MECHANICS OF SOLIDS LABORATORY

III SEMESTER: AE								
Course Code	Category	Hours / Week			Credits	Maximum Marks		
AAEC05	Core	L	T	P	C	CIA	SEE	Total
		0	0	3	1.5	30	70	100
Contact Classes: Nil	Tutorial Classes: Nil	Practical Classes: 45				Total Classes: 45		
Prerequisite: There are no prerequisites to take this course.								

I. COURSEOVERVIEW:

The objective of the Mechanics of Solids lab is to demonstrate the basic principles in the area of strength and mechanics of materials and structural analysis to the undergraduate students through a series of experiments. In this lab the experiments are performed to measure the properties of the materials such as impact strength, tensile strength, compressive strength, hardness, ductility etc.

This lab also used in project works for testing of various materials like composite materials, ferrous and nonferrous alloys, etc. It also useful to identify suitable materials for aero structures based on mechanical properties and its characterization.

II. COURSE OBJECTIVES:

The students will try to learn:

I. The mechanics of materials and structural analysis through a series of experiments using appropriate codes and standards.
II. The behaviour and failure modes of the materials under different mechanical loading conditions
III. The writing process and evaluation of the experimental results materials based on characterization.

III. COURSE OUTCOMES

CO1 Compare the hardness of ferrous and nonferrous materials using Rockwell and Brinell's hardness testing machines.

CO2 Choose the regions of elasticity and plasticity, stress-strain relationships using universal testing machine for determining the safety factor.

CO3 Summarize performance of a material or product using torsion tests, when undergoes rotational motion when in service

CO4 Identify the quality performance of springs or structural elements for specified requirements such as energy storage and energy conversion.

CO5 Demonstrate toughness and capacity to resist the energy of a product subjected to shock loading by adopting Charpy and Izod test

CO6 Make use of shear force and bending moment distribution along the length of beams under various loads for design of structural members

Do's

1) For safety purpose the students should compulsorily wear shoes.
2) Enter laboratory with appropriate laboratory uniform and shoes.
    i. For boys, half sleeve shirts, tucked in trousers
    ii. For ladies, half sleeve overcoat, hair put inside the overcoat
3) Don't use mobile phones during laboratory hours
4) Bring the laboratory manual, observation and record without fail.
5) Keep all your belongings in the book rack or at the place suggested by lab instructor

6) Be punctual to the classes.
7) To come prepared with procedure relevant to the experiment.

Don’t

1) Don’t operate any machine without permission of the lab uncharged
2) Don’t unplug any machine from power supply.
3) Don’t remove any parts of the machine.

IV. COURE CONTENT:

EXERCISES ON MECHANICS OF SOLIDS LABORATORY

1. Getting Started Exercises

1.1 Introduction to Laboratory

The solid Mechanics of Solids (MoS) Laboratory is well equipped with destructive testing machineries. Students will be able to understand the basic concepts of Mechanics of Solids and enable to apply them to practical problems in this laboratory. Different types of tests are conducted in this laboratory as per standards (ASTM and IS) for the estimation of mechanical properties of various materials such as Young's Modulus, Shear Modulus, Hardness, Toughness, Stiffness, etc. Many students of Final year are utilizing this laboratory for testing of various materials like composite materials, ferrous and nonferrous alloys for the design of components of aircraft and machine elements.

- To familiarize students with lab equipments
- Inform the students on lab evaluation process
- Inform the students about laboratory precautions
- To familiarize students sample preparations
- Learning outcomes of the lab

2. Brinell Hardness test

2.1. Introduction

Hardness is defined as a material's ability to resist permanent indentation (that is plastic deformation). Typically, the harder the material, the better it resists wear or deformation. The term hardness, thus, also refers to local surface stiffness of a material or its resistance to scratching, abrasion, or cutting.

