materials and structural elements to the analysis of simple structures.

INSTRUCTIONS TO THE STUDENTS

1. Every student should obtain a copy of the laboratory manual
2. It is important that all students arrive at each session on time.
3. Dress code: Students must come to the laboratory wearing:
    - Trousers.
    - half-sleeve tops.
    - Leather shoes.
    - Half pants, loosely hanging garments and slippers are not allowed.
4. Students should come with thorough preparation for the experiment to be conducted.
5. Students will not be permitted to attend the laboratory unless they bring the practical record fully completed in all respects pertaining to the experiment conducted in the previous class.
6. Experiment should be started only after the staff-in-charge has checked the experimental setup.
7. All the calculations should be made in the observation book. Specimen calculations for one set of readings have to be shown in the practical record.
8. Wherever graphs are to be drawn, A-4 size graphs only should be used and the same should be firmly attached to the practical record.
9. Practical record and observation should be neatly maintained.
10. They should obtain the signature of the staff-in-charge in the observation book after completing each experiment.
11. Theory regarding each experiment should be written in the practical record before procedure in your own words.

LABORATORY SAFETY PRECAUTIONS

1. Laboratory uniform, shoes & safety glasses are compulsory in the lab.
2. Do not touch anything with which you are not completely familiar. Carelessness may not only break the valuable equipment in the lab but may also cause serious injury to you and others in the lab.
3. Please follow instructions precisely as instructed by your supervisor. Do not start the experiment unless your setup is verified & approved by your supervisor.
4. Do not leave the experiments unattended while in progress.
5. Do not crowd around the equipment's & run inside the laboratory.
6. During experiments material may fail and disperse, please wear safety glasses and maintain a safe distance from the experiment.
7. If any part of the equipment fails while being used, report it immediately to your supervisor. Never try to fix the problem yourself because you could further damage the equipment and harm yourself and others in the lab.
8. Keep the work area clear of all materials except those needed for your work and cleanup after your work.

LIST OF EXPERIMENTS:

1. Preparation and study of crystal models for simple cubic, body centered cubic, face centered cubic and hexagonal close packed structures.
2. Preparation and study of the Microstructure of pure metals like Iron, Cu and Al.
3. Preparation and study of the Microstructure of Mild steels, low carbon steels, high – C steels.
4. Study of the Microstructure of Cast iron.
5. Study of the Microstructure of Non-Ferrous Alloys.
6. Hardenability of steels by Jominy End Quench Test.
7. Direct tension test.
8. Bending test on Simple supported beam.
9. Bending test on Cantilever beam.
10. Torsion test.
11. Brinell hardness test/Rockwell hardness test.
12. Test on springs.
13. Izod Impact test/Charpy Impact test.

Contents

S No	Title of The Experiments	Page No
1	Preparation and study of crystal models for simple cubic, body centered cubic, face centered cubic and hexagonal close packed structures	10-16
2	Preparation and study of the Microstructure of pure metals like Iron, Cu and Al	17-28
3	Preparation and study of the Microstructure of Mild steels, low carbon steels, high – C steels.	29-38
4	Study of the Microstructures of Cast Irons.	39-42
5	Study of the Microstructures of Non-Ferrous alloys	43-45
6	Hardenability of steels by Jominy End Quench Test	46-50
7	Find The Hardness of the Various Treated and Untreated plain carbon Steels	51-54
8	Direct tension test	55-63
9	Bending test on Simple supported beam.	64-69
10	Bending test on Cantilever beam	70-73
11	Torsion test	74-80
12	Brinell hardness test / Rockwell hardness test	81-90
13	Test on springs	91-100
14	Izod Impact test / Charpy Impact test	101-111

EXPERIMENT NO: 1

Preparation and study of crystal models for simple cubic, body centered cubic, face centered cubic and hexagonal close packed structures

Objective:

Preparation and Study the Crystal Models for Simple Cubic, Body Centered Cubic, Face Centered Cubic and Hexagonal Close Packed Structures

Outcomes:

The student will be able to

Describe the arrangement of atoms and ions in crystalline structures

Compute ionic radii using unit cell dimensions

Scope of the Experiment:

Importance of crystal structures every physical body in this world is made up of a basic entity called atoms. When these atoms arranged in a regular pattern, unique arrangement, they form a lattice structure for a crystalline solid/liquid body. The lattice structure finally determines one's physical properties.

Theory:

BCC:

In body centered cubic structure each one atom is placed at the corner of the cube and one atom is placed at the Centre of the cube. Iron has BCC structure. At room temperature the unit cell of iron has an atom at each corner and another at the body center of the cube. Each iron atom in BCC structure is surrounded by eight adjacent iron atoms. The unit cell of a cubic cell contains eight atoms at corners which are shared by the adjoining eight cubes.

Hence the share of each cube = ⅛ of each corner atoms

Total no of atoms = ⅛ × 8 = 1 atom BCC crystal has one atom at center. So, total no. of atoms in BCC = 2 atoms

FCC:

In this type of structure, the unit cell contains one atom at center of each corner plus at each face. Examples of such type of crystal structure are copper, silver, gold etc. In FCC crystal the atom on each face is surrounded or shared by two cubes. Son contribution of each towards crystal is ½, one atom at each corner. i.e., shared by eight other cubes so that its contribution towards crystal is ⅛. So total no of atoms = ⅛ × 8 + ′ ×6 = 4 atoms

HCP:

In case of hexagonal closed packing structure there are 12 atoms at corner. One atom at the center of two hexagonal faces and three atoms symmetrically arranged in the body of unit cell.

Total no of atoms per unit cell = $1/6 \times 6 + 1/6 \times 6 + ½ \times 2 + 3 = 6$ atoms

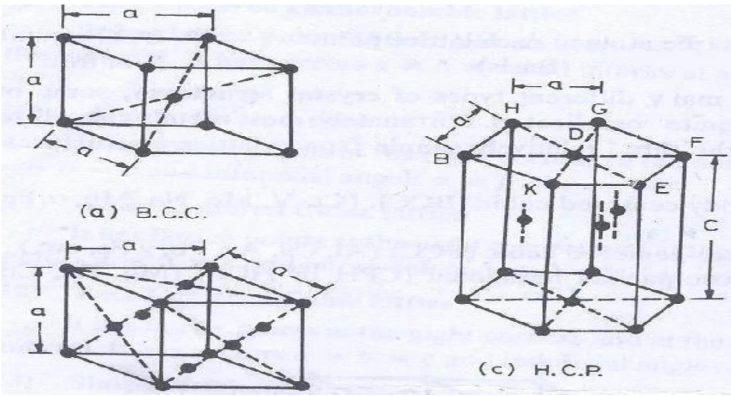


Fig: Type’s crystal structures (BCC FCC and HCP)

Atomic Radius:

It is defined as half the distance between the nearest neighbors in the crystal structure of a pure element. It is expressed in terms of the cube edge element and denoted by r.

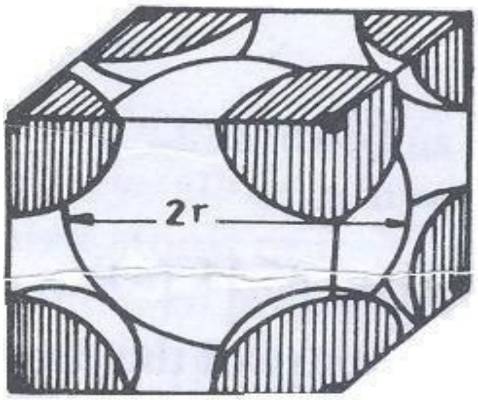
BCC:

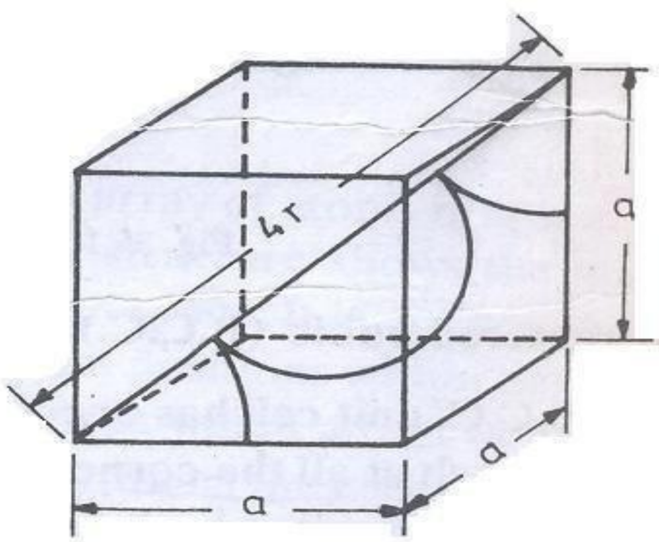
In this structure, the atoms touch each corner along the diagonal of the cube. So, $AB^2 = a^2 + a^2$

$AB^2 = 2a^2$

$(AC^2) = (AB^2) + (BC^2)$ $(AC^2) = 2a^2 + a^2$

$4r = \sqrt{3}\ a^2$ $r = \sqrt{3}/4a$



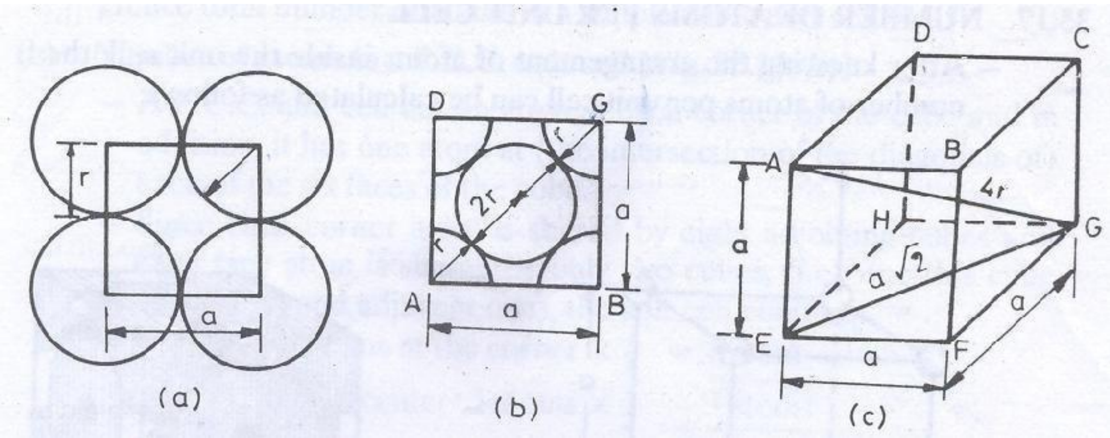


FCC:

In this structure, one atom at each eight corners in addition to one atom at each face is present. From the geometry of the fig.

BD = 4r = $\sqrt{a^2 + a^2}$ 4r = $\sqrt{2}$ a

R = $\sqrt{2}/4 \times a$



Atomic Packing Factor:

It may be defined as the fraction of volume occupied by spherical atoms as compared to the total available volume of the structure.

A.P.F. = volume of atoms in a crystal / volume of unit cell =H/V

FOR BCC CRYSTAL: -

Atoms per unit cell = 2 Volume = $2 \times 4/3\ \pi\ r^3$

V = $2 \times 4/3\ \pi \times (\sqrt{3}/4 \times a)^3$ APF= $(2*4/3\pi r3)/(4r/\sqrt{3})^3$

=0.68

Atomic packing factor for BCC crystal is 0.68.

FOR FCC:

Total no of atoms=4 Volume of 4atoms = $4x4x\pi x r^3$

$$APF = \frac{4 * \frac{4}{3}\pi r3}{(2\sqrt{2}\,r3)3}$$

$$= 0.74$$

Atomic packing factor for FCC crystal is 0.7

RESULT:

Student will be able understand the crystal structures and prepare the cubic structutres.

APPLICATIONS:

Importance of crystal structures

These atoms arranged in a regular pattern, unique arrangement, they form a lattice structure for a crystalline solid/liquid body. The lattice structure finally **determines one's physical properties**
Understanding different type of crystal structures like bcc,fcc,hcp . We can increase the packing efficiency in crystals nd fill the voids by rearranging the atoms if possible by another packing

Experiment No-1

Viva Questions

1. If Cell edge of a simple cubic lattice is 'a', then radius of atom in lattice is?

2. State the Number of lattice points in a unit cell.

3. Calculate the Co-ordination number in case of Simple cubic structure

4. State an Example for the Diamond crystal structure.

5. What are the group of points arranged in regular fashion in three dimensions called?

6. Define the following: a) Unit cell b) Packing Factor

7. Determine the side of the body centered unit cell if the radius of atom is R

8. What is packing factor?

9. Determine the Atomic Packing factor of FCC lattice?

10. Give an example for the HCP crystal structure.

EXPERIMENT NO: 2

Preparation and study of the Microstructure of pure metals like Iron, Cu and Al

Objective:

Observation of microstructure of Aluminum specimen under metallurgic microscope

Outcomes:

The student will be able to

- Understand the micro structure of Al
- Draw the micro structure of the given metal.
- Identify the difference in microstructure before and after etching

Scope of the Experiment:

The microstructure of Iron, Copper and Al can influence its physical properties including corrosion resistance, strength, toughness, ductility, and hardness. These properties help determine how the material will perform in a given application.

Theory:

Aluminum is a chemical element in the boron group with symbol Al and atomic number 13. It is a silvery white, soft, nonmagnetic, ductile metal. Aluminum 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. Aluminum 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 aluminum is bauxite. Aluminum 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 aluminum 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 aluminum, at least on a weight basis, are the oxides and sulfates.

Apparatus Required:

- Sample Specimen,
- Belt Grinder
- Sand paper (80,150,180, 220, 400, 600),
- Emery Paper (1/0, 3/0, 4/0, grade),
- Disc polisher machine

- Etchant
- Drier
- Metallurgical Microscope

Material Sample: Aluminum

Etchants: 30ml distilled water +5ml nitric acid+HF2.3 ml

Procedure:

1. Cut the specimen into required shape by using cutoff machine.
2. The mounted specimen surface is ground until unevenness of surface is eliminated using Belt Grinder
3. Then polish the specimen again by using sand papers (80,150,180, 220, 400, 600, grade), and emery papers (1/0, 3/0, 4/0, grade).
4. Fine Polishing is done on a disc Polisher (Rotating Polishing Wheel), the wheel is fitted with a Polishing cloth and suspension of fine alumina powder in water used as a polishing medium.
5. A Scratch free surface is obtained after fine polishing for sufficient period (15minutes).
6. After fine polishing specimen is thoroughly washed with water and dried.
7. Observe the micro-structure of specimen under microscope and note it down.
8. Apply approximate etchant to the specimen and avoid under or over etching.

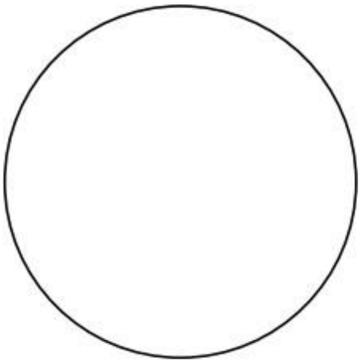
   Observe the micro scope structure and note it down

Precautions:

- Grinding should be done on the emery papers only in one direction
- While polishing the specimen uniform pressure should be exerted on the specimen
- While going to the next grade of emery papers, the specimen has to be rotated through 90^0
- While switching over to new emery paper, specimen should be thoroughly washed with water to remove all loose particles.
- After etching the specimen should be washed away within a few seconds
- Operate the Microscope Knobs gently (without jerks)

Observation:

Before Etching



Magnification:

Name of the sample:

Heat/Mechanical Treatment:

Etchant:

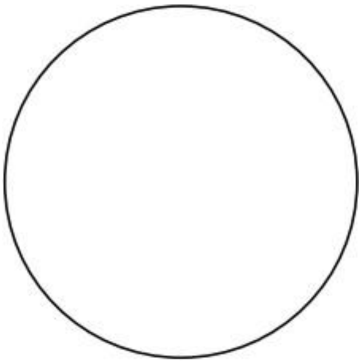
Etching Time:

Composition:

Phase's description:

Properties (if any):

After Etching



Magnification:

Name of the sample:

Heat/Mechanical Treatment:

Etchant:

Etching Time:

Composition:

Phase's description:

Properties (if any):

Applications:

Aluminum and its alloys are also widely used in the production of electronic and microelectronic components, in particular, capacitors. It is also used to produce antennae, including TV antennae. This metal is used in radar construction. In some countries even pylons for power lines are made of aluminum.

Viva Questions

Experiment No 2(a)

1. Presence of which material in aluminum alloy provides ductility to the alloy?

2. What is the melting point of pure aluminum?

3. What is the tensile strength of aluminum?

4. Compared to copper, how is the electrical conductivity of aluminum?

5. _______ is coated onto aluminum to improve its soldering ability.

6. Which aluminum alloy is known as aircraft aluminum?

7. Which material in aluminum alloy provides ductility to the alloy?

8. Which aluminum alloy is strongest?

9. How many aluminum alloys are there?

10. What are the uses of Aluminum alloys?

EXPERIMENT NO: 2(b)

Objective:

Observation of microstructure of copper specimen under metallurgic microscope.

Apparatus:

- Sample Specimen,
- Belt Grinder
- Sand paper (80,150,180, 220, 400, 600),
- Emery Paper (1/0, 3/0, 4/0, grade),
- Disc polisher machine
- Etchant
- Drier

Sample: COPPER

Etchants: 30ml distilled water 2% + nitric acid (12 to 30%)

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.

