SRM VALLIAMMAI ENGINEERING COLLEGE

(An Autonomous Institution)

SRM Nagar, Kattankulathur – 603 203

DEPARTMENT OF MECHANICAL ENGINEERING

QUESTION BANK

IV SEMESTER

ME3468 – STRENGTH OF MATERIALS LABORATORY

Regulation – 2023

Academic Year 2024 – 25 (EVEN SEMESTER)

Prepared by

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ME3468	STRENGTH OF MATERIALS LABORATORY	L	T	P	C
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OBJECTIVES

- To Performing various destructive testing on metal samples.
- To analyzing the effect of torsion on metal rods.
- To performing various hardness tests
- To understanding the effects of hardening on metal specimens.
- To analyzing the effects of tempering on metal specimens.

LIST OF EXPERIMENTS:

1. Tension test on a mild steel rod
2. Double shear test on Mild steel and Aluminum rods
3. Torsion test on mild steel rod
4. Impact test on metal specimen
5. Hardness test on metals - Brinnell and Rockwell Hardness Number
6. Deflection test on beams
7. Compression test on helical springs
8. Strain Measurement using Rosette strain gauge
9. Effect of hardening- Improvement in hardness and impact resistance of steels.
10. Tempering- Improvement Mechanical properties Comparison
11. Unhardened specimen
12. Quenched Specimen and
13. Quenched and tempered specimen.
14. Microscopic Examination of
15. Hardened samples and
16. Hardened and tempered samples.

OUTCOMES:

Upon completion of this course, the students will be able to:

- Ability to perform various destructive testing on metal samples.

- Analyze the effect of torsion on metal rods.
- Ability to perform various hardness tests.
- Ability to understand the effects of hardening on metal specimens.
- Ability to analyze the effects of tempering on metal specimens.

LIST OF EQUIPMENT FOR BATCH OF 30 STUDENTS

S.No.	NAME OF THE EQUIPMENT	Quantity
1	Universal Tensile Testing machine with double 1 shear attachment – 40 Ton Capacity	1
2	Torsion Testing Machine (60 NM Capacity)	1
3	Impact Testing Machine (300 J Capacity)	1
4	Brinell Hardness Testing Machine	1
5	Rockwell Hardness Testing Machine	1
6	Spring Testing Machine for tensile and compressive loads (2500 N)	1
7	Metallurgical Microscopes	3
8	Muffle Furnace (800 C)	1

LIST OF BASIC SAFETY RULES

- When you handle chemicals wear eye protection (chemical splash goggles or full-face shield).
- When you work with furnaces for heat treatment procedures or other thermally activated equipment you should use special gloves to protect your hands.
- Students should wear durable clothing that covers the arms, legs, and feet. (Note: sandals, shorts, tank tops etc. have no place in the lab. Students inappropriately dressed for lab, at the instructor's discretion, be denied access)
- To protect clothing from chemical damage or dirt, wear a lab apron or lab coat. Tie back long hair to prevent it from encountering lab chemicals or flames.
- In case of injury (cut, burn, fire etc.) notify the instructor immediately.
- In case of a fire or imminently dangerous situation, notify everyone who may be affected immediately; be sure the lab instructor is also notified.
- If chemicals splash into someone's eyes act quickly and get them into the eye wash station, do not wait for the instructor.
- In case of a serious cut, stop blood flow using direct pressure using a clean towel,

notify the lab instructor immediately.

- Eating, drinking, and smoking are always prohibited in the laboratory.
- Never work in the laboratory without proper supervision by an instructor.
- Never carry out unauthorized experiments. Come to the laboratory prepared. If you are unsure about what to do, please ask the instructor.
- Always remember that HOT metal or ceramic pieces look the same as COLD pieces are careful what you touch.
- Know the location and operation of fire alarms, fire extinguisher, first aid kit and telephone.

LABARATORY CLASSES - INSTRUCTIONS TO STUDENTS

- Students must attend the lab classes with ID cards and in the prescribed uniform.
- Boys-shirts tucked in and wearing closed leather shoes. Girls students with cut shoes, overcoat, and plait incite the coat. Girls students should not wear loose garments.
- Students must check if the components, instruments, and machinery are in working condition before setting up the experiment.
- Power supply to the experimental set up/ equipment/ machine must be switched on only after the faculty checks and gives approval for doing the experiment. Students must start to the experiment. Students must start doing the experiments only after getting permissions from the faculty.
- Any damage to any of the equipment/instrument/machine caused due to carelessness, the cost will be fully recovered from the individual (or) group of students.
- Students may contact the lab in charge immediately for any unexpected incidents and emergency.
- The apparatus used for the experiments must be cleaned and returned to the technicians, safely without any damage.
- Make sure, while leaving the lab after the stipulated time, that all the power connections are switched off.