2.2. Objectives

1. To determine the hardness number from Brinell hardness test.
2. To measure the ultimate tensile strength of the specimen from the Brinell hardness test.
3. The specimen prepared as per the given dimensions in fig.2.1

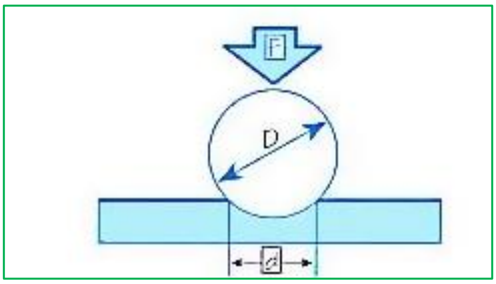


fig.2.1: Brinell hardness test

Where D = Ball diameter

d = impression diameter

F = load

HB = Brinell result

2.3 Further Probing Experiments

1. Measure the hardness values for different conventional materials.
2. Compare the hardness values same material with different loads and comment on the results.

3. Rockwell Hardness test

3.1.Introduction

Hardness is defined as a material's ability to resist permanent indentation (that is plastic deformation). Typically, the harder the material, the better it resists wear or deformation. The term hardness, thus, also refers to local surface stiffness of a material or its resistance to scratching, abrasion, or cutting.

3.2. Procedure

1. To determine the Brinell hardness number from the Rockwell hardness test
2. To find the ultimate tensile strength of the metal specimens from the Brinell hardness number by using empirical relationships as shown in fig.3.1

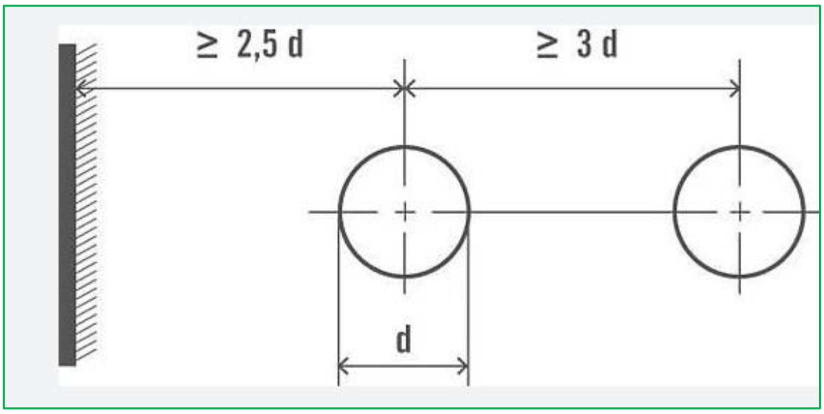


fig.3.1: Rockwell Hardness test specimen as per ISO 6508

3.3 Further Probing Experiments

1. Measure the hardness values for different materials which needs unusual scales.
2. Compare the hardness values same material with different loads and comment on the results.

4. Tension test of Mild Steel

4.1.Introduction

The objective of this experiment is to evaluate the mechanical (tensile) properties of selected metallic materials using the tensile test method. These mechanical properties include modulus of elasticity, yield strength, ultimate tensile strength, failure strength, ductility, and strain to failure.

4.2.Procedure

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

2. Insert the specimen into grips of the test machine and attach strain-measuring device to it.
3. Begin the load application and record load versus elongation data.
4. Take readings more frequently as yield point is approached.
5. Measure elongation values with the help of dividers and a ruler.
6. Continue the test till Fracture occurs.
7. By joining the two broken halves of the specimen together, measure the final length and diameter of specimen as shown in fig.4.1.