Procedure:

1. Cut the specimen into required shape by using cutoff machine.
2. The mounted specimen surface is ground until unevenness of surface is eliminated using Belt Grinder.
3. Then polish the specimen again by using sand papers (80,150,180, 220, 400, 600, grade), and emery papers (1/0, 3/0, 4/0, grade).
4. Fine Polishing is done on a disc Polisher (Rotating Polishing Wheel), the wheel is fitted with a Polishing cloth and suspension of fine alumina powder in water used as a polishing medium.

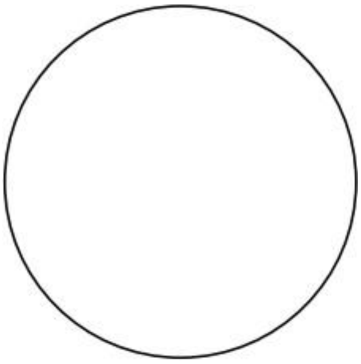
5. A Scratch free surface is obtained after fine polishing for sufficient period (15minutes).
6. After fine polishing specimen is thoroughly washed with water and dried.
7. Observe the micro-structure of specimen under microscope and note it down.
8. Apply approximate etchant to the specimen and avoid under or over etching.
9. Observe the micro scope structure and note it down.

Precautions:

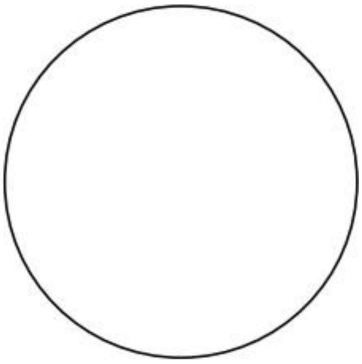
- Grinding should be done on the emery papers only in one direction
- While polishing the specimen uniform pressure should be exerted on the specimen
- While going to the next grade of emery papers, the specimen has to be rotated through 90^0
- While switching over to new emery paper, specimen should be thoroughly washed With water to remove all loose particles.
- After etching the specimen should be washed away within a few seconds
- Operate the Microscope Knobs gently (without jerks)

Observation:

Before Etching



After Etching



Magnification:

Name of the sample:

Heat/Mechanical Treatment:

Etchant:

Etching Time:

Magnification:

Name of the sample:

Heat/Mechanical Treatment:

Etchant:

Etching Time:

Composition:

Phase's description:

Properties (if any):

Composition:

Phases description:

Properties (if any):

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

Viva Questions

Experiment No 2(b)

1. How much copper is present in deoxidized copper?

2. High conductivity copper is used ______

3. Which copper grade is used to manufacture semiconductors and particle accelerator component?
4. What is the melting point of copper?

5. Brass is an alloy of copper and ______

6. Alloys containing copper, tin, and zinc are known as ______

7. Copper coins are made using ______

8. Highest corrosion resistance in seawater is found is ______ copper alloys.

9. Which copper alloy is used for making cutlery?

10. Highest corrosion resistance in seawater is found is ______ copper alloys.

EXPERIMENT NO: 2(C)

Objectives:

Observation of microstructure of Iron specimen under metallurgic microscope.

Apparatus:

- Sample Specimen,
- Belt Grinder
- Sand paper (80,150,180, 220, 400, 600),
- Emery Paper (1/0, 3/0, 4/0, grade),
- Disc polisher machine
- Etchant
- Drier
- Metallurgical Microscope

Sample: IRON

Etchants: Ethanol Alcohol 99.9 %+ Nitric Acid 10ML

Theory:

Iron is an enigma – it rusts easily, yet it is the most important of all metals. 90% of all metal that is refined today is iron. Most is used to manufacture steel, used in civil engineering (reinforced concrete, girders etc.) and in manufacturing. There are many different types of steel with different properties and uses. Ordinary carbon steel is an alloy of iron with carbon (from 0.1% for mild steel up to 2% for high carbon steels), with small amounts of other elements.

Alloy steels are carbon steels with other additives such as nickel, chromium, vanadium, tungsten and manganese. These are stronger and tougher than carbon steels and have a huge variety of applications including bridges, electricity pylons, bicycle chains, cutting tools and rifle barrels.

Stainless steel is very resistant to corrosion. It contains at least 10.5% chromium. Other metals such as nickel, molybdenum, titanium and copper are added to enhance its strength and workability. It is used in architecture, bearings, cutlery, surgical instruments and jewellery.

Cast iron contains 3–5% carbon. It is used for pipes, valves and pumps. It is not as tough as steel but it is cheaper. Magnets can be made of iron and its alloys and compounds.

Iron catalysts are used in the Haber process for producing ammonia, and in the Fischer–Tropsch process for converting syngas (hydrogen and carbon monoxide) into liquid fuels.

Procedure:

1. Cut the specimen into required shape by using cutoff machine.
2. The mounted specimen surface is ground until unevenness of surface is eliminated using Belt Grinder
3. Then polish the specimen again by using sand papers (80,150,180, 220, 400, 600, grade), and emery papers (1/0, 3/0, 4/0, grade).
4. Fine Polishing is done on a disc Polisher (Rotating Polishing Wheel), the wheel is fitted with a Polishing cloth and suspension of fine alumina powder in water used as a polishing medium.
5. A Scratch free surface is obtained after fine polishing for sufficient period (15minutes).
6. After fine polishing specimen is thoroughly washed with water and dried.
7. Observe the micro-structure of specimen under microscope and note it down.
8. Apply approximate etchant to the specimen and avoid under or over etching.
9. Observe the micro scope structure and note it down.
10. While switching over to new emery paper, specimen should be thoroughly washed with water to remove all loose particles.
11. After etching the specimen should be washed away within a few seconds
12. Operate the Microscope Knobs gently (without jerks)

Observation:

Before Etching **After Etching**

Magnification: **Magnification:**

Name of the sample: **Name of the sample:**

Heat/Mechanical Treatment:

Etchant:

Etching Time:

Composition:

Phase's description:

Properties (if any):

Heat/Mechanical Treatment:

Etchant:

Etching Time:

Composition:

Phases description:

Properties (if any):

Precautions:

- Grinding should be done on the emery papers only in one direction
- While polishing the specimen uniform pressure should be exerted on the specimen
- While going to the next grade of emery papers, the specimen has to be rotated through90^0
- While switching over to new emery paper, specimen should be thoroughly washedwith water to remove all loose particles.
- After etching the specimen should be washed away within a few seconds
- Operate the Microscope Knobs gently (without jerks)

Applications:

Iron is used in numerous sectors such as electronics, manufacturing, automotive, and construction and building.

The following are the application areas of iron:

- As the primary constituent of ferrous metals/alloys and steels
- Alloyed with carbon, nickel, chromium and various other elements to form cast iron or steel
- In magnets
- In fabricated metal products
- In industrial machinery
- In transportation equipment
- In instruments
- In toys and sport goods

Viva Questions

Experiment No: 2(C)

1. How much carbon is present in cast irons?
2. Cast iron is an _____ alloy.
3. Iron obtained from broken ______ is known as white iron.
4. If the iron surface contains graphite, it is known as ________
5. Which element causes cementite to behave in a stable manner?
6. An iron with high-silicon content is a ______
7. What is the effect of phosphorus and Sulphur in cast irons?
8. Decomposition of cementite to form ferrite and graphite is known as _______
9. State the applications of grey cast iron?
10. How are malleable cast irons designated for different grades?

EXPERIMENT NO: 3

Preparation and study of the Microstructure of Mild steels, low carbon steels, high – C steels.

Objective:

Observation of microstructure of **Medium Carbon Steel** specimen under metallurgicmicroscope

Outcomes:

The student will be able to

- Understand the micro structure of Mild steels, low carbon steels, high – C steels
- Draw the micro structure of the given metal.
- Identify the difference in microstructure before and after etching

Scope of the Experiment:

The microstructure of Mild, Low and High Carbon steels can influence its physical properties including corrosion resistance, strength, toughness, ductility, and hardness. These properties help determine how the material will perform in a given application.

Theory:

Medium carbon steel is carbon steel that contains between 0.30 and 0.60 percent carbon. It also has 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.

Apparatus:

- Sample Specimen,
- Belt Grinder
- Sand paper (80,150,180, 220, 400, 600),
- Emery Paper (1/0, 3/0, 4/0, grade),
- Disc polisher machine
- Etchant
- Drier
- Metallurgical Microscope

Sample: Medium Carbon Steel

Etchants: 2%Nital

Procedure:

1. Cut the specimen into required shape by using cutoff machine.
2. The mounted specimen surface is ground until unevenness of surface is eliminated using Belt Grinder
3. Then polish the specimen again by using sand papers (80,150,180, 220, 400, 600, grade), and emery papers (1/0, 3/0, 4/0, grade).
4. Fine Polishing is done on a disc Polisher (Rotating Polishing Wheel), the wheel is fitted with a Polishing cloth and suspension of fine alumina powder in water used as apolishing medium.
5. A Scratch free surface is obtained after fine polishing for sufficient period (15minutes).
6. After fine polishing specimen is thoroughly washed with water and dried.
7. Observe the micro-structure of specimen under microscope and note it down.
8. Apply approximate etchant to the specimen and avoid under or over etching.
9. Observe the micro scope structure and note it down

Precautions:

1. Grinding should be done on the emery papers only in one direction
2. While polishing the specimen uniform pressure should be exerted on the specimen
3. While going to the next grade of emery papers, the specimen has to be rotated through90^0
4. While switching over to new emery paper, specimen should be thoroughly washedwith water to remove all loose particles.
5. After etching the specimen should be washed away within a few seconds
6. Operate the Microscope Knobs gently (without jerks).

Observation:

Before Etching

After Etching

Magnification:

Name of the sample:

Magnification:

Name of the sample:

Heat/Mechanical Treatment:

Etchant:

Etching Time:

Composition:

Phase's description:

Properties (if any):

Heat/Mechanical Treatment:

Etchant:

Etching Time:

Composition:

Phases description:

Properties (if any):

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.

Viva Questions

Experiment No: 3(a)

1. What kind of steel requires definite amounts of other alloying elements?

2. Which of these is not a function of alloy steels?

3. What does AISI steel stand for?

4. Steels containing up to 3% to 4% of one or more alloying elements are known as _________

5. Which of these is not an application of HSLA steels?

6. Which family of steels are referred to as commonly?

7. Alloy steels containing 0.05% to 0.15% of alloying elements are called _______

8. Plain carbon steels are alloys mainly consisting of __________

9. ________ Following is also known as mild steel?

10. What is the composition of carbon in medium carbon steels?

EXPERIMENT NO: 3(b)

Objective:

Observation of microstructure of Low **Carbon Steel specimen** under metallurgicmicroscope.

Apparatus:

- Sample Specimen,
- Belt Grinder
- Sand paper (80,150,180, 220, 400, 600),
- Emery Paper (1/0, 3/0, 4/0, grade),
- Disc polisher machine
- Etchant
- Drier
- Metallurgical Microscope

Sample: Low Carbon Steel

Etchants: 2% Natal

Theory:

Carbon steel is steel in which the main interstitial alloying constituent is carbon in the rangeof 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/cm3 (7850 kg/m3 or 0.284 lb./in3) and the Young's modulus is 210 GA(30,000,000 psi).

Procedure:

1. Cut the specimen into required shape by using cutoff machine.
2. The mounted specimen surface is ground until unevenness of surface is eliminatedusing Belt Grinder
3. Then polish the specimen again by using sand papers (80,150,180, 220, 400, 600,grade), and emery papers (1/0, 3/0, 4/0, grade).
4. Fine Polishing is done on a disc Polisher (Rotating Polishing Wheel), the wheel is fitted with a Polishing cloth and suspension of fine alumina powder in water used as apolishing medium.
5. A Scratch free surface is obtained after fine polishing for sufficient period(15minutes).
6. After fine polishing specimen is thoroughly washed with water and dried.
7. Observe the micro-structure of specimen under microscope and note it down.
8. Apply approximate etchant to the specimen and avoid under or over etching.
9. Observe the micro scope structure and note it down.

Precautions:

- Grinding should be done on the emery papers only in one direction
- While polishing the specimen uniform pressure should be exerted on the specimen
- While going to the next grade of emery papers, the specimen has to be rotated through90^0
- While switching over to new emery paper, specimen should be thoroughly washedwith water to remove all loose particles.
- After etching the specimen should be washed away within a few seconds
- Operate the Microscope Knobs gently (without jerks).

Observation:

Before Etching

Magnification:

Name of the sample:

Heat/Mechanical Treatment:

Etchant:

Etching Time:

Composition:

Phase's description:

Properties (if any):

After Etching

Magnification:

Name of the sample:

Heat/Mechanical Treatment:

Etchant:

Etching Time:

Composition:

Phases description:

Properties (if any):

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.

Viva Questions

Experiment No: 3(b)

1. What is the Cooling curve?

2. What is Curie temperature?

3. What is the percentage of carbon in cementite?

4. What are the different phases in Fe-Fe_3C equilibrium diagram?

5. How cast iron and steel are distinguished with respect to carbon percentage?

6. What is eutectoid reaction?

7. What is eutectic reaction?

8. What is peritectic reaction?

9. What is peritectoid reaction?

10. Define ferrite, cementite, pearlite and ledeburite?

EXPERIMENT NO: 3(c)

Objective:

Observation of microstructure of High Carbon Steel specimen under metallurgic microscope.

Apparatus:

- Sample Specimen,
- Belt Grinder
- Sand paper (80,150,180, 220, 400, 600),
- Emery Paper (1/0, 3/0, 4/0, grade),
- Disc polisher machine
- Etchant
- Drier
- Metallurgical Microscope

Sample: High Carbon Steel

Etchants: 4%picral

Theory:

High carbon steel will be any type of steel that contains over 0.8% carbon but less than2.11% carbon in its composition. The average level of carbon found in this metal usually fallsright 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.

Procedure:

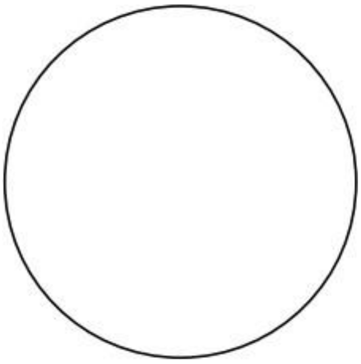
1. Cut the specimen into required shape by using cutoff machine.
2. The mounted specimen surface is ground until unevenness of surface is eliminatedusing Belt Grinder
3. Then polish the specimen again by using sand papers (80,150,180, 220, 400, 600,grade), and emery papers (1/0, 3/0, 4/0, grade).
4. Fine Polishing is done on a disc Polisher (Rotating Polishing Wheel), the wheel is fitted with a Polishing cloth and suspension of fine alumina powder in water used as apolishing medium.
5. A Scratch free surface is obtained after fine polishing for sufficient period(15minutes).
6. After fine polishing specimen is thoroughly washed with water and dried.
7. Observe the micro-structure of specimen under microscope and note it down.
8. Apply approximate etchant to the specimen and avoid under or over etching.
9. Observe the micro scope structure and note it down.

Precautions:

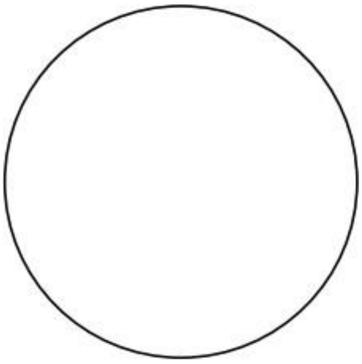
- Grinding should be done on the emery papers only in one direction
- While polishing the specimen uniform pressure should be exerted on the specimen
- While going to the next grade of emery papers, the specimen has to be rotated through90^0
- While switching over to new emery paper, specimen should be thoroughly washedwith water to re-move After etching the specimen should be washed away within a few seconds
- Operate the Microscope Knobs gently (without jerks) all loose particles.

Observation:

Before Etching



After Etching



Magnification:

Name of the sample:

Heat/Mechanical Treatment:

Etchant:

Etching Time:

Composition:

Phase's description:

Properties (if any):

Magnification:

Name of the sample:

Heat/Mechanical Treatment:

Etchant:

Etching Time:

Composition:

Phases description:

Properties (if any):

Applications:

Depending on the specific needs of the person using it, high carbon steel can have manyadvantages 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 alsorated very highly. High carbon steel is also preferred by many manufacturers who createmetal 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 inthe manufacturing of many tools such as drill bits, knives, masonry nails, saws, metal cuttingtools, and woodcutting tools.

Viva Questions

Experiment No: 3(c)

1. What are the applications of high-carbon steel?

2. Which steels are generally used for making connecting rods and gear shafts?

3. What is the maximum forging temperature of 1.1% carbon steel?

4. What is the maximum amount of manganese in carbon steels?

5. What are the advantages of plain carbon steels over alloy steels?

6. Which is the primary element used for making stainless steel alloy?

7. Stainless steels with little carbon and no nickel are called _________

8. Stainless steels with high strength, but low corrosion resistance is known as ________

9. Mushet steel belongs to which group of tool steels?

10. What property does the AISI-SAE tool steel grade 'L' possess?

EXPERIMENT NO: 4

Study of the Microstructures of Cast Irons

Objective:

Observation of microstructure of **Grey Cast Iron** specimen under metallurgic microscope.

Outcomes:

The student will be able to

- Understand the micro structure of **Grey Cast Iron**
- Draw the micro structure of the given metal.
- Identify the difference in microstructure before and after etching

Scope of the Experiment:

Gray iron experiences less solidification shrinkage than other cast irons that do not form a graphite microstructure. The silicon promotes good corrosion resistance and increased fluidity when casting. Gray iron is generally considered easy to weld.