EVALUATIONS:

- All students should go through the lab manual for the experiment to be carried out for that day and come fully prepared to complete the experiment within the prescribed periods. Student should complete the lab record work within the prescribed periods.
- Students must be fully aware of the core competencies to be gained by doing experiment/exercise/programs.
- Students should complete the lab record work within the prescribed periods.
- The following aspects will be assessed during every exercise, in every lab class and

marks will be awarded accordingly.

- Preparedness, conducting experiment, observation, calculation, results, record presentation, basic understanding and answering for viva questions.
- In case of repetition/redo, 25% of marks to be reduced for the respective component.

Note:

- **Preparation** means coming to the lab classes with neatly drawn circuit diagram / Experimental setup /written programs /flowchart, tabular columns, formula, model graphs etc. in the observation notebook and must know the step-by-step procedure to conduct the experiment.
- **Conducting experiment** means making connection, preparing the experimental setup without any mistakes at the time of reporting to the faculty.
- **Observation** means taking correct readings in the proper order and tabulating the readings in the tabular columns.
- **Calculation** means calculating the required parameters using the approximate formula and readings.
- **Result** means correct value of the required parameters and getting the correct shape of the characteristics at the time of reporting of the faculty.
- **Viva voice** means answering all the questions given in the manual pertaining to the experiments.
- Full marks will be awarded if the students perform well in each case of the above given instruction.
- **Absenteeism** due to genuine reasons will be considered for doing the missed experiments.
- The **end semester practical internal assessment** marks will be based on the average of all the experiments.

TABLE OF CONTENT

Ex.No.	TENSION TEST ON MILD STEEL ROD
Date:	

AIM:

To observe the stress–strain relation of a mild steel rod by performing a tensile test.

APPARATUS REQUIRED:

1. Universal testing machine
2. Vernier caliper
3. Steel rule
4. Mild steel rod.

FORMULAE USED:

- Young's modulus = $stress/strain$ N/ mm²
- Yield stress = $(yield\ load)/(original\ c\ /\ s\ \ area)$ N/ mm²
- Ultimate tensile stress = $(Ulimate\ load)/(original\ c\ /\ s\ \ area)$ N/ mm²
- Breaking stress (Engineering) = $(Breakin\ load)/(original\ c\ /\ s\ \ area)$ N/ mm²
- Breaking stress (True) = $(Breakin\ load)/(final\ c\ /\ s\ \ area)$ N/ mm²
- % Elongation = $(L\_f - L\_o)/L\_o$ × 100 %
- % Reduction in area = $(A\_f - A\_o)/A\_o$ × 100 %

Where,

L_f = Final length (mm)

L_o = Original length (mm)

A_f= Final Area (mm²)

A_o= Original Area (mm²)

THEORY:

The engineering tension test is widely used to provide basic design information on the strength of the materials and as an acceptance test for the specification of materials. In tension test a specimen is subjected to a continually increasing uniaxial tensile force while simultaneous observations are made of the elongation of the specimen. An engineering stress-strain curve is constructed from the load-elongation measurements. The shape and magnitude of the stress-strain curve of a metal will depend on its composition, heat treatment, strain rate, temperature, and state of stress imposed during the testing. The parameters which are used to describe the stress-strain curve of a metal are the tensile strength, yield strength, percent elongation and reduction of area. The first two are strength parameters; the last two indicate ductility.

This test is mainly used to determine strength, ductility, toughness, resilience, and other mechanical properties. The machine used for tensile testing is the universal testing machine.

PROCEDURE:

- The diameter of the given rod is measured at three places using vernier caliper
- The gauge length is marked over the mild steel rod
- The specimen is gripped in the machine and set the extension measuring device to zero
- The machine is switched on and the specimen is loaded gradually
- The various load reading and the corresponding elongation are record
- Repeat the procedure till the specimen fractures.
- The final length and final diameter are measured by joining the broken specimen.

TABULATION:

S.NO	Load (KN)	Extensometer reading (mm)			Stress (N/mm^2)	Strain (No Unit)	Young's modulus X 10^5 (N/mm^2)
		Left	Right	Mean			

CALCULATION:

RESULT:

Tension test on mild steel rod was conducted and the following results were obtained. The graph stress Vs strain was plotted

1. Young's modulus = ________________ N/ mm²
2. Yield stress = _____________________N/ mm²
3. Ultimate tensile stress = ____________ N/ mm²
4. Breaking stress (Engineering) = _________________ N/ mm²
5. Breaking stress (True) = _________________ N/ mm²
6. % Elongation in length= _________________ %
7. % Reduction in area = ____________________ %

REVIEW QUESTIONS:

1. Describe about Stress,

Stress is a measure of the internal force experienced by a material per unit area. It represents the distribution of forces within a material when subjected to an external load.