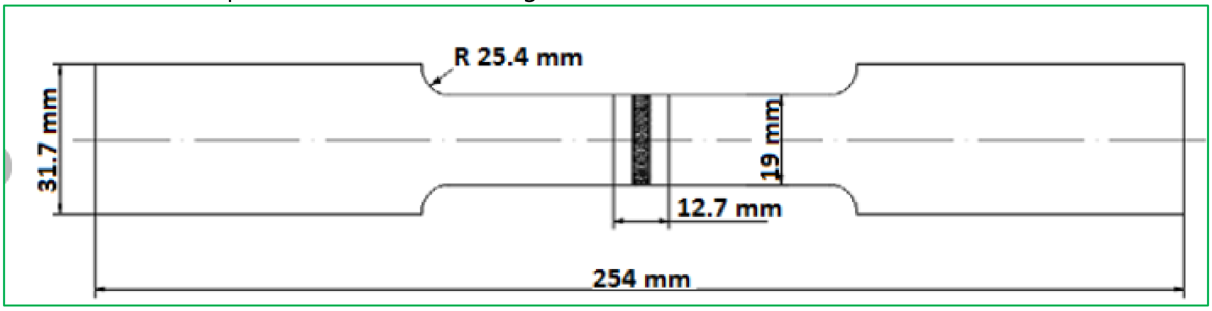


fig.4.1: Tension test specimen preparation

4.3. Further Probing Experiments

1. Calculate the Young's Modulus for ductile materials.
2. Generate stress Vs strain diagram for different materials using servo driven Universal Testing Machine.

5. Torsion test of Mild Steel

5.1. Introduction

The stress resulting from torsion load can be determined by means of the torsion test. This test resembles the tension test in that a load deflection curve is also development (which is transformed to a shear-strain curve).In a torsion test, a solid or hollow cylindrical specimen is twisted and the resultant deformation, measured as the angle through which the bar is twisted. The test then consists of measuring the angle of twist, Φ(rad) at selected increments of torque, T (N.m). Expressing Φ as the angular deflection curve per unit gage length.

5.2. Procedure

1. Measure the original length and diameter of the specimen. The length may either be length of gauge section which is marked on the specimen with a preset punch or the total length of the specimen.
2. Insert the specimen into grips of the test machine and attach strain-measuring device to it.
3. Begin the load application and record load versus elongation data.
4. Take readings more frequently as yield point is approached.
5. Measure elongation values with the help of dividers and a ruler.
6. Continue the test till Fracture occurs.
7. By joining the two broken halves of the specimen together, measure the final length and diameter of specimen as shown in fig.7.1. (All dimensions are in mm).

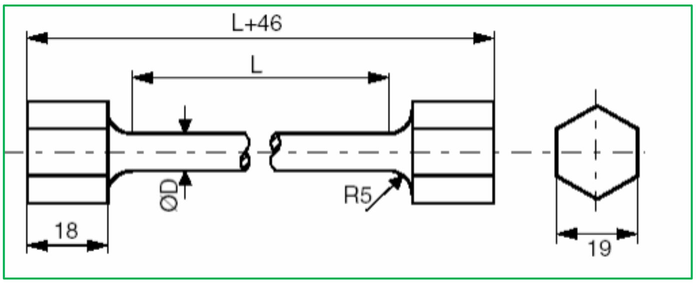


fig.5.1: Torsion test specimen dimensions

5.3. Precautions

1. Wear tight overalls and shoe for safety.
2. If the strain measuring device is an extensometer it should be removed before necking begins.
3. Measure deflection on scale accurately and carefully.

5.4. Further Probing Experiments

1. Calculate the Young's Modulus for various ductile materials.
2. Generate stress Vs strain diagram for different materials using servo driven Universal Testing Machine.

6. Izod impact test

6.1. Introduction

Impact test determines the amount of energy absorbed by a material during fracture. This absorbed energy is a measure of a given material's toughness and acts as a tool to study temperature-dependent brittle-ductile transition.

6.2. Procedure

1. With the striking hammer (pendulum) in safe test position, firmly hold the steel specimen in impact testing machines vice in such a way that the notch faces the hammer and is half inside and half above the top surface of the vice.
2. Bring the striking hammer to its top most striking position unless it is already there, and lock it at that position.
3. Bring indicator of the machine to zero, or follow the instructions of the operating manual supplied with the machine.
4. Release the hammer. It will fall due to gravity and break the specimen through its momentum, the total energy is not absorbed by the specimen. Then it continues to swing.
5. At its topmost height after breaking the specimen, the indicator stops moving, while the pendulum falls back. Note the indicator at that topmost final position as shown in fig.6.1