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.

Apparatus:

- Sample Specimen,
- Belt Grinder
- Sand paper (80,150,180, 220, 400, 600),
- Emery Paper (1/0, 3/0, 4/0, grade),
- Disc polisher machine
- Etchant
- Drier
- Metallurgical Microscope

Sample: Grey Cast Iron

Etchants: 3%Nital

Procedure:

1. Cut the specimen into required shape by using cutoff machine.
2. The mounted specimen surface is ground until unevenness of surface is eliminated using Belt Grinder
3. Then polish the specimen again by using sand papers (80,150,180, 220, 400, 600, grade), and emery papers (1/0, 3/0, 4/0, grade).
4. Fine Polishing is done on a disc Polisher (Rotating Polishing Wheel), the wheel is fitted with a Polishing cloth and suspension of fine alumina powder in water used as a polishing medium.
5. A Scratch free surface is obtained after fine polishing for sufficient period (15minutes).
6. After fine polishing specimen is thoroughly washed with water and dried.
7. Observe the micro-structure of specimen under microscope and note it down.
8. Apply approximate etchant to the specimen and avoid under or over etching.
9. Observe the micro scope structure and note it down.

Precautions:

- Grinding should be done on the emery papers only in one direction
- While polishing the specimen uniform pressure should be exerted on the specimen
- While going to the next grade of emery papers, the specimen has to be rotated through90^0
- While switching over to new emery paper, specimen should be thoroughly washedwith water to remove all loose particles.
- After etching the specimen should be washed away within a few seconds
- Operate the Microscope Knobs gently (without jerks).

Observation:

Before Etching

After Etching

Magnification:

Name of the sample:

Heat/Mechanical Treatment:

Etchant:

Etching Time:

Composition:

Phase's description:

Properties (if any):

Magnification:

Name of the sample:

Heat/Mechanical Treatment:

Etchant:

Etching Time:

Composition:

Phases description:

Properties (if any):

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

Viva Questions

Experiment No: 4

1. What are cast irons?

2. What are the different types of cast irons?

3. Why grey cast iron is so brittle?

4. Mention the etchant for cast irons.

5. What is the difference between nodular and malleable cast iron?

6. Why white cast iron has limited applications?

7. What is the difference between white cast iron and grey cast iron?

8. What is the additional metal added for spheroidization for hypo and hyper eutectic cast irons? How they act?

9. What is graphitization?

10. Explain important properties of different types of cast irons.

EXPERIMENT NO: 5

Study of the Microstructures of Non-Ferrous alloys

(METALLOGRAPHY OF BRASS)

Objective:

Identification of micro – constituents present in the brass.

Outcomes:

The student will be able to

- Understand the micro structure of **Brass**
- Draw the micro structure of the given metal.
- Identify the difference in microstructure before and after etching

Scope of the Experiment:

The microstructure of brass can influence its physical properties including corrosion resistance, strength, toughness, ductility, and hardness. These properties help determine how the material will perform in a given application.

Theory:

Brasses are alloys of copper; contain zinc as a principal alloying element. The equilibrium solubility of Zn in Cu is around 38% and is sharply influenced by cooling rate. Under the conditions of usual cooling rates encountered in industrial practice, the solubility limit may godown to 30%. With Zn additions exceeding the solubility limit, a second phase β is formed Beta intermediate phase exhibits order-disorder transformation between 453 and 470 ^{0}C. Below this temperature, the structure of β is ordered and above this is disordered. With more than 50 % Zn another phase (intermediate phase) is formed Brasses are classified either on

the basis of structure i.e., α brasses and α – β Brasses or color i.e., red brasses and yellow brasses.

α - brasses are soft, ductile malleable and have fairly good corrosion resistance. Commercial α

β Brasses contain zinc between 32 to 40%. They are hard and strong as compared to α- brasses and are fabricated by hot working process. these two phases' alloys become single phase β (disordered) alloys at higher temperatures. Disordered β has more ductility and malleability as compared to β and therefore, α β brasses are hot worked at a temperature of above 600 ^{0}C. Since zinc is cheaper than copper, α – β brasses are cheaper compared to α – Brasses.

Equipment &Materials:

- Sample Specimen,
- Belt Grinder
- Sand paper (80,150,180, 220, 400, 600),
- Emery Paper (1/0, 3/0, 4/0, grade),

- Disc polisher machine
- Etchant
- Drier
- Metallurgical Microscope

Procedure:

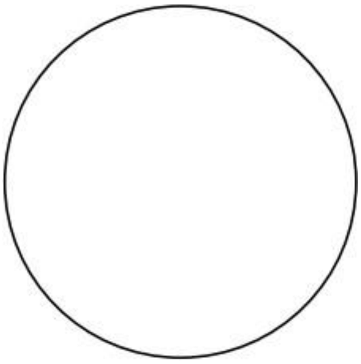
1. Cut the specimen into required shape by using cutoff machine.
2. The mounted specimen surface is ground until unevenness of surface is eliminated using Belt Grinder
3. Then polish the specimen again by using sand papers (80,150,180, 220, 400, 600, grade), and emery papers (1/0, 3/0, 4/0, grade).
4. Fine Polishing is done on a disc Polisher (Rotating Polishing Wheel), the wheel is fitted with a Polishing cloth and suspension of fine alumina powder in water used as a polishing medium.
5. A Scratch free surface is obtained after fine polishing for sufficient period (15minutes).
6. After fine polishing specimen is thoroughly washed with water and dried.
7. Observe the micro-structure of specimen under microscope and note it down.
8. Apply approximate etchant to the specimen and avoid under or over etching.
9. Observe the micro scope structure and note it down.

Precautions:

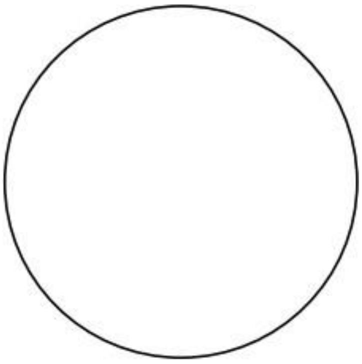
- Grinding should be done on the emery papers only in one direction
- While polishing the specimen uniform pressure should be exerted on the specimen
- While going to the next grade of emery papers, the specimen has to be rotated through90^0
- While switching over to new emery paper, specimen should be thoroughly washedwith water to remove all loose particles.
- After etching the specimen should be washed away within a few seconds
- Operate the Microscope Knobs gently (without jerks)

Observation:

Before Etching



After Etching



Magnification:

Name of the sample:

Heat/Mechanical Treatment:

Etchant:

Etching Time:

Composition:

Phase's description:

Properties (if any):

Magnification:

Name of the sample:

Heat/Mechanical Treatment:

Etchant:

Etching Time:

Composition:

Phases description:

Properties (if any):

Applications:

Brass is still commonly used in applications where corrosion resistance and low friction are required, such as locks, hinges, gears, bearings, ammunition casings, zippers, plumbing, hose couplings, valves, and electrical plugs and sockets. It is used extensively for musical instruments such as horns and bells, and also used as a substitute for copper in making costume jewelry, fashion jewelry, and other imitation jewelry. The composition of brass, generally 66% copper and 34% zinc, makes it a favorable substitute for copper-based jewelry, as it exhibits greater resistance to corrosion. Brass is not suitable for such items as boat propellers because the zinc reacts with minerals in salt water, leaving porous copper behind. Brass is often used in situations in which it is important that sparks not be struck, such as in fittings and tools used near flammable or explosive materials.

Viva Questions

1. Brass is an alloy of
2. Brass (alloy of copper and zinc) is an example of___________________?
3. α brasses contain ______ of zinc.
4. Yellow metal is more commonly known as ______
5. Which brass alloy has high tensile strength and can be used for cast molding?
6. Which brass alloy is used to make imitation jewelry and decorative work?
7. Which brass alloy is suitable for high-speed machining?
8. _______ is an alloy of copper and tin.
9. What High conductivity copper is used _____t is the melting point of Copper?
10. How much copper is present in deoxidized copper?

EXPERIMENT NO: 6

Hardenability of steels by Jiminy End Quench Test

Objective:

To determine the hardenability of a given steel.

Outcomes:

The student will be able to

- Understand the micro structure of **steels**
- Draw the micro structure of the given metal.
- Identify the difference in microstructure before and after etching
- Calculate the Hardenability of given steel

Scope of the Experiment:

The microstructure of steel can influence its physical properties including corrosion resistance, strength, toughness, ductility, and hardness. These properties help determine how the material will perform in a given application

Theory:

Jominy end quench test is used to determine hardenability of steels. The process of increasing the hardness of steel is known as Hardening. Specific specimen with standard dimensions, used for the test is given in fig.1. The hardness of hardened bar is measured along its length.

Hardenability:

The depth up to which steel can be hardened is defined as hardenability. A steel having high hardness need not have high hardenability. Hardenability may be defined as susceptibility to hardening by quenching. A material that has high hardenability is said to be hardened more uniformly throughout the section that one that has lower hardenability.

Critical diameter:

The size of the bar in which the zone of 50% martensite occurs at center is taken as critical diameter. This is a measure of hardenability of steel for a particular quenching medium employed.

M.A Gross man devised a method to decide hardenability.

Severity of Quench:

The severity of quench is indicated by heat transfer equivalent.

$H = f/k$

f = Heat transfer factor of Quenching medium and the turbulence of the bath.k = Thermal conductivity of bar material.

The most rapid cooling is possible with severity of quench as infinity.

Ideal Critical Diameter:

The hardenability of steel can be expressed as the diameter of bar that will form a structure composed of 50% martensite at the center when quenched with H = infinity. This diameter is defined as ideal critical diameter.

Apparatus:

Jominy test apparatus, furnace, Rockwell hardness tester and a grinder.

Description of Apparatus:

Jominy end quench apparatus is shown in fig 2.

The apparatus consists of a cylindrical drum. At the top of the drum provision is made for fixing the test specimen. A pipe line is connected for water flow, which can be controlled by means of a stop cock.

Procedure:

1. Out of the given steel bar, the standard sample is to be prepared as per the dimensionsshown in the fig.
2. The austenitising temperature and time for the given steel is to be determineddepending 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 the furnace for a predetermined time (based on chemical composition of steel) then it is taken out of the furnace and is kept fixed in the test apparatus.
5. The water flow is directed onto the bottom end of the sample. The water flowis adjusted such that it obtains shape of umbrella over bottom of sample.
6. The quenching to be continued for approximately 15minutes.
7. A flat near about 0.4 mm deep is grounded on the specimen.
8. The hardness of the sample can be determined at various points starting from the quenched end and the results are tabulated.
9. The graph is plotted with hardness values versus distance from quenched end. From the results and graph Plotted the depth of hardening of the given steel sample can be determined.

Precautions:

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

Observation Table

S.No.	Distance from quenched end	Hardness

Results:

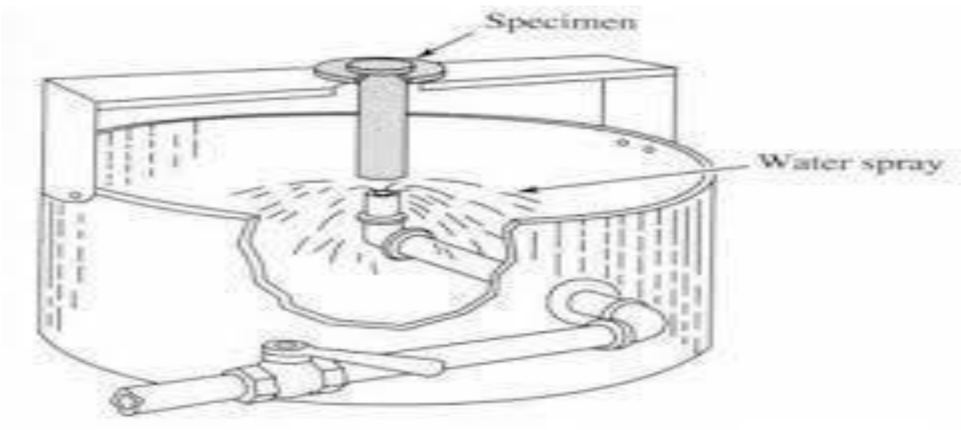
Hence determine the hardenability of steel.

Fig 1

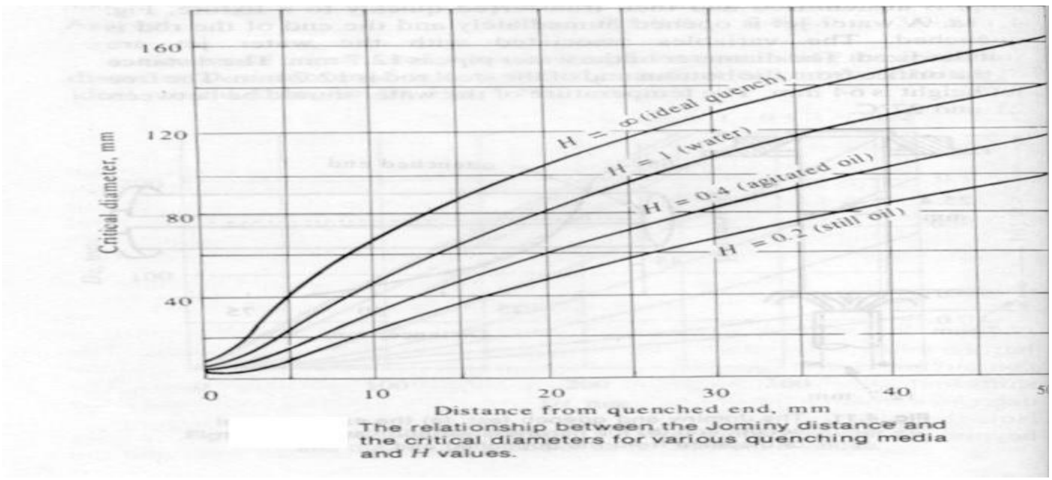
MUFURNACE

Fig 2

Jominey End Quench Test Apparatus



Jominy End Quench Test Setup



Applications:

Steel, as noted, is used in the automobile industry. Think of the number of cars on the roads of just your own city during rush hour, all of them with bodies, doors, engines, suspensions and interiors consisting largely of steel.

On average, 50 percent of a car is made of steel.

Apart from its role in passenger vehicles, steel is used in the production of farm vehicles and machines. Most of the appliances in modern homes, such as refrigerators, televisions, sinks, ovens and so on are made of "plain" steel. Also, those with a yen for spending time in the kitchen are keenly aware of stainless steel's role in fine cutlery. Stainless steels notably lend themselves to the easy maintenance of a sterile environment, which is one of the qualities that makes it a good choice for surgical instruments and implants. Because it lends itself to the easy formation of welds, steel, more than just making up the invisible framework of modern structures, has become featured in its own right in examples of contemporary architecture. So-called "mild" steel is used for everyday building construction, especially in areas where high winds are a feature of the local climate.

Viva questions

1. What kind of steel requires definite amounts of other alloying elements?
2. Steels containing up to 3% to 4% of one or more alloying elements are known as _____
3. What does AISI steel stand for?
4. Steels containing more than 5% of one or more alloying elements are known as ___
5. What is the common name of COR-TEN steel?
6. Alloy steels containing 0.05% to 0.15% of alloying elements are called ______
7. Which is the primary element used for making stainless steel alloy?
8. Addition of _______ gives stainless steels an austenitic structure.
9. Stainless steels with little carbon and no nickel are called ________
10. Stainless steels with high strength, but low corrosion resistance are known as _______

EXPERIMENT NO: 7

(Newly Added)

Find The Hardness of the Various Treated and Untreated plain carbon Steels.

Objective:

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

Outcomes:

The student will be able to

- Understand the micro structure of **treated and untreated plain carbon steels**
- Draw the micro structure of the given metal.
- Identify the difference in microstructure before and after etching
- Calculate the Hardenability of both treated and untreated plain carbon steels.

Scope of the Experiment:

The microstructure of treated and untreated can influence its physical properties including corrosion resistance, strength, toughness, ductility, and hardness. These properties help determine how the material will perform in a given application

Theory:

The method of testing introduced by J.A.Brinell in 1900 consisting of indenting the metal with a "d" mm diameter and tempered steel ball subjected to a definite load. ball of10 mm, 5 mm, ad 2.5 mm are generally used. The load is maintained for a definite period (usually 10 or 15 sec) after which the load is removed and the diameter of the impression or indentation is measured. The hardness of the material expressed as number and representedby the symbol "HB".

h= depth of indentation$(D-\sqrt{(D^2 - d^2)})/2$

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

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

Apparatus:

The given specimens Hardness tester.

Procedure:

1. The face of the specimen is lightly grind and rubbed with fine emery paper if required.
2. Select the proper test table base do the size and shape of the specimen and place Iton main screw or elevating screw
3. Select the diameter of the indenter as 10mm or 5 mm based on the thickness of thespecimen and place it I the corresponding ball holder and fix the ball holder.

4. Place the required weights on the weight hanger based on the type of material ofthe specimen and diameter of the indenter
5. Check and keep the operating level in horizontal position
6. Place the specimen securely on testing table
7. Turn the hand wheel in clock wise direction so that the specimen touches the ballIndenter
8. Lift the operating lever from the horizontal position upwards slightly, after which itRotates automatically.
9. Wait for 10 to 15 sec after lever becomes stand still.
10. Bring the lever back to horizontal position
11. Turn back the hand wheel and remove the specimen
12. Measure the diameter of impression of indentation by Brinell microscope and find theBrinell hardness number.
13. Repeat the above procedure for three to four times

Precautions:

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

Observation Table

S.No.	Distance from quenched end	Hardness

Result:

The Brinell hardness number of the give material is -------

Jominy End Quench Test Apparatus **Brinell Hardness Test**

Applications:

Low carbon steel is usually made into flat-rolled sheets and strips, used for shipbuilding, wire, vehicle bodies and domestic appliances. It’s widely used for fabrication and paneling because it can’t be altered by heat treatment. Carbon steel with the lowest possible amount of carbon is called ‘wrought iron’, used for fencing, gates and railings, hard but not brittle.

Medium carbon steel is a lot easier to machine and adding small amounts of silicon and manganese improves the quality. Also called mild steel, it’s commonly used structurally in buildings and bridges, axles, gears, shafts, rails, pipelines and couplings, cars, fridges and washing machines.

High carbon steel has a much better tensile strength, used to make cutting tools, blades, punches, dies, springs and high-strength wire.

Ultra-high carbon steel is brittle and very hard, and can’t be cold-worked. It’s used to make extremely hard components like blades, cutting tools and large machine parts, hot water radiators, industrial castings and metal lamp posts. It’s also called ‘cast iron’, and it’s the material used to make old fashioned cooking pots.

EXPERIMENT NO 7
Viva questions

1. Steels containing up to 3% to 4% of one or more alloying elements are known as _____
2. What does AISI steel stand for?
3. Steels containing more than 5% of one or more alloying elements are known as ___
4. What is the common name of COR-TEN steel?
5. Alloy steels containing 0.05% to 0.15% of alloying elements are called ______
6. Which is the primary element used for making stainless steel alloy?
7. Addition of _______ gives stainless steels an austenitic structure.
8. Stainless steels with little carbon and no nickel are called ________
9. Stainless steels with high strength, but low corrosion resistance are known as _______
10. What kind of steel requires definite amounts of other alloying elements?

EXPERIMENT NO: 8

Direct tension test

Objective:

To study the behavior of a mild steel specimen under a gradually increasing tensile load and to determine the following mechanical properties.

a) Tensile strength. b) Yield strength. c) Ultimate stress

d) young's modulus. e) Percentage of Elongation. f) Percentage of reduction of area

Outcomes:

The student will be able to

- Understand the behavior of mild steel on tensile loading
- Perform the experiments on Ultimate tensile testing machine
- Draw the stress strain graph for the mild steel
- Understand basic concepts

Scope of the Experiment:

Ultimate tensile strength (or just tensile strength for short) is an important property of materials to determine their mechanical performance. It is the ability of a material to resist tearing due to tension. This parameter applies to all types of materials such as wires, ropes, metal beams, etc.

Theory:

The Universal Testing Machine (UTM) mainly consists of two units

1. loading unit and
2. control panel

The loading unit consists of

- Lower cross head
- Middle cross head
- Upper cross head

The specimen is tested on the loading unit and the corresponding readings are taken from the fixed dial on the control panel. The main hydraulic cylinders fitted in the Centre of the base and the piston slides over the cylinder when the machine is under operation. A lower table is rigidly connected to an upper cross head by two straight columns. This assembly moves up and down with the main piston. The test is conducted by fixing the specimen in between the lower and upper crossheads by jaws inserts. An elongation scale is also kept sliding which is fitted between lower table and upper crosshead.

The two valves on the control panel one on the right side and the other one on the left side are used to control the oil flow in the hydraulic system. The right-side valve is a pressure flow control valve and the left side valve is a return valve to allow the oil from the cylinder to go back to the tank. Control panel also consists of dynamometer which measures and indicates the load on the specimen.

Apparatus:

Universal testing machine (UTM), Extensometer.

Specimen required:

Mild steel rod of 10 mm dia, steel rule, vernier calipers.

Procedure:

1) Measure the length and diameter of given specimen.
2) Fix the load range by placing counter weights on the balancing pendulum at the back of the machine.
3) With the pressure release valve open adjust the middle cross head to fix the specimen between upper and middle cross head by operating the up and down switches. Also adjust the machine to read zero.
4) Fix the specimen between upper and middle cross head properly so that load is applied axially.
5) Before operating the UTM ensure that the oil delivery valve (left) is open and the pressure release valve (right) is closed.
6) After switching on the UTM open the pressure release valve and close the oil delivery valve.
7) Now, push the 'ON' button on the control panel and there will be tension acting on the specimen due to fluid pressure.
8) Before applying the pressure adjust the pencil to the graph roll.
9) Position the Extensometer on the specimen. Position Upper clamp to press upper knife on the speci-men.
10) The extensometer will now be fixed to the specimen by spring pressure. Set zero on both the dial gauges.
11) Start loading the test specimen and take the reading of load on the machine at required elongation or the elongation at required load.
12) For better accuracies mean of both dial gauge readings should be taken as elongation.
13) The yield point is observed when the line needle is suddenly stops for a second and continues to move.

14) At one stage the line needle begins to return, leaving the dummy needle there itself. At this point the ultimate strength of the specimen is observed.

15) After some time, the specimen breaks making a huge sound.

16) As the specimen breaks the graph is metallically plotted according to the behavior of specimen under tension due to applied load.

17) Note and record the required reading and the graph plotted.

18) Remove the broken pieces of the specimen from the machine and safely switch off the machine.

19) Measure the gauge length of the test specimen and diameter of the neck.

Precautions:

1. Carefully switch 'ON' the machine
2. Hold the loads carefully, so that it doesn't fall on your feet and gets you injured.
3. Set the dial corresponding to the load applied.
4. While operating the machine do not touch the rod column along which the piston moves
5. Be careful while fixing the specimen between the jaws of the UTM
6. Keep your hands away from the parts of the UTM, after the specimen is fixed between the jaws of the machine

Observation Table:

S.No.	Load (P)in "N"	Specimen Dia. as per applied load(d) in mm	Area of the specimen as per applied load(A) in mm^2	Original gauge length of specimen(l) in mm	Extension (δl) in mm	Stress" f" (P/A) N/mm^2	Strain" e" (δl/l)	Modulus of elasticity(E)=f/e – N/mm^2
1								
2								
3								
4								
5								

Sample calculations:

1. Diameter of the specimen, d =
2. Length of the specimen, L=
3. Lower Yield point found at =
4. Upper Yield point found at=
5. Ultimate strength found at =
6. Break point found at =

Stress: The resistance offered by a body against the deformation is called stress.

Stress (f) = Load (p)/area of cross section (A)

= P/A N / mm^2

Strain: The ratio of change in length to the original length is called strain

Strain (e) = Change in length (δ l)

Original length (l)

Young's modulus: The ratio of stress to strain within the elastic limit is called modulus of elasticity (or) young's modulus.

E = Stress (f)/ Strain (e)

Tensile Strength:

The tensile strength or ultimate tensile strength is the maximum load obtained in a tensile test divided by the original area of the cross-section of the specimen. It is used for the quality control of the product. It can be co-related to other properties such as hardness and fatigue strength.

$$P_u = P_{max}/A_0$$

Where P_u = ultimate tensile strength in kg/mm^2

P_{max}= Maximum load obtained in tensile test in Kgs

A_0 = original cross-sectional area of load specimen in mm^2.

Yield Strength:

It is defined as the stress which will produce a small amount of permanent deformation.

Yield strength $P_y = P_e/ A_0$

P_e= load obtained at yield point

A_0 = original area of cross-section in mm^2.

Percentage Elongation:

$\%E = (L-L_0)/ L_0 \times 100$

E = percentage elongation

L = Increased length or gauge length at fracture.

L_0 = original length.

Total % elongation up to fracture point is an indication of ductility (ability of a material to with stand plastic deformation).

Reduction of Area: It is the ratio of decrease in cross-sectional area to the original area expressed in percentage.

$\% R_A = (A_0-A)/ A_0 \times 100$

R_A = percentage reduction in area.

A_0 = original cross-sectional area

A = final cross-sectional area after fracture.

Result:

a) Tensile strength: N/mm^2

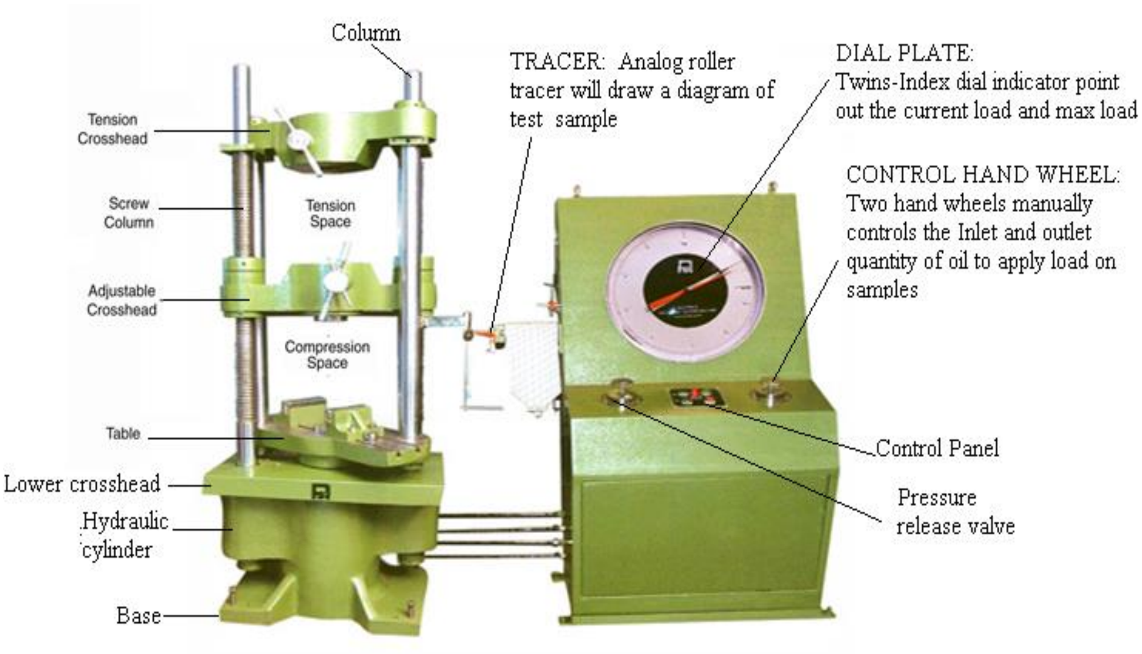
b) Yield strength: N/mm^2

c) Ultimate stress: N/mm^2

d) young's modulus: N/mm^2

e) Percentage of Elongation: %

f) Percentage of reduction of area: %



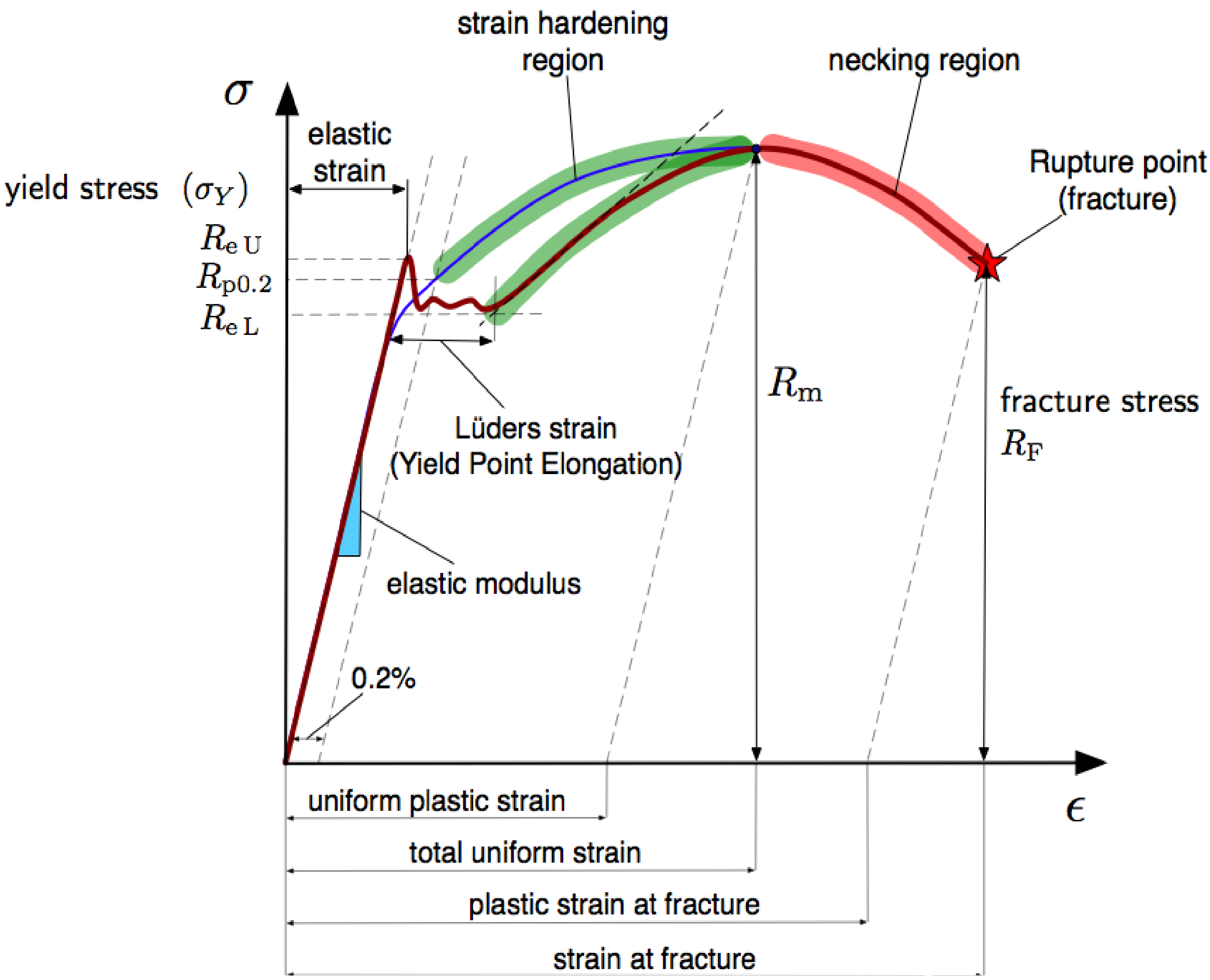
SKETCH-UTM Machine

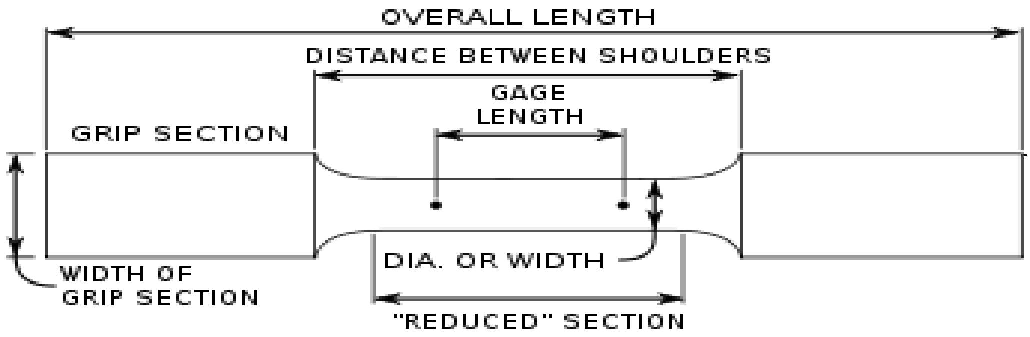
MECHANICAL EXTENSOMETER

LOAD INDICATOR SYSTEM

GRAPH DRUM **PENDULUM DYNAMOMETER**

Stress strain curves and derived properties for Mildsteel





Applications:

The tension test or tensile test is widely used to assess the quality of the materials that are manufactured in different industries. This test is directly related to the safety of the products. The test is essential to perform to measure the quality of the materials under extreme tension forces during usage. Here are some of the uses of tension test.

Rubber Products

The elasticity of the rubbers can be determined when the material is stretched from both the ends in the opposite direction to create extreme tension force. This helps to measure the force that rubbers can bear to its maximum without experiencing any type of deformation or failure. The tension test helps to measure the elastic modulus of the products or materials for various applications.

Metal Products

Metals are widely known for tits hardness and elasticity properties. To determine how much the metal is elastic, a considerable amount of tension is applied to the materials. This can be determined using tension test. The tension test helps to determine the strength of various metal products such as metal cables, construction angles, girders and other metal products that are used in different industries

To analyze the strength of different materials, it is important for the manufacturer to make use of the high-quality tensile testing machine.

VIVA QUESTIONS

EXPERIMENT NO: 8

1) Loading accuracy of the machine is?

2) Which type of motor used in the UTM?

3) Define stress?

4) Define strain?

5) What is the unit of stress?

6) What is the unit of strain?

7) Why we are using only rectangular threading in the UTM is

.

8) Define young's modulus of elasticity

9) What is the unit for young's modulus of elasticity

10) What is the purpose of UTM

EXPERIMENT NO: 9

Bending test on Simple supported beam

Objective:

To determine the deflection(y) of Beam specimen (M.S & Al) and correspondingly workout for the young's modulus (E)of the given structural material.

Outcomes:

The student will be able to

- Understand the concept of deflection in beam
- Calculate the deflection for given specimen
- Find the strength of the given beam specimen

Scope of the Experiment:

The bend test is a simple and inexpensive qualitative test that can be used to evaluate both the ductility and soundness of a material. It is often used as a quality control test for butt-welded joints, having the advantage of simplicity of both test piece and equipment.