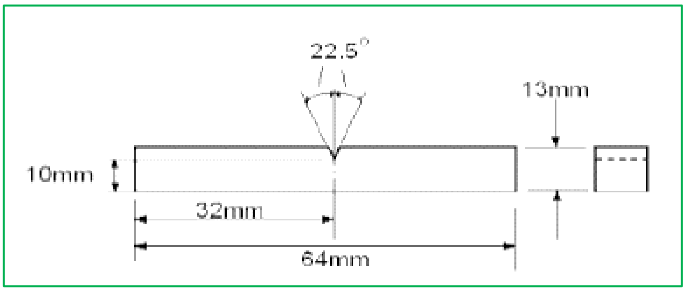


fig.6.1: Izod impact test specimen dimensions

6.3 Further Probing Experiments

1. Calculate the impact strength of unnotched specimens.
2. Determine the impact strength of U-Notched specimens.

7. Charpy impact test

7.1. Introduction

Impact test determines the amount of energy absorbed by a material during fracture. This absorbed energy is a measure of a given material's toughness and acts as a tool to study temperature-dependent brittle-ductile transition.

7.2. Procedure

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

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

3. Bring indicator of the machine to zero, or follow the instructions of the operating manual supplied with the machine as shown in figure below.

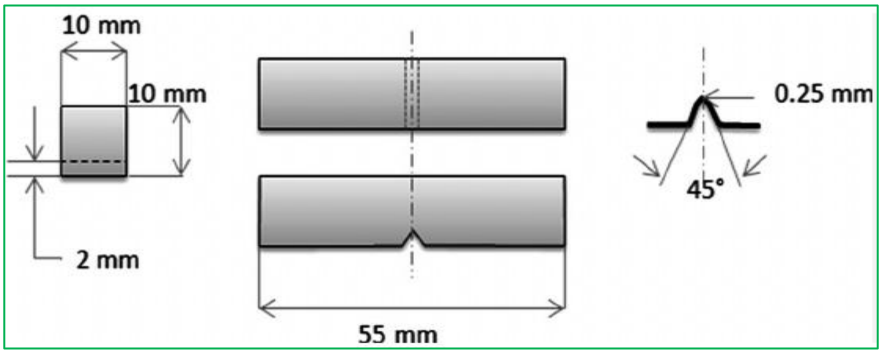


fig.7.1: Charpy Impact Test Specimen Dimensions

7.3 Further Probing Experiments

1. Calculate the impact strength of a unnotched specimens.
2. Determine the impact strength of a U-Notched specimens.

8 Compression test for short columns

8.1 Introduction

Compression tests on short columns are used to determine a material's behaviour under applied crushing loads, and are typically conducted by applying compressive pressure using a universal testing machine. By using this experiment the load corresponding to the crushing stress, is called crushing load will be determined for the short columns.

During the test, various properties of the material are calculated and plotted as a stress-strain diagram which is used to determine qualities such as elastic limit, proportional limit, yield point, yield strength and, for some materials, compressive strength.

1.2 Objectives

Compressive strength of the long columns.

8.3 Further Probing Experiments

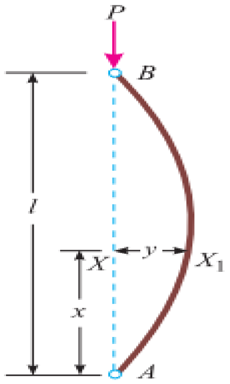
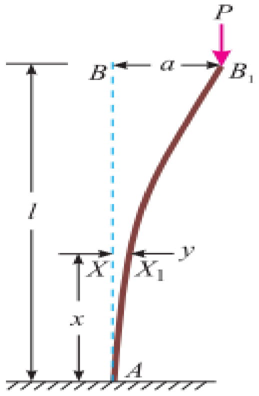
1. Calculate the compressive strength of a non ferrous metal cube.
2. Determine the compressive strength of a metallic columns