Theory:

Young's modulus is defined as linear stress required producing unit linear strain, within the elastic limit. Young's modulus can be found from the theory of simple bending.

The bending test apparatus consists of a long rectangular steel bar resting on stands at both the ends. On this horizontal steel bar, two sliding supports rest vertically. A dial guage with a pointer on its head is provided, which can be adjusted with the nut provided.

A Beam is a structural member subjected to a system of external forces at right angles to its axis. If such member is built or fixed in at one end while its other end is free, the member is called as cantilever beam. It is shown in fig.1

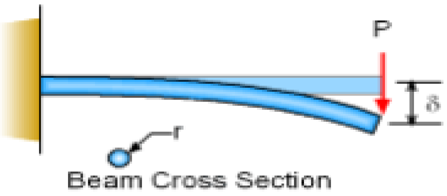


Fig 1. Cantilever beam

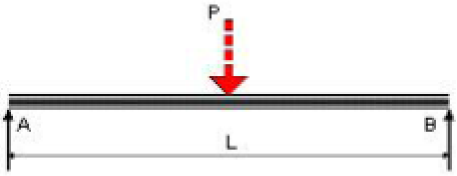


Fig 2. Simply supported beam

If the two ends of the beam is made to freely rest on supports the beam is called the freely or simply supported beam as shown in the fig2. In this case the beam is resting freely on brick masonry walls. The clear horizontal distance between the walls is called clear span of the beam. The horizontal distance between the centers of the end bearings is called effective span of the beam. If the intensity of the bearing reaction is not uniform the effective span is the horizontal distance between the lines of action of the end reactions.

If the beam is fixed at both ends it is called a built-in, built-up, fixed beam is shown in the fig3. A beam which is provided with more than two supports is called a continuous beam it is shown in the fig4.

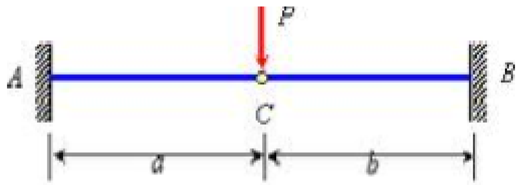


Fig 3. Fixed beam

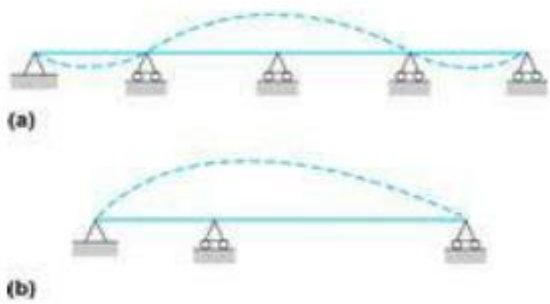


Fig 4. Continous beam

On the application of the load on the beam will bent into a circular shape. The deviation from its initial position is called deflection. If a member is subjected to a uniform bending moment M: the radius of curvature of the deflected form of the member is given by

$$M / I = E / R.$$

Where I= Moment of Inertia $BD^3/12$(B=Breadth, D= Depth)

E= Young's modulus = f/e

R= radius of curvature

If the member be subjected to a bending moment which is not same at all sections the radius of curvature at any point of the centre line is given again by the above relation

Considering a simply supported beam carrying a point load at the middle of the span C. since the load symmetrically applied the maximum deflection occurs the mid of the span. Then deflection equation is given by

$$EIy = (Wx3/12) - (WL2x/16) \quad \text{-------------} \ (1)$$

The maximum deflection occurs at the middle of the span i.e. at x = L / 2.

Y_C= (WL3/48 EI)

The deflection at a distance of L/4 can be obtained by substituting x= L/4 in eqn (1)

y = (11 WL3/ 768 EI)

Therefore **= (11 WL3/ 768 YI)** (Quarter -span deflection at point D)

Calculation of young's modulus using this equation is called indirect method as stress and strain is not involved in this equation.

Apparatus:

Simply supported beam, dial gauge to measure the deflection of the beam.

Materials and Equipment:

a. Deflection of beam apparatus
b. Weights
c. Beam of different cross-sections and materials
d. Vernier calipers
e. Beam supports
f. Measuring scale

Procedure:

1. Measure the effective span width & depth of the simply supported beam by using vernier caliper and Moment of inertia of the section is calculated.
2. Place the simply supported beam on the two supports properly.
3. Place the load hook at the middle of span.
4. Mark the center and quarter span for the beam.
5. Place the dial indicator in between the two supports where deflection needs to be calculated say at length L / 4 from left support.
6. Load is applied at mid-span and deflections are measured at quarter span by using dial indicator. Deflections are measured while loading and unloading and average value is taken as deflection for the respective loads and young's modulus is calculated.
7. Calculate the young's modulus of the given beam material by using the formula.

Precautions:

1. The beam must be loaded below its ultimate load. So that it may not fail under loading.
2. Adjust the dial indicator at the exact place where deflection needs to be calculated.
3. Note down the dial indicator readings carefully
4. Be sure that the distance marked on the beam is equal.
5. Before applying load do not forget to set the dial gauge pointer to the initial point.
6. Make sure there is nothing placed on the table except the apparatus a smallest pressure on the table can spoil the experiment.
7. Make sure that the beam and load are placed in the proper position

Observation Table:

S no.	Load Applied (W) in (kg	Dial Indicator Reading (D)			D(avg) x Least Count (0.10)	Deflection in 'y'mm	Stiffness (w/y)	Young's modulus (E)
		Loading	Unloading	Avg.				
1.								
2.								
3.								
4.								
5.								
6								

Sample calculations:

Deflection at quarter span **y = (11 WL3/ 768 EI)**

Assume W=1Kg= 1 X 9.81 = 9.81 N, y=0.16mm

L= Length of span in mm = 1000mm

B= Breadth in mm=50mm

D= Depth in mm =10mm

I= Moment of inertia(mm^4) = $BD^3/12$ = 50 x $10^3/12$=4166.66mm^4

E = (11 WL3/ 768 YI) = 2.1 x 10^5 N/mm^2

Result:

Young's modulus (E) of beam material is =

Graph:

Draw the graph between **load vs. deflection**

Simply supported Beam with Loads

Beam **Supports**

Applications:

Generally a bending test is performed on metals or metallic materials but can also be applied to any substance that can experience plastic deformation, such as polymers and plastics. These materials can take any feasible shape but when used in a bend test most commonly appear in sheets, strips, bars, shells, and pipes. Bend test machines are normally used on materials that have an acceptably high ductility.

One of the more popular uses of bend testing is in the area of welds. The purpose of bend testing welds is to make sure that the weld has properly fused to the parent metal and that the weld itself does not contain any defects that may cause it to fail when it experiences bending stresses. The sample weld is deformed using a guided bend test so that it forms a "U" subjecting the material on the outer surface to a tensile force and the material on the inside to a compressive force. If the weld holds and shows no sign of fracture it has passed the test and is deemed an acceptable weld

Viva Questions

EXPERIMENT NO: 9

1. Define beam?

2. What is meant by bending?

3. How many types of bending are there?

4. Define plane bending

5. Define oblique bending?

6. Explain the types of loads

7. Define point load

8. Define distributed load.

9. Define UDL?

10. Explain the types of beams.

EXPERIMENT NO: 10

Bending test on Cantilever beam

Objective:

To determine the deflection(y) of M.S & Al Beam specimen and correspondingly workout for the young's modulus (E)of the given structural material.

Outcomes:

The student will be able to

- Understand the concept of deflection in beam
- Calculate the deflection for given specimen
- Find the strength of the given beam specimen

Scope of the Experiment:

The bend test is a simple and inexpensive qualitative test that can be used to evaluate both the ductility and soundness of a material. It is often used as a quality control test for butt-welded joints, having the advantage of simplicity of both test piece and equipment

Theory:

Young's modulus is defined as linear stress required producing unit linear strain, within the elastic limit. Young's modulus can be found from the theory of simple bending.

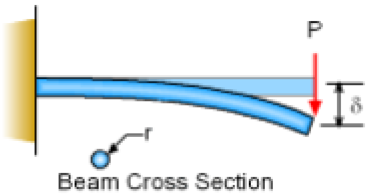


Fig 1. Cantilever beam

Consider a cantilever beam carrying a point load at the free end C. Then deflection equation is given by

$EIy = (Wx2/6) (3L-x)$ ------------- (1)

The maximum deflection occurs at the free end of the beam i.e at x = L.

$Y_{c=} (WL3/ 3EI)$

The deflection at the middle of the beam can be obtained by substituting x= L/2 in eqn (1)

$y = (5 WL3/ 48EI)$

Therefore **E = (5 WL3/ 48 yI)**

Calculation of young's modulus using this equation is called indirect method as stress and strain is not involved in this equation.

Apparatus:

The deflection of a beam apparatus consists of the following items:

1. Cantilever beam
2. Loading yoke-1 No.
3. Slotted weight hanger- 1 No.
4. Slotted weights
5. Dial gauge-10mm x 0.1mm – 1 No.
6. Dial gauge stand
7. Measuring scale
8. Vernier caliper

Procedure:

1. Measure the effective span width & depth of the cantilever beam.
2. Place the cantilever beam on the support properly.
3. Place the load hook at the free end of the beam.
4. L and L/2 marked on the beam, load is applied at L/2 and deflection is measured at L using dial indicator. Deflections are measured while loading and unloading and their avg is taken as deflection for the respective load.
5. Place the dial indicator in between the two ends where deflection needs to be calculated say at length L / 2 from left support.
6. Calculate the young's modulus of the given beam material by using the formula.

Precautions:

1. The beam must be loaded below its ultimate load. So that it may not fail under loading.
2. Adjust the dial indicator at the exact place where deflection needs to be calculated.
3. Note down the dial indicator readings carefully

Observation Table:

S no.	Load Applied (W) in (kg	Dial Indicator Reading			D(avg) x Least Count (0.10)	Deflection in mm	Stiffness (w/y)	Young's modulus (E)
		Loading	Unloading	Avg.				
1.								
2.								
3.								
4.								
5.								
6								

Result:

Young's modulus (E) of beam material is=

Graph:

Draw the graph between load vs deflection

Applications:

Generally a bending test is performed on metals or metallic materials but can also be applied to any substance that can experience plastic deformation, such as polymers and plastics. These materials can take any feasible shape but when used in a bend test most commonly appear in sheets, strips, bars, shells, and pipes. Bend test machines are normally used on materials that have an acceptably high ductility

Viva Questions

EXPERIMENT NO: 10

1. Explain the types of beams.
2. Define Maxwell’s reciprocal theorem
3. What is bending equation?
4. What are the units of bending moment?
5. What are the units of moment of Inertia?
6. What are the units for bending stress?
7. What is the Deflection of simply supported beam
8. Define load
9. Define cantilever beam
10. Define simply supported beam
11. Define fixed beam
12. Define continuous beam

EXPERIMENT NO: 11

Torsion test

Objective:

To determine the shear strength and rigidity modulus of mild steel specimen.

Outcomes:

- The student will be able to
- Understand the concept of torsion
- Calculate the rigidity modulus for the given specimen
- Determine the shear strength

Scope of the Experiment:

Torsional testing can help the engineer identify an appropriate material that will possess the required torsional strength while also contributing to the goal of light weighting. Many finished products are also subjected to torsional forces during their operation.

Theory:

In many areas of engineering applications, materials are sometimes subjected to torsion in services, for example, drive shafts, axles and twisted drills. Moreover, structural applications such as bridges, springs, car bodies, airplane fuselages and boat hulls are randomly subjected to torsion. The materials used in this case should require not only adequate strength but also be able to withstand torque in operation.

Generally, torsion occurs when the twisting moment or torque is applied to a member. The torque is the product of tangential force multiplied by the radial distance from the twisting axis and the tangent, measured in a unit of N.m. In torsion testing, the relationship between torque and degree of rotation is graphically presented and parameters such as ultimate torsional shearing strength (modulus of rupture), shear strength at proportional limit and shear modulus (modulus of rigidity) are generally investigated.

In order to study the response of materials under a torsional force, the torsion test is performed by mounting the specimen onto a torsion testing machine as shown and then applying the twisting moment till failure. It can be seen that higher torsional force is required at the higher degrees of rotation. Normally, the test specimens used are of a cylindrical rod type since the stress distribution across the section of the rod is the simplest geometry, which is easy for the calculation of the stresses. Both ends of the cylindrical specimen are tightened to hexagonal sockets in which one is fitted to a torque shaft and another is fitted to an input shaft. The twisting moment is applied by turning the input wheel to produce torque until the specimen fails.

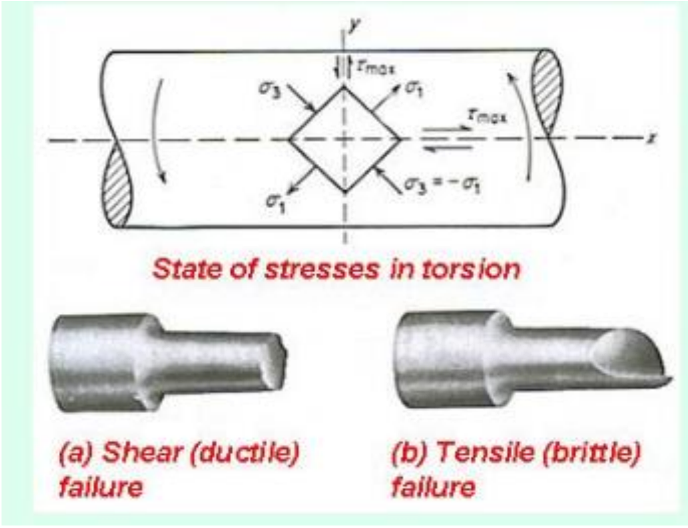
To test the material in torsion the proper test procedure is needed. It involves mounting a shaft into the testing machine, applying torque incrementally and measuring both the applied torque and the corresponding angle of twist. Using the appropriate formulae, relationships and the measured dimensions, we can determine the shear stress and shear strain on the shaft. Then, one can plot the torque vs. angle of twist, and shear stress vs. shear strain from which one can find the material properties previously mentioned.

Apparatus:

Torsion testing Machine, steel rule, vernier calipers, mild steel specimen.

Procedure:

1. Measure initial diameter, initial length and initial gauge length of the specimen. Record these parameters on the table provided. Measure the diameter of the test specimen using the caliper (take an average of 5 readings).
2. Draw a line down the length of the test section of the specimen with a pencil; this serves as a visual aid to the degree of twist being put on the specimen during loading.
3. Grip the test specimen on to the torsion testing machine using square sockets and make sure the specimens are firmly mounted. Fit both ends of the specimen to input and torque shafts and set reading on the torque meter to zero.
4. Start twisting the specimen at strain increment of 0.5^ountil failure occurs. Record the received data rotation in the table provided for the construction of torque and degree relationship.
5. Apply torque; record the angle of twist and torque at regular intervals till the specimen breaks.
6. Construct the relationship between shear stress and shear strain. Determine maximum shear stress, shear stress at proportional limit and modulus of rigidity.
7. Plot the graph between torque vs. angle of twist and find the rigidity modulus using the above formulae.



Types of failure in torsion

Precautions:

1. Before starting the machine ensure that the specimen is firmly fixed between the jaws.
2. Don't touch the specimen when the machine is running.
3. Wash your hands with soap after removing the specimen.
4. Take all the readings carefully.

Observation Table:

S. No	Torque" T" (Kg-cm x9.81 x 10) N-mm	Angle of Twist" θ"		Modulus of Rigidity" G"
		Degrees (θ)	Radians (θ x π/180)	

1.Initialdiameterofthespecimen=

2.Initiallengthofthespecimen=

3. Polar Moment of Inertia=

Calculations:

Modulus of Rigidity(G)=**TL/Jθ**

Result:

Rigidity Modulus of the material = N/mm^2

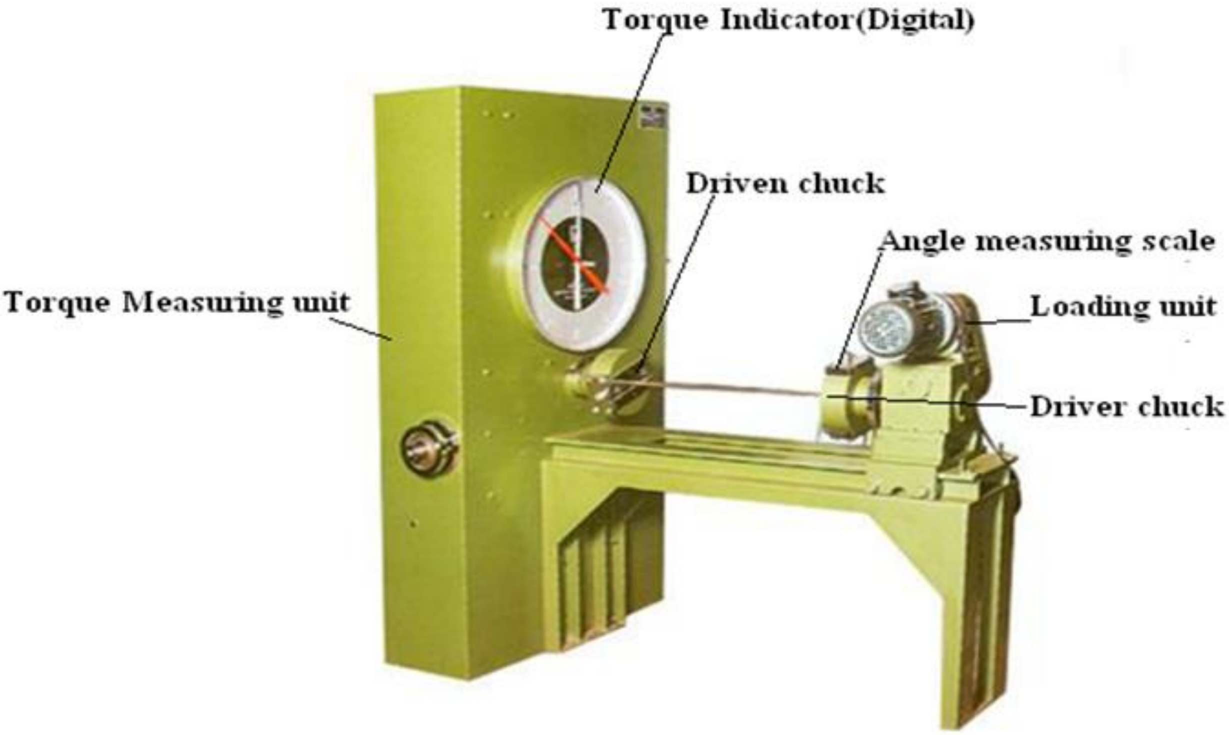


Fig 1. Torsion testing Machine

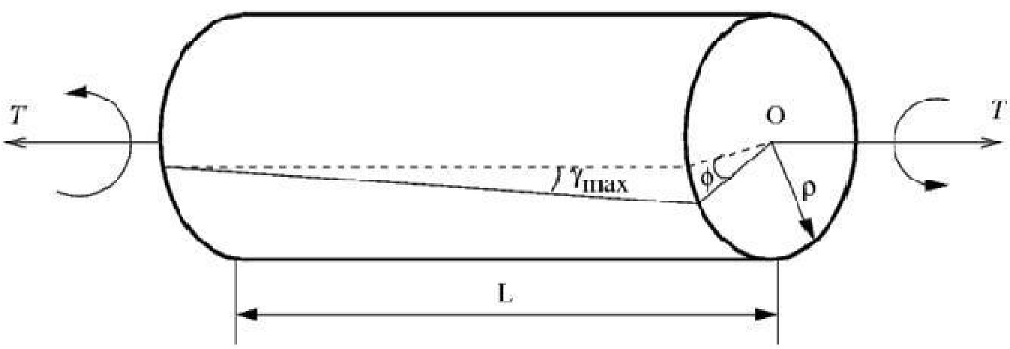
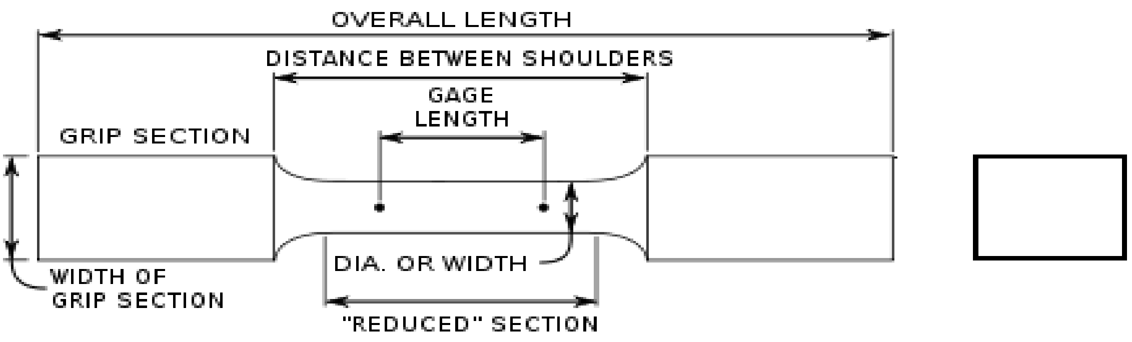
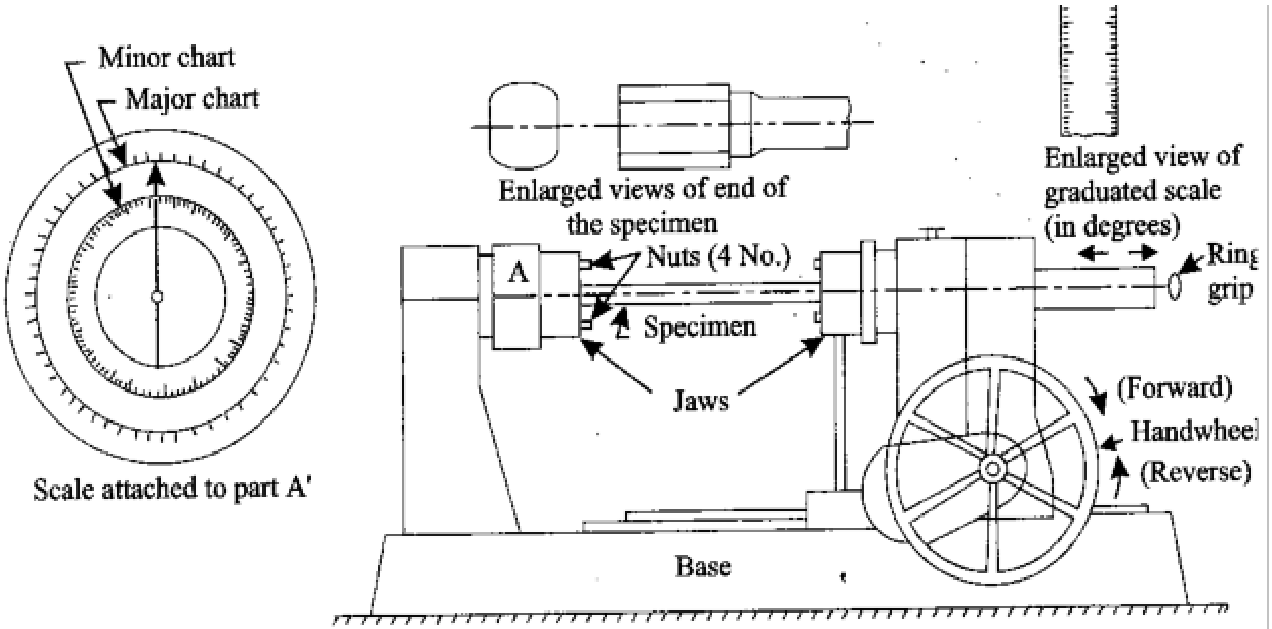


Fig 2 Torsion applied on circular rod



Test specimen(squre ends for gripping)

- Overall Length=250mm
- Length of Reduced section =140mm
- Distance between shoulders =150mm
- Diameter of reduced section= 8mm
- Width or dia of grip section =15mm



- **Fig. 9.** Torsion testing machine.

Applications:

Torsional testing can help the engineer identify an appropriate material that will possess the required torsional strength while also contributing to the goal of light weighting. Many finished products are also subjected to torsional forces during their operation.

Torsional testing machines are used to simulate real life service conditions and to check product quality for products such as drill tool bit tips and medical devices, screws and other fasteners, wire, and much more.

Viva Questions

EXPERIMENT NO: 11

1. Define torsion?

2. What is the formula torsion equation for circular shafts?

3. Write assumptions for torsion on shafts.

4. What are the effects of torsion?

5. Define modulus of rigidity?

6. Define angle of twist.

7. Define shaft.

8. What are the torque carrying engineering members?

9. Write formula to calculate polar moment of inertia (J)?

EXPERIMENT NO: 12

Brinell hardness test / Rockwell hardness test

BRINELL HARDNESS TEST

Objective:

To determine the Hardness number of the given specimen by using Brinell hardness test

Outcomes:

The student will be able to

- Understand the concept of hardness
- Find the hardness number for given specimen

Scope of the Experiment:

Brinell Hardness Testing is a nondestructive testing method that determines the hardness of a metal by measuring the size of an indentation left by an indenter. At a defined ball diameter and test force, larger indents left in the surface by the Brinell Hardness Testing Machine indicate a softer material

Theory:

1. HARDNESS:

It is defined as the ability of a material to resist abrasion, scratching (or) indentation. This is the desirable property for the parts subjected to wear.

2. BRINELL HARDNESS NUMBER:

Hardness is the property of a material that enables it to resist plastic deformation, usually by penetration. However, the term hardness may also refer to resistance to bending, scratching, abrasion or cutting. Hardness is not an intrinsic material property dictated by precise definitions in terms of fundamental units of mass, length and time. A hardness property value is the result of a defined measurement procedure.

Hardness of materials has probably long been assessed by resistance to scratching or cutting. An example would be material B scratches material C, but not material A. Alternatively, material A scratches material B slightly and scratches material C heavily. Relative hardness of materials can be assessed by reference to the Mohr's scale that ranks the ability of materials to resist scratching by another material. Similar methods of relative hardness assessment are still commonly used today.

The usual method to achieve a hardness value is to measure the depth or area of an indentation left by an indenter of a specific shape, with a specific force applied for a specific time.

There are three principal standard test methods for expressing the relationship between hardness and the size of the impression, these being Brinell, Vickers, and Rockwell. For practical and calibration reasons, each of these methods is divided into a range of scales, defined by a combination of applied load and indenter geometry.

The Brinell hardness test method consists of indenting the test material with a 10 mm diameter hardened steel or carbide ball subjected to a load of 3000 kg. For softer materials the load can be reduced to 1500 kg or 500 kg to avoid excessive indentation. The full load is normally applied for 10 to 15 seconds in the case of iron and steel and for at least 30 seconds in the case of other metals. The diameter of the indentation left in the test material is measured with a low powered microscope. The Brinell harness number is calculated by dividing the load applied by the surface area of the indentation.

$$BHN=2P/\pi D\,(D-\sqrt{(D^2}\text{ -}d^2)$$

Where p = applied load in N

D = Diameter of ball in mm

d= die of indentation in mm

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

Structures.

The standard combinations of’ P” (Total load applied) and diameter “D” of the ball that may be used indicated below.

Synod.	**Approximate B.H. N**	**P/D^2 ratio**	**Material**
1	Above 160	30	Steel, Cast iron
2	160-60	10	Copper alloy
3	60-20	5	Copper, Aluminum
4	Lessthan 20	1	Lead, Tin and their alloys

Example:

1) Let the specimen be made of steel

If D= 10mm desirable values of P= 3000Kg (30 X 10^2)

If D=2.5mm desirable values of P= 187.5Kg (30 X 2.5^2)

2) Let the specimen be made of copper

If D= 5mm desirable values of P= 250Kg (10 X5^2)

Apparatus:

Brinell's hardness machine, test specimen and Microscope

Indents used: 2.5 mm steel

Load selection: 10kgf, 60kgf 100 kgf, 150 kgf

Procedure:

1. Select in advance the diameter of the ball and total load to be applied.
2. Fix the proper ball indenter and clamp the indenter to the machine.
3. Clean the test specimen to be free from dirt, oil and scales.
4. The given specimen is placed in the Brinell hardness test machine
5. Using the align keys; the indent is placed in a position perpendicular to the M.S piece placed in the apparatus.
6. Place the specimen on the platform and rotate the wheel until the specimen touches the indenter and minor load scale reading is 3(set)
7. Apply the load by rotating the lever clock wise. Wait for a few seconds. After the lever comes to rest, rotate the lever anticlockwise.
8. Lower the platform by rotating the wheel and remove the specimen.
9. Mark the indentation by ink or pencil to identify it.
10. Measure the diameter "d" by using microscope.

Precautions:

1. The given specimen material must be kept tangentially to the indent in the apparatus.
2. Make sure that, when the load is applied, the apparatus should not be disturbed by any external means.
3. Be careful while checking the indentations diameter.

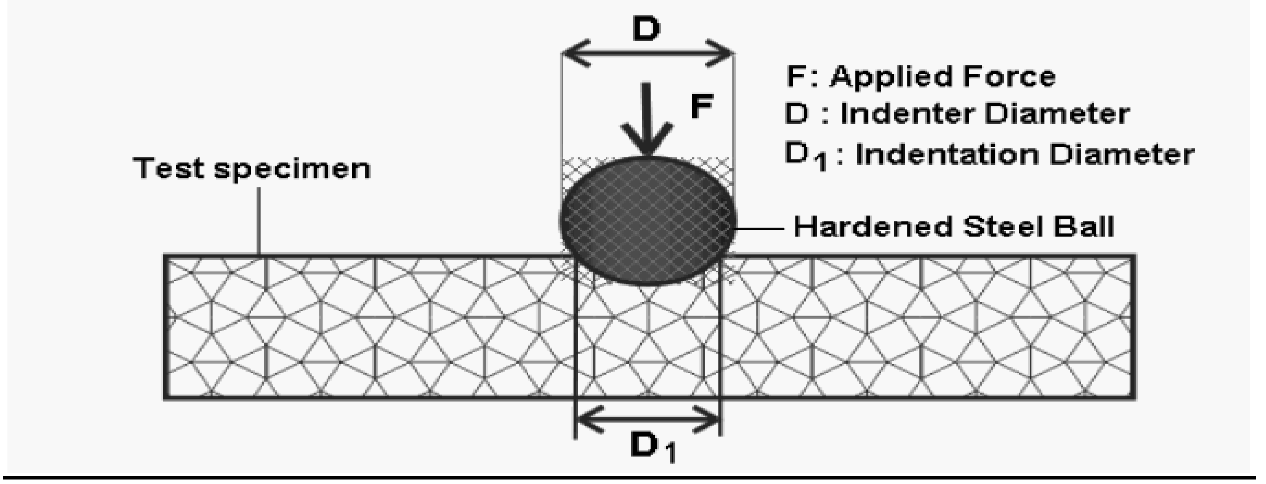
Observation Table:

S. No	**1**		**2**		**3**		**4**	
Material								
	Trial 1	**Trial 2**	**Trial 1**	**Trial 2**	**Trial 1**	**Trial 2**	**Trial 1**	**Trial 2**
Diameter of ball indenter (D)								
Load applied (P)								
Diameter of the indentation made (d)								
Brinell's Hardness Number (BHN)								

Result:

The Brinell's hardness number of the given M.S specimen is =

Brinell hardness test / Rockwell hardness testing machine



ROCKWELLS HARDNESS TEST

Objective:

To determine the hardness of the given specimen material (mild steel - MS) using the Rockwell's hardness testing machine

Outcomes:

The student will be able to

- Understand the concept of hardness
- Find the hardness number for given specimen

Scope of the Experiment:

Rockwell hardness testing is a general method for measuring the bulk hardness of metallic and polymer materials. Although hardness testing does not give a direct measurement of any performance properties, hardness of a material correlates directly with its strength, wear resistance, and other properties

Theory:

HARDNESS: The resistance of a material to plastic deformation against indentation scratching, abrasion or cutting.

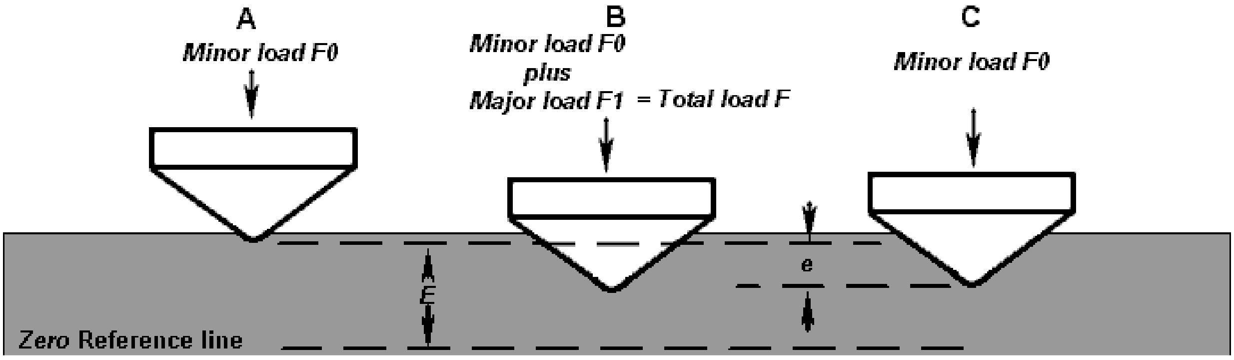
The hardness of a material by Rockwell hardness test method is measured by the depth of penetration of the indenter. The depth of penetration is proportional to the hardness. Both ball and diamond cone type indenters are used in this test.

There are three scales on machine for taking hardness readings.

Scale A: With load 60 kgf or 588.4 N and diamond indenter is used for performing tests on this steel and shallow care hardened steel.

Scale B: With load 100 kgf or 980.7 N and ball indenter is used for performing tests on soft steel, malleable iron, copper is aluminum alloys.

Scale C: With load of 150 kgf or 1471 N and diamond indenter is used for hard steel, hard cast steel, deep case-hardened steel and other metals which are harder.



First minor load is applied to overcome the film thickness on the metal surface. Minor loads also eliminate errors in the depth of the measurements due to spring of the machine or setting down of the specimen and table attachments.

The Rockwell hardness is derived from the measurement of the depth of the impression.

Ep: depth of penetration due to minor load of 98.07 N

Ea: increase in depth of penetration due to major load

E: Permanent increase of depth of indentation under minor load at 98.07N even after the removal of major load.

This method is suitable for finished or machined parts of simple shapes.

The types of indenters used are:1) 1/16" or 1.587mm diameter steel ball.2) Diamond tipped indenter with 120^0 cone angle.

The total load to be applied differs with the indenter. In all the tests the initial or minor load is 10kg. This can be applied by raising the platform by raising the hand wheel, so that the specimen gets passed by the indenter and causes a deflection of the dial gauge pointer(small) up to the point indicated as red dot.