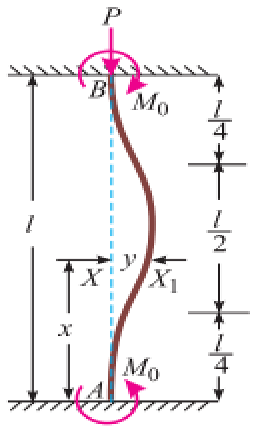
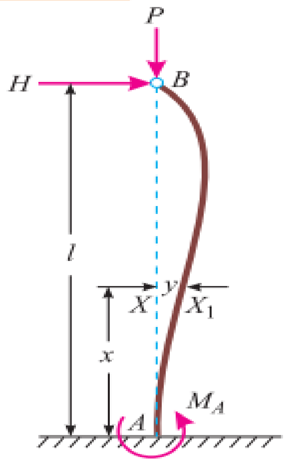
9 Compression test for long columns

9.1 Introduction

Compression tests on long columns are used to determine a material's behaviour under applied buckling loads, and are typically conducted by applying compressive pressure using a universal testing machine. The column will fail due to buckling before the yield strength of the member is reached. Buckling occurs suddenly, and is characterized by large deflections perpendicular to the axis of the column. The stability of long columns also effects end conditions, which are 1. Both ends hinged, 2. Both ends fixed, 3. One end is fixed and the other hinged, and 4. One end is fixed and the other free.

During the test, various properties of the material are calculated and plotted as a stress-strain diagram which is used to determine qualities such as elastic limit, proportional limit, yield point, yield strength and, for some materials, compressive strength.

S,No	Columns	Types of end conditions
1	Columns with Both Ends Hinged	
2	Columns with One End Fixed and the Other Free	

3	Columns with Both Ends Fixed	
4	Columns with One End Fixed and the Other Hinged	

9.2 Objectives

1. Buckling strength of the long columns.
2. Compressive strength of the long columns.

9.3 Further Probing Experiments

1. Calculate the compressive strength of a non ferrous metal cube.
2. Determine the compressive strength of a metallic columns

10 Spring test

10.1 Introduction

Spring test is used to determine the stiffness of helical spring. Stiffness is the ability of a material withstand load per unit deflection. The modulus of rigidity of a spring material varies as a function of chemical composition, cold working, and degree of aging,

10.2 Procedure

1. Measure the diameter of the wire of the spring by using the micrometre.
2. Measure the diameter of spring coils by using the Vernier calliper
3. Count the number of turns.
4. Insert the spring in the spring testing machine and load the spring by a suitable weight and note the corresponding axial deflection in tension or compression.
5. Increase the load and take the corresponding axial deflection readings.

6. Plot a curve between load and deflection. The shape of the curve gives the stiffness of the spring.

10.3 Further Probing Experiments

1. Measure the hardness values for different materials which needs unusual scales.
2. Compare the hardness values same material with different loads and comment on the results.

11 Deflection test for simple supported beam

11.1 Introduction

In Designing of beams two design criteria ate important, one Strength which is resist to shear force and bending moment, and other is the stiffness, which is resistance to deflection under different types of loads. There are many methods to find out the slope and deflection at a section in a loaded beam, but 1. Double integration method and 2. Macaulay's methods are the important.

11.2 Procedure

In this experiment Macaulay's method shown in fig. 11.2, and using out the slopes and deflection of beams with the following rules

a. Always take origin on the extreme left of the beam.
b. Take left clockwise moment as negative and left anticlockwise moment as positive.
c. While calculating the slopes and deflections, it is convenient to use the values first in terms of kN and metres.

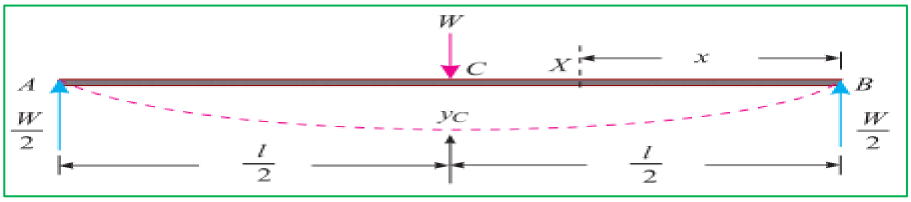


fig.11.2: Deflection of simple supported beam

11.3 Further Probing Experiments

1. Measure the slope and deflection values for simple supported beam with different loads.
2. Repeat the experiment, by changing the point of applications of loads.