The major load to be applied for various indenters is given below:

Indenter	**Scale**	**Minor load**	**Major load**	**Total load**
Rockwell-/16"	"B"	10kg	90kg	100kg
Rockwell-120^0	"C"	10Kg	140 kg	150kg

Apparatus:

Rockwell's hardness testing machine, the given specimen material, indenter, Ellen key.

Procedure:

1. Select the load rotating the knob and fix the suitable indenter
2. Clean the test piece and place on the special anvil or work table of the machine
3. Turn the capstan wheel to elevate test specimen into contact with the indenter point.
4. Further the turn the wheel for three rotations forcing the test specimen against the indenter. This will ensure that the minor load of 98.07 N has been applied.
5. Set the pointer on the dial at the appropriate positions
6. Push the lever to apply the major load
7. As soon as the pointer comes to rest pull the handle in reverse direction slowly this releases the major load but not the minor load. The pointer will however rotate in the reverse direction.
8. The Rockwell hardness can be read from the dial on the appropriate scale after the pointer comes to rest

Precautions:

1. Select the specimen as per the Rockwell scale
2. The specimen should be indentation free
3. Do not forget to change the units of load before calculations
4. Apply little mobile oil once a week on the elevating screw
5. Neglect first one or two readings whenever indentor or anvil is changed
6. The surface of the specimen must be flat and clean
7. Install the machine in a room which is free from vibrations, dust /smoke.
8. Do not test too close to the edge of specimen or near to earlier indentation.

Observation Table:

Standard piece Materials	Trail 1	Trail 2	Trail 3

1) Test piece material

2) Thickness of test specimen

3) Hardness scale used

4) Minor load

5) Major load

6) Hardness number from the scale

Result:

Rockwell hardness number of the given M.S material is =

Applications:

Rockwell hardness testing is a general method for measuring the bulk hardness of metallic and polymer materials. Although hardness testing does not give a direct measurement of any performance properties, hardness of a material correlates directly with its strength, wear resistance, and other properties.

Viva Questions

EXPERIMENT NO: 13

1. Define hardness
2. How many positions does knurling thumbscrew have?
3. What are the positions of knurling thumbscrew?
4. Which type of indenter is used for Rockwell hardness testing machine?
5. Which is the type of indenter used for Brinell hardness testing machine
6. Which type of indenter is used for hard materials?
7. Write down equation for calculating hardness number using Brinell hardness test
8. Define toughness
9. Define malleability
10. What are the different types of ferrous materials we have

EXPERIMENT NO: 13

Test on springs

1. COMPRESSION TEST ON SPRING

Objective:

To determine the Stiffness of the spring while Compression loads are applied and modulus of rigidity of wire material.

Outcomes:

The student will be able to

- Understand the concept of stiffness
- Calculate the modulus of rigidity for given specimen
- Understand compressive loads

Scope of the Experiment:

Compression tests are important to measure the elastic and compressive fracture properties of brittle materials or low-ductility materials. Compression tests are also used to determine the modulus of elasticity, proportional limit, compressive yield point, compressive yield strength, and compressive strength

Theory:

STIFFNESS: The resistance of a material to elastic deformation is called stiffness. A material which suffers light deformation under load has high degree of stiffness.

It is denoted by 'K'

Thus, stiffness K = Load (P)/ Unit deflection (δ l)

Where, load (p) is kg

Deflection (δ l) in mm.

The change in length is given by kg/mm

A spring may be defined as an elastic member whose primary function is to deflect or distort under the action of applied load; it recovers its original shape when load is released or springs are energy absorbing units whose function is to store energy and to restore it slowly or rapidly depending on the particular application.

Important types of springs are: There are various types of springs such as

(i) Helical spring: They are made of wire coiled into a helical form; the load being applied along the axis of the helix. In this type of springs, the major stresses are torsional shear stress due to twisting. They are both used in tension and compression.

(ii) Spiral springs: They are made of flat strip of metal wound in the form of spiral and loaded in torsion. In this the major stresses are tensile and compression due to bending.

(iii) Leaf springs: They are composed of flat bars of varying lengths clamped together so as to obtain greater efficiency. Leaf springs may be full elliptic, semi elliptic or cantilever types, in these types of springs the major stresses which come into picture are tensile & compressive. This type of springs is used in the automobile suspension system

Uses of springs:

(a) To apply forces and to control motions as in brakes and clutches.

(b) To measure forces as in spring balance.

(c) To store energy as in clock springs.

(d) To reduce the effect of shock or impact loading as in carriage springs

(e) To change the vibrating characteristics of a member as inflexible mounting of motors.

This test is conducted to find the material properties of the spring like modulus of rigidity. This can be obtained by observing the values of deflections of the spring with the application of different amounts of the load applied along the axis of the spring. The observed Values of deflections are compared with the theoretical value for the deflection of the spring under the load and shear modulus is to be obtained. In a closely coiled helical spring the angle of the helix is so small that the bending effects can be neglected and it is subjected to only torsional shear stresses. In an open helical spring, the angle of helix is large due to which bending stresses are introduced in addition to torsional shear stresses.

FORMULAE:

1. We have $T/J = C\theta/L$ (Torsion Equation)

Were,

W=Load applied in Newton's

J= Polar moment of inertia $mm^4 = \Pi d^4/32$

R_m=Mean radius of spring coil = (D-d) / 2

D= Outer dia of wire in mm

d=Dia of spring wire in mm

Dm = D-d

1. T= Torque in N-mm = $W \times R_m$
2. L=Length of spring in mm = $2\Pi \times R_m \times n$
3. $\theta = \dfrac{64 \times W \times R_m^2 \times n}{C\, d^4}$ (TL/CJ)

Where, n= No of Coils

4. δ =Deflection of spring in mm $= R_m \times \theta$

$$\delta = \frac{64 \times W \times (R_m)^3 \times n}{C\, d^4}$$

5. C=Modulus of rigidity of spring Material $= C = \frac{64 \times W \times (R_m)^3 \times n}{\delta\, d^4}$

$$C = \frac{8W\,(D_M)^3 \times n}{\delta\, d^4}$$

6. Maximum energy stores = 0.5 x Wmax x d max

Where,

Wmax=Maximum load applied

δmax=Maximum deflection

Apparatus:

Spring test machine, Springs for testing, Vernier Caliper

Specifications:

Make	**:** Tech track, Haryana, India.
Mode of operation	**:** Hand operator, Hydraulic pump.
Dia of spring coil	**:** 35 mm
Number of turns of spring coil	**:** 10
Dia of loading platform	**:** 150 mm
Max. Load capacity	**:** 2000 kg

Procedure:

1. Insert the pumping rod into the rod holder of the hand-pumping unit.
2. Now create pressure, inside the unit by pumping air by moving the rod up and down till the deflection starts.
3. Tight the release valve so that the pressure inside the machine is locked.

4. Note down the dial guage reading and the deflection on the scale in mm
5. Now change the load and note down the deflection.
6. Likewise take at least 3 readings.
7. After testing the spring for tension, change the spring to test for compression.
8. After changing the spring set up using the spanner apply load and measure the deflection by using following the equation.

   $K = W/\delta$ N/mm

   Where K = stiffness of spring n/mm

   W = applied load, n

   δ = deflection of length mm
9. After taking the reading for bottom tension and compression calculate the deflection and change in length and tabulate it.

Precautions:

1. Properly handle the pumping rod and prevent slipping from hand.
2. See that the release valve is fully tightened.
3. Carefully change the spring as the spring used for compression is too heavy and little slippery
4. Before starting cleaning of any arrangement, the main should be put off.
5. The load when applied must be kept constant by tightening the knob provided for this purpose.

Observation Table:

S no.	Axial Load applied 'W' kgfx9.8 (in Newtons)	Deflection "δ" in mm	Stiffness of spring $k= W/\delta$ - N/mm	Modulus of Rigidity $C= \frac{8W (D_M)^3 \times n}{\delta d^4}$

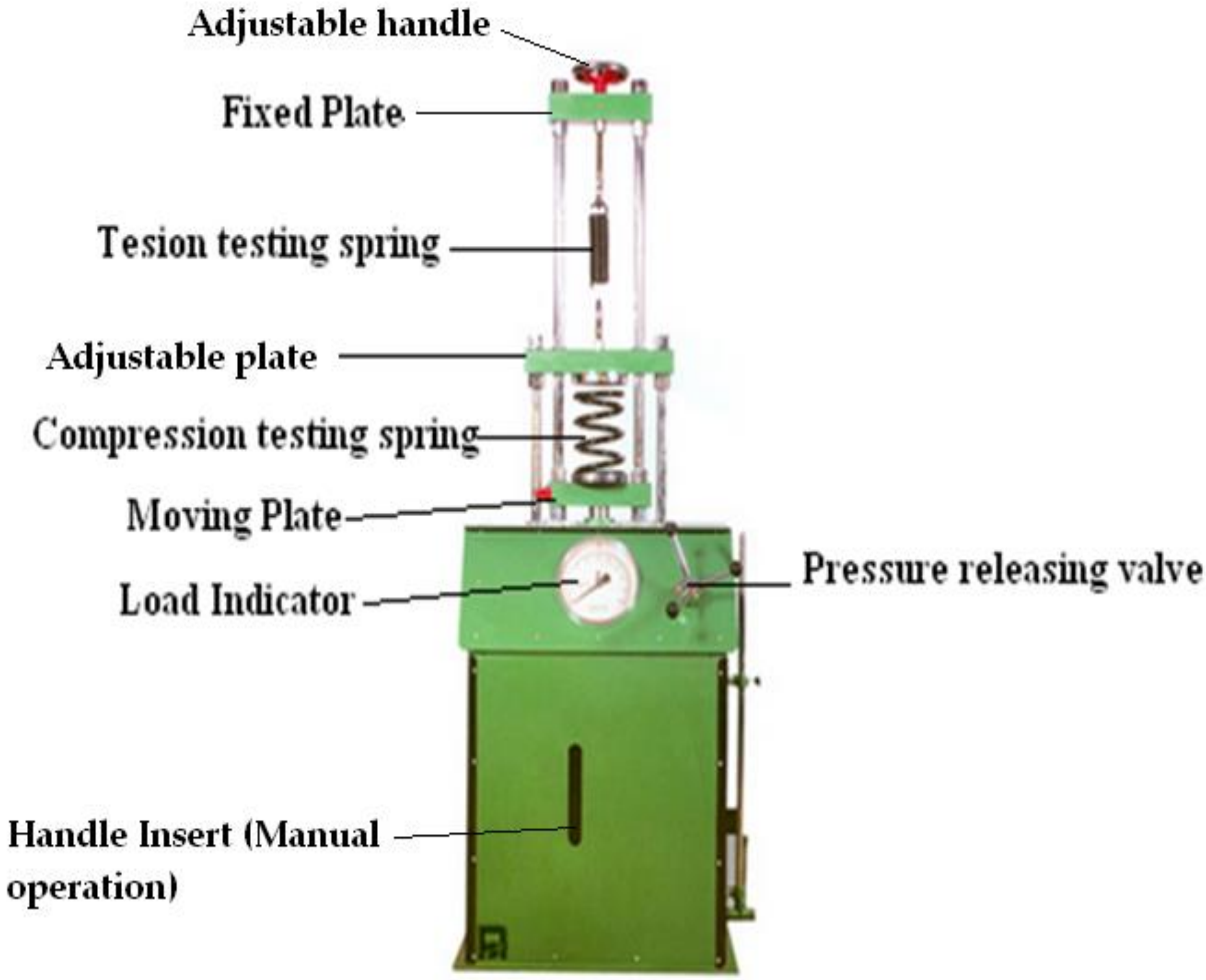
Result:

Under compression test on open coil helical spring

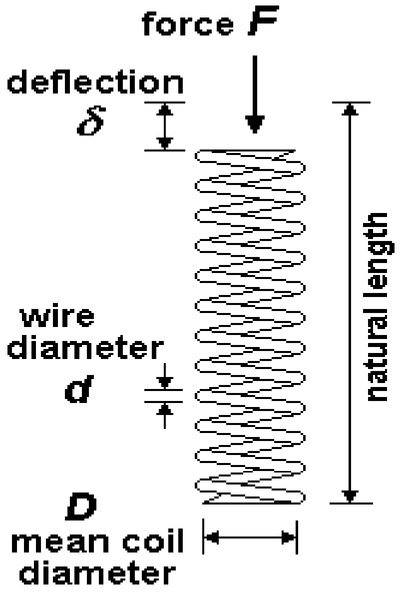
a. Rigidity Modulus (N) =

b. Stiffness of spring (K)=

c. Maximum Energy stored(U) =



Spring Tester



Valves

Pressure Gauge

Measuring Scale

TENSION TEST ON SPRING

Objective:

To determine the modulus of rigidity of the material of given helical spring.

Outcomes:

The student will be able to

- Understand the concept of stiffness
- Calculate the modulus of rigidity for given specimen
- Understand compressive loads

Scope of the Experiment:

The spring testing can be done efficiently with the help of spring testing machine. The testing process is performed to differentiate the quality of the bad spring and the good spring on the basis of the creating pressure on the spring sample in the form of tension and compression. The testing method helps to categorize the quality of the springs on the basis of its performance. This test is performed on the specimens to enhance the performance of the product

Theory:

A spring maybe defined as an elastic member whose primary function is to deflector distort under the action of applied load; it recovers its original shape when load is released or springs are energy absorbing units whose function is to store energy and to restore its lowly or rapidly depending on the particular application.

Important types of springs are:

There are various types of springs such as

(iv) **Helical spring:** They are made of wire coiled into a helical form; the load being applied along the axis of the helix. In this type of springs, the major stresses are torsional shear stress due to twisting. They are both used in tension and compression.

(v) **Spiral springs:** They are made of flat strip of metal wound in the form of spiral and loaded in torsion. In this the major stresses are tensile and compression due to bending.

(vi) **Leaf springs:** They are composed of flat bars of varying lengths clamped together so as to obtain greater efficiency. Leaf springs maybe full elliptic, semi elliptic or cantilever types, in these types of springs the major stresses which come into picture are tensile & compressive. This type of springs is used in the automobile suspension system

Uses ofsprings:

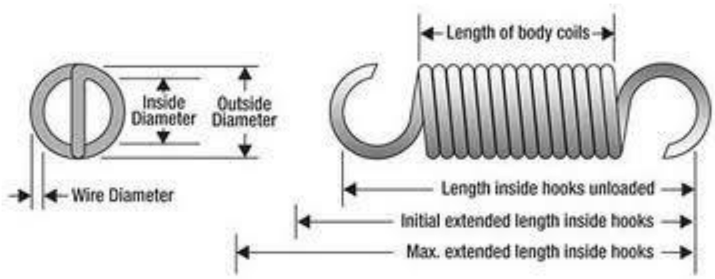
(a)To apply forces and to control motions as in brakes and clutches.

(b)To measure forces as in spring balance.

(c)To store energy as in clock springs.

(d)To reduce the effect of shock or impact loading as in carriage springs.

(e)To change the vibrating characteristics of a member as in flexible mounting of motors



Apparatus:

Spring testing machine, vernier calipers, screw gauge close coiled helical spring.

Procedure:

1. by usingVerniercalipermeasurethediameterofthewireofthespringandalsothe diameterofspringcoil.
2. Count the number of turns.
3. Insert the spring in the spring testing machine and load the spring by a suitable weight and note the core spending axial deflection in tension.
4. Increasetheloadandtakethecorrespondingaxialdeflectionreadings.
5. Plotacurvebetweenloadanddeflection.Theslopeofthecurvegives thestiffness ofthe Spring

Observation Table:

Diameter of spring coil(D)=
Diameter of spring wire (d)=
Number of turns in spring(n)=

S no.	Axial Load applied 'W' kgfx9.8 (in Newtons)	Deflection "δ "in mm	Stiffness of spring k= W/ δ - N/mm	Modulus of Rigidity C= $\frac{8W (D_M)^3 \times n}{\delta d^4}$

Result:

Under Tensile test on open coil helical spring

b. Rigidity Modulus (N)=

c. Stiffness of spring(K)=

Viva Questions

EXPERIMENT NO: 14

1. What is meant by stiffness:
2. If deformation is decrease stiffness is________________
3. The stiffness is denoted by______________
4. Define spring
5. How many types of springs are there?
6. Define helical spring
7. Define load
8. Define compressive stress
9. What is the total stiffness when the springs are in parallel?
10. How many types of helical springs are there?

EXPERIMENT NO: 14

Izod Impact test / Charpy test

Izod Test

Objective:

To determine the impact strength of the given specimen of material by performing the pendulum test.

Outcomes:

The student will be able to

- Determine the impact strength
- Understand the types of loads

Scope of the Experiment:

The Izod impact test is a standard test that measures the impact energy needed to fracture a material. This test helps engineers and scientists assess the fracture properties of a given part or component.

Theory:

The pendulum is mounted on antifriction bearings. It has two starting positions, the upper one for Charpy and the lower one for Izod testing. On release the pendulum swings down to break the specimen and the energy absorbed in doing so is measured as the difference between the height of drop before rupture and the height of rise after rupture of the test specimen and is read from the maximum pointer position on the dial scale.

There are two strikers and one combined support available for lifting into the pendulum and on to the base of the machine for Izod, Charpy test changing from one striker to another is achieved simply by fixing the new striker into its position.

Impact strength: The high resistance of material to fracture under suddenly applied loads.

Related formulae I = K / A

Where I = impact strength

K = impact energy

A = area of cross section of the specimen.

Apparatus:

Izod testing machine, specimen of given material, Vernier calipers, steels rule.