12 Deflection test for cantilever beam

12.1 Introduction

In Designing of beams two design criteria ate important, one Strength which is resist to shear force and bending moment, and other is the stiffness, which is resistance to deflection under different types of loads. There are many methods to find out the slope and deflection at a section in a loaded beam, but 1. Double integration method and 2. Macaulay's methods are the important.

12.2 Procedure

In this experiment Macaulay’s method shown in fig. 12.2, using out the slopes and deflection of beams with the following rules

Always take origin on the extreme left of the beam.
Take left clockwise moment as negative and left anticlockwise moment as positive.
While calculating the slopes and deflections, it is convenient to use the values first in terms of kN and metres.

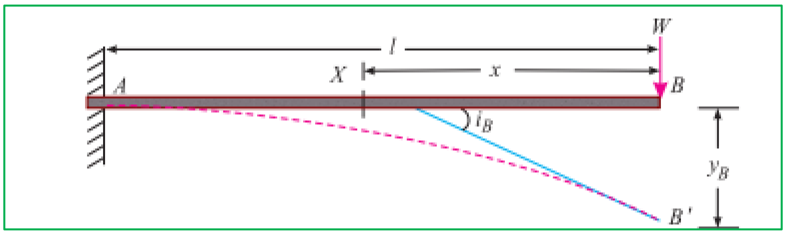


fig.12.2: Charpy Impact Test Specimen Dimensions

Further Probing Experiments

1. Measure the slope and deflection values for cantilever beam with different loads.
2. Repeat the same experiment, by changing the point of applications of loads.

13. Microstructure of Steels

Metallic materials, when considered in a broad sense, may be divided into two large groups, ferrous and nonferrous. The ferrous materials are iron-based, and the nonferrous materials have some element other than iron as the principal constituent. The bulk of the nonferrous materials is made up of the alloys of copper, aluminium, magnesium, nickel, tin, lead, and zinc. The temperature at which the allotropic changes take place in iron is influenced by alloying elements, the most important of which is carbon. This is the part between pure iron and an interstitial compound, iron carbide, Fe,C, containing 6.67 percent carbon by weight.

13.1 Study of microstructure of steels

- Introduction
- Procedure
- Observations
- Further probing experiments

13.2 Observations

The microstructure of low carbon steels as shown in fig. 13.2

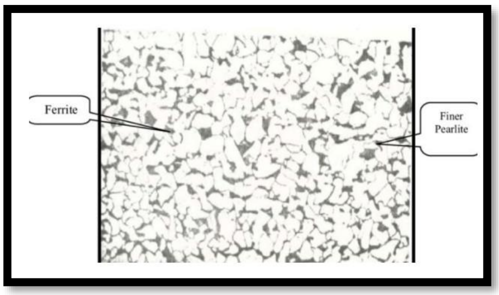


fig. 13.2: Microstructure of low carbon steels

The microstructure of medium carbon steels as shown in fig. 13.3

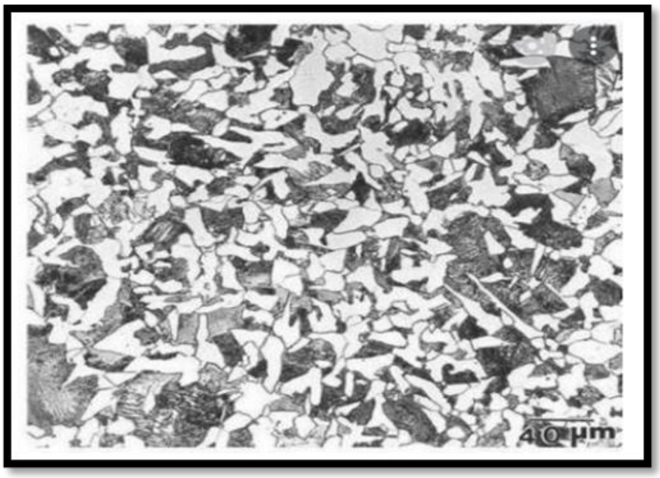
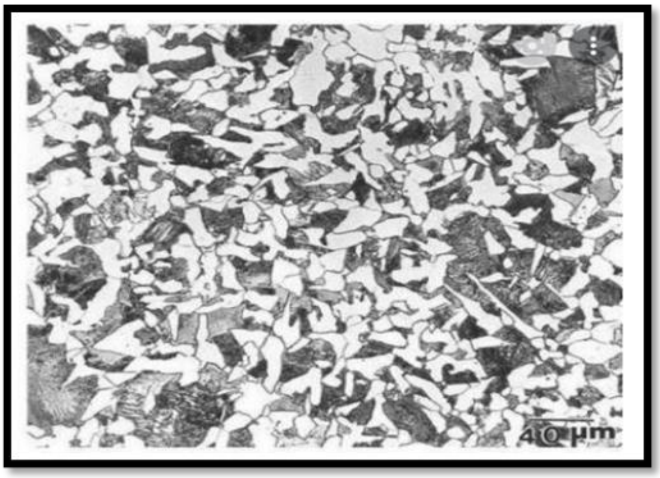


fig. 13.3: Microstructure of medium carbon steels

13.3 Precautions

- Wear tight overalls and shoe for safety.
- Be aware about mounting press and the time of etching process.
- Don't touch the specimen when it is so hot and use tongs for hold it.
- Be away at the time of belt polishing and disc polishing.



The microstructure of medium carbon steels as shown in fig. 13.3

13.4 Further Probing Experiments

1. Change the values of magnification lens and obtain the microstructures.
2. Obtain the microstructures of LCS, MCS and HCS using trinocular.

14 Microstructure of Cast Iron

14.1 Introduction

Cast irons are a class of ferrous alloys with carbon contents above 2.14 % by weightage; in practice, however, most cast irons contain between 3.0 and 4.5 % of Carbon and, in addition, other alloying elements. A re-examination of the iron–iron carbide phase diagram reveals that alloys within this composition range become completely liquid at temperatures between approximately 1150 and 13000C (2100 and 2350F), which is considerably lower than for steels. Thus, they are easily melted and amenable to casting. Furthermore, some cast irons are very brittle, and casting is the most convenient fabrication technique.

14.2 Procedure

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

14.3 Observation

The microstructure of medium Grey Cast Iron as shown in fig.14.3

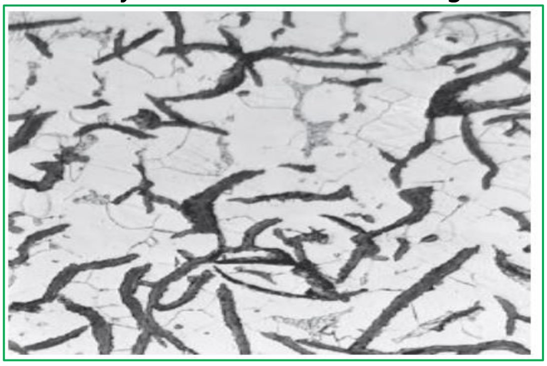


fig. 14.3: Microstructure of Grey Cast Iron

14.4 Further Probing Experiments

1. Change the values of magnification lens and obtain the microstructures.
2. Obtain the microstructures of different cast irons using trinocular.

V. TEXT BOOKS:

1. Engineering Mechanics of Solids by Popov, Egor P, 2nd edition 2013.
2. James M. Gere, Stephen Timoshenko, "Mechanics of materials". 2nd edition 2016.

VI. WEB REFERENCES:

1. https://www.labtesting.com/about/capabilities/metal-and-material-analysis/metallurgical-analysis/

VII. Electronics References

1. https://onlinecourses.nptel.ac.in/noc23_me140/preview
2. https://archive.nptel.ac.in/courses/105/105/105105108/
3. https://nptel.ac.in/courses/112107146

VIII. Materials Online

1. Course template
2. Lab manual