Specifications:

Make	: tech track, Haryana, India
Type of test carried out	: Izod test
Angle of drop	: 90^0

Striking energy : 165f $\pm$3.4 J

Dimensions of specimen used : (75x10x10) mm with ‘V’ notch at 28 mm

Depth is $\leq 45^{0}$

Maximum Impact Energy : 165J

Angle between top face of grips holding the specimen vertical is: $90^{0+} 1^{0}$

Angle of tip hammer : $100^{+} 1^{0}$

Procedure:

1. For conducting the Izod test, a proper striker is to be fitted firmly to the bottom of the hammer with the help of the clamping piece.
2. The latching take for Izod test is to be firmly fitted to the bearing housing at side of the columns.
3. Adjust the reading pointer along with pointer carries on 168 J reading on the dial when the pendulum is hanging free vertically
4. The frictional test can be determined from the free fall test. Raise the hammer by hands and latch in. Release the hammer by operating lever, the pointer will then indicate the energy loss due to friction. From this reading confirm that the friction loss is not exceeding 0.5 % of the initial potential energy. Other wise friction loss has to be added to the final reading.
5. Now raise the pendulum by hands and latch in with latch.
6. The specimen for Izod tests is firmly fitted in the specimen support with the help of clamping screw and align key care is to be taken that the notch on the specimen should face the pendulum striker.
7. After ascertaining that there is no person in the range of swing pendulum release the pendulum to smash the specimen.
8. Carefully operate the pendulum break when returning after one swing to stop the oscillations.
9. Read off position of reading pointer on dial and note indicated value.

The notch impact strength depends largely on the shape of the specimen and the notch. The value determined with other specimens therefore may not be compare with each other.

Precautions:

The impact tester is dangerous with the potential for bodily injury. Pay attention at all times

and observe these safety considerations.

1. Safety glasses shall be worn by all participants.

2. Prior to performing any operations, such as changing striking bits or placement of specimens, pull the pendulum arm back and engage the safety latch, prohibiting movement of the pendulum arm.
3. Avoid placing fingers in pinch areas.

4. All participants shall remain behind the caution tape during the actual test.

5. Make sure the safety latch is in the clear when raising the pendulum arm into the test position.
6. The test operator shall apply brake upon breakage of the test specimen. All other participants shall remain clear until the brake has brought the pendulum to a complete stop.

Observation table:

K = impact energy KJ

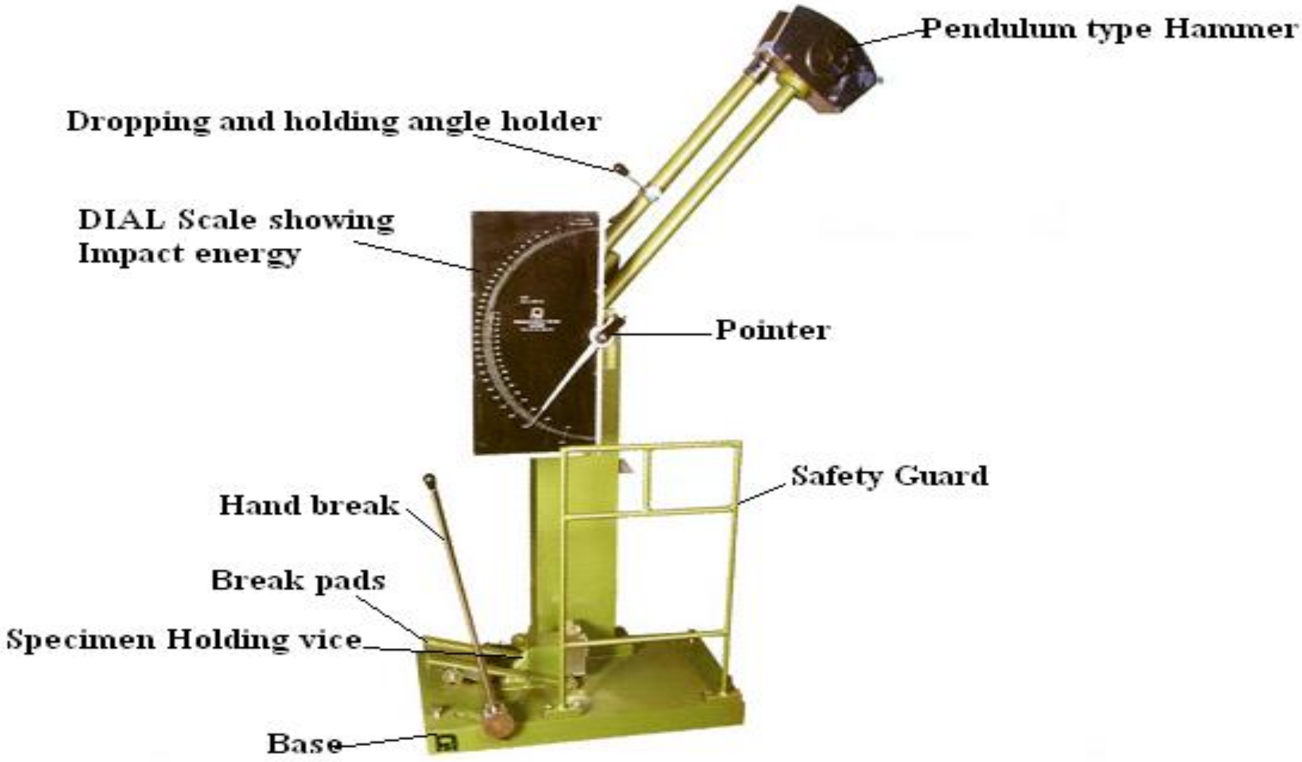
A= Area of cross-section of the specimen mm^2

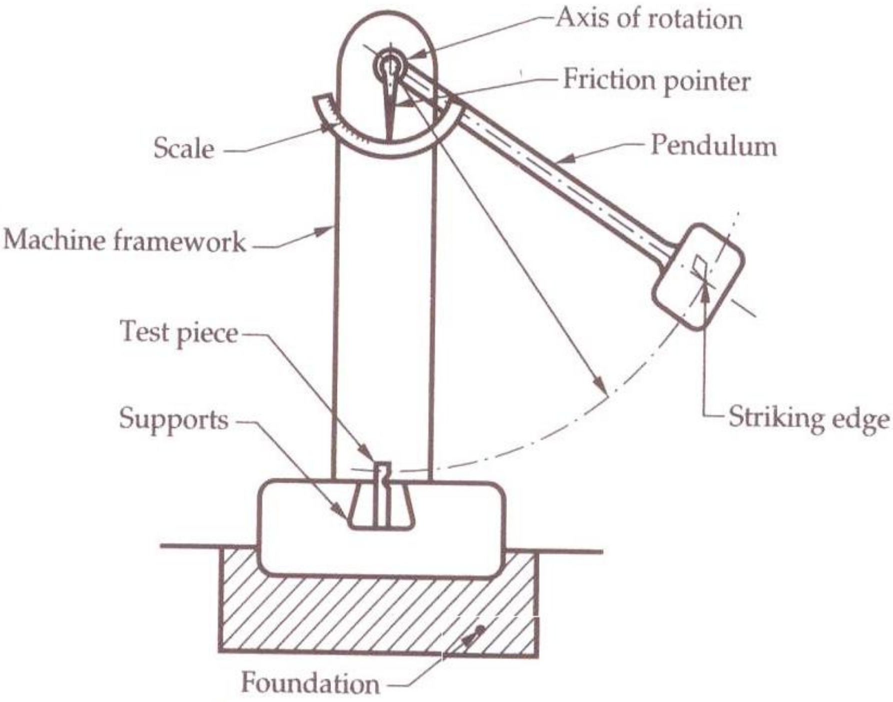
Calculate value of I = K/A

S NO.	Area of cross-section A, m2	Impact energy factor (k) joules	Impact strength (I=K/A)kJ /m^2

Result:

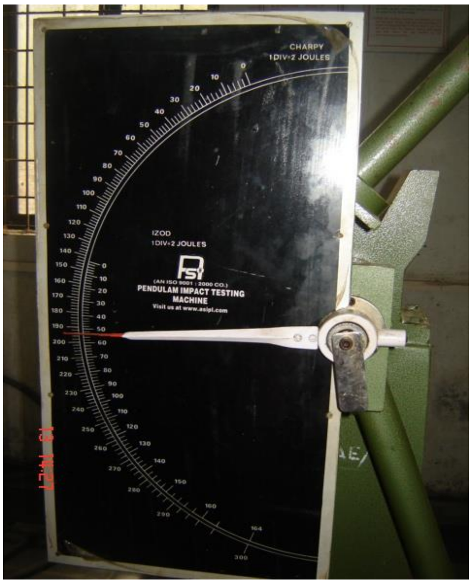
The impact strength of the given specimen found by:





Izod impact testing machine

PENDULUM TYPE HAMMER **HAND BREAK**



VICE **DIAL GUAGE**

Applications:

Charpy Impact Test is the most commonly used test which is used for determining the amount of forces that are absorbed by materials when it reaches the point of fracture. This amount of energy gives the analysis of the notch hardness of material.

CHARPY TEST

Objective:

To conduct Charpy test on the given specimen and to determine its impact strength

Outcomes:

The student will be able to

- Determine the impact strength
- Understand the types of loads

Scope of the Experiment:

Charpy Impact Test is the most commonly used test which is used for determining the amount of forces that are absorbed by materials when it reaches the point of fracture. This amount of energy gives the analysis of the notch hardness of material.

Theory:

The pendulum is mounted on antifriction bearings. It has two starting positions, the upper one for Charpy and the lower one for Izod testing. On release the pendulum swings down to break the specimen and the energy absorbed in doing so is measured as the difference between the height of drop before rupture and the height of rise after rupture of the test specimen and is read from the maximum pointer position on the dial scale.

There are two strikers and one combined support available for lifting into the pendulum and on to the base of the machine for Izod, Charpy test changing from one striker to another is achieved simply by fixed the new striker into its position.

Impact strength: the high resistance of material to fracture under suddenly applied loads.

Related formulae $I = k / A$

Where I = impact strength

K = impact energy

A = area of cross section of the specimen.

Apparatus:

Impact testing machine, specimen of given material, Vernier calipers, steels rule.

Specifications:

Make	: Tech track, Haryana, India
Type of test carried out	: 120D and Charpy test
Angle of drop	: 140^0
Max. Impact energy	: 300J

Dimensions of specimen used : (55x10x10) mm with ‘U’ notch at 27.5 mm,2mm Depth and 45^0

Procedure:

1. For conducting charpy test a proper striker is to be fitted firmly to the bottom of the hammer with the help of the clamping piece.
2. The latching taken for charpy test is to be firmly fitted to the bearing housing at the side of the column.
3. Adjust the reading pointer along the pointer carrier on 168 J on the dial when the pendulum is hanging vertically.
4. The frictional test can be determined from the free fall test. Raise the hammer by hands and latch and release the hammer by opening lever, the pointer will then indicate the energy loss due to friction. From this reading confirm that the friction loss is not exceeding 0.5 % of the initial potential energy. Otherwise, friction loss has to be added to the final reading.
5. Now raise the pendulum by hands and latch.
6. The specimen for the Charpy test is fitted firmly in the specimen support provided with the help of the clamping screw & align key. Care should be taken that the notch on the specimen should face the pendulum strokes.
7. After checking that there is no person in the range of the swing of the pendulum, release the pendulum to smash the specimen.
8. Carefully operate the pendulum brake while returning after performing one swing to stop the oscillations.
9. Read “off position” of reading pointer on the dial gauge and note the indicated value.
10. Remove the broken specimen by loosening the clamping screw.

Note: The notch impact strength depends largely on the shape of the specimen and notch. The values determined with other specimens therefore do not match with each other.

Precautions:

The impact tester is dangerous with the potential for bodily injury. Pay attention at all times and observe these safety considerations.

1. Safety glasses shall be worn by all participants.
2. Prior to performing any operations, such as changing striking bits or placement of specimens, pull the pendulum arm back and engage the safety latch, prohibiting movement of the pendulum arm.
3. Avoid placing fingers in pinch areas.
4. All participants shall remain behind the caution tape during the actual test.
5. Make sure the safety latch is in the clear when raising the pendulum arm into the test position.
6. The test operator shall apply brake upon breakage of the test specimen. All other participants shall remain clear until the brake has brought the pendulum to a complete stop.

Observation table:

Area of cross section of specimen A =

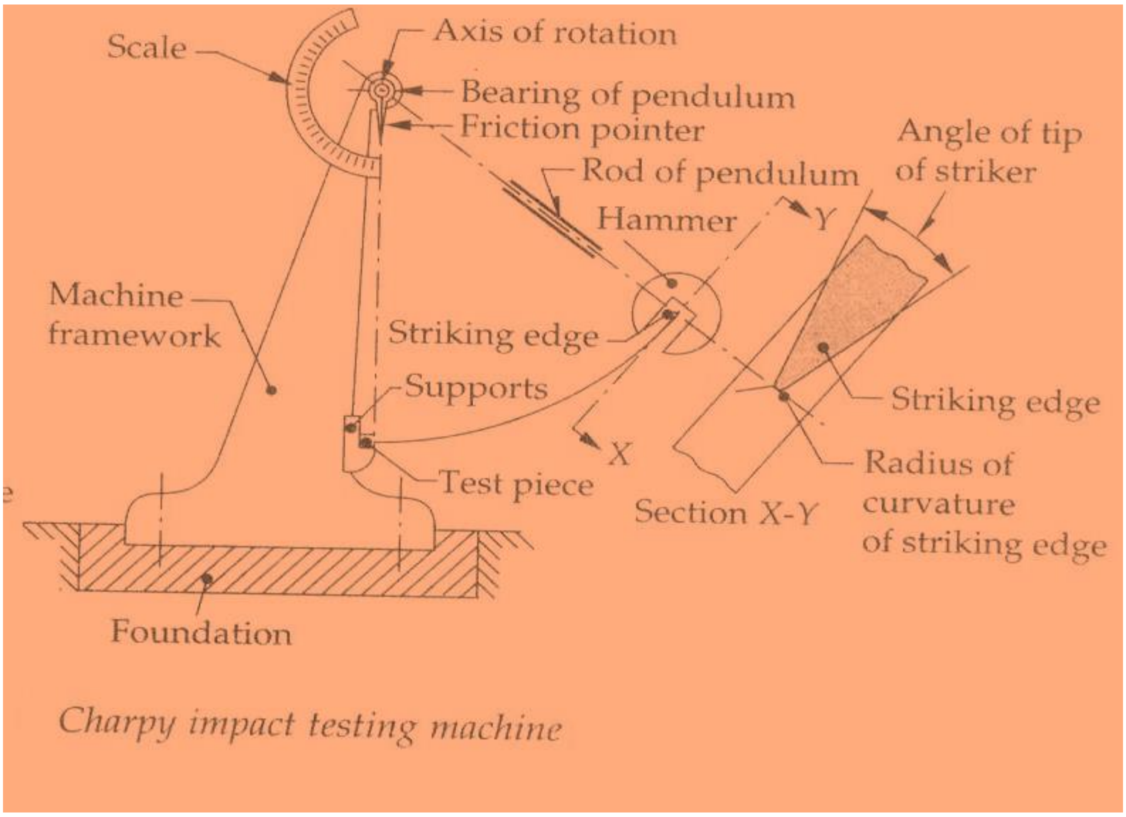
Impact energy k =

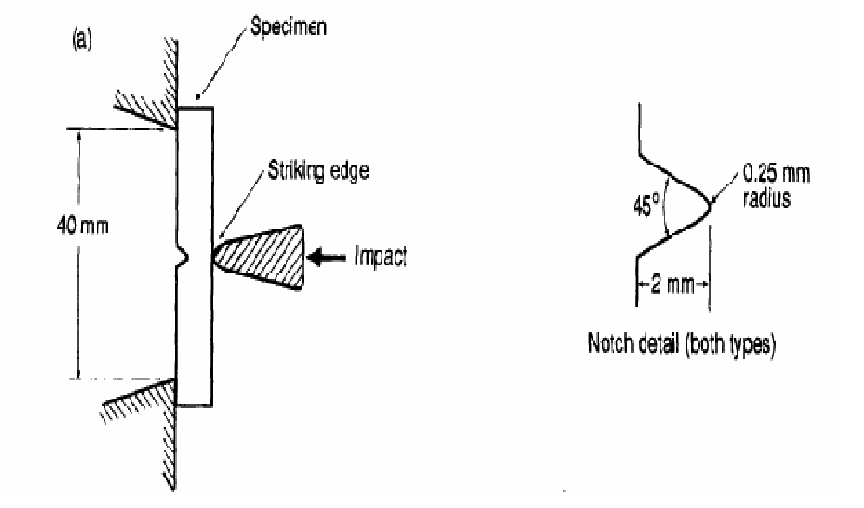
Impact strength of the specimen I = K/A

S NO.	Area of the speci-men (A), m^2	Impact energy (k) joules	Impact strength (I=K/A)Kj /m2

Result:

The impact strength of the given specimen is





Applications:

Charpy Impact Test is the most commonly used test which is used for determining the amount of forces that are absorbed by materials when it reaches the point of fracture. This amount of energy gives the analysis of the notch hardness of material.

Viva Questions

EXPERIMENT NO 14

1. Define load.
2. Define impact strength
3. Define impact load
4. Define suddenly applied load
5. Define gradually applied load
6. How many types of hardness machines we have
7. What is the range of dial gauge for the Izod test?
8. Write down the formula for impact strength
9. What is the purpose for conducting impact test
10. What is the range of dial gauge for the Izod test?