Stress (σ) = Force / Area

2. Describe about Strain.

Strain is a measure of the deformation or elongation a material undergoes in response to stress. It quantifies the relative change in size or shape of a material.

Strain (ε) = Change in Length / Original Length.

3. **Describe the following**

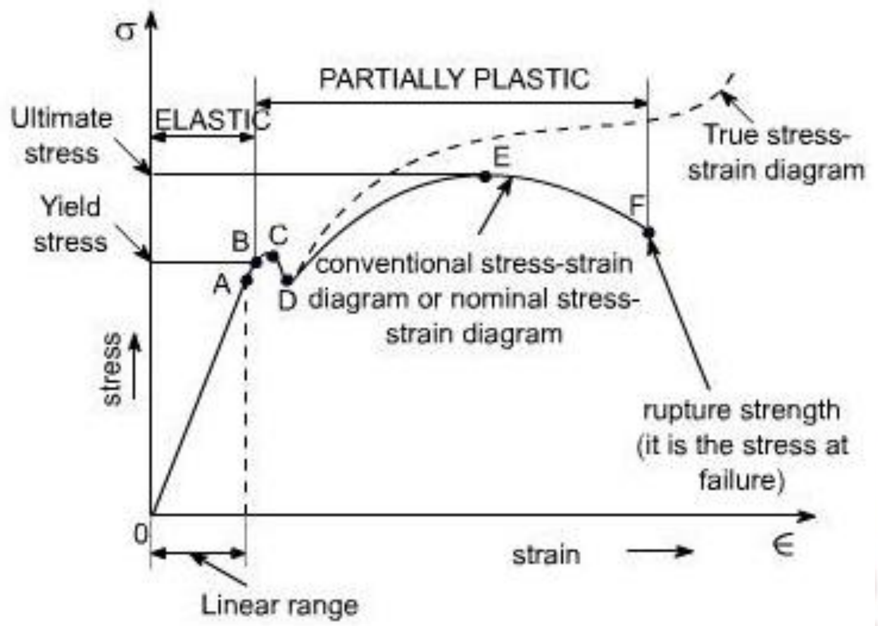
Proportional Limit: Indicated by point A on the graph, stress and strain remain directly proportional up to this limit, adhering to Hooke's law Beyond this, stress no longer maintains a linear relationship with strain.

Elastic Limit: Point B signifies the elastic limit, where the material demonstrates elasticity. The specimen fully regains its original form upon removing the external load without any residual deformations. Beyond this juncture, plastic behaviour emerges.

Yield Point: The yield point is a region delimited by the upper yield point 'C' and the lower yield point 'D'. The stress-strain curve here is nearly horizontal, signifying a significant strain increase for a minor stress rise. Yielding transpires from 'C' to 'D'. After 'D', due to strain hardening, the curve ascends as the material carries the load, marking the transition to plastic deformation of a nearly permanent nature.

Ultimate Tensile Stress: Represented by point 'E', this is the peak stress a material withstands prior to failure. Notably, the specimen does not fail at this juncture, and the curve commences descending thereafter.

Breaking Point: The point of specimen failure, post the ultimate stress, is the breaking point. After the ultimate tensile stress, necking occurs, reducing the load-bearing capacity and eventually causing failure. This critical point is denoted on the curve by point 'F'



Ex.No.	TORSION TEST ON MILD STEEL ROD
Date:	

AIM:

To determine the modulus of rigidity, polar moment of inertia, and twisting moment, torsional rigidity maximum shear stress induced of the given mild steel rod.

APPARATUS REQUIRED:

1. Torsion testing machine
2. Vernier caliper
3. Specimen

FORMULAE USED:

1. Torsion Equation = $T/J = C\theta/L = \boldsymbol{\tau}/(R)$
2. Polar Moment of Inertia = $(\pi d^4)/32$ mm^4
3. Torsional rigidity $= TL/\theta$ N mm^2/ rad

Where,

T = Twisting moment or Torque (Nm)

J = Polar Moment of Inertia (mm^4)

C = Modulus of rigidity (N/ mm^2)

Θ = Angle of twist (radian)

L = length of the rod (mm)

R = Radius of the rod (mm)

$\boldsymbol{\tau}$ **=** Maximum shear stress induced on rod (N/ mm^2)

THEORY:

A Shaft is said to be in torsion, when equal and opposite torques are applied at the two ends of the shaft. The torque is equal to the product of the forces applied and radius of the shaft. Due to the application of torques at the two ends, the shaft is subjected to a twisting moment. This causes the shear stresses and shear strains in the material of the shaft.

The theory of pure torsion is based on the following assumptions.

- The material of the shaft is uniform throughout.
- The twist along the shaft is uniform.
- The shaft is of uniform circular cross section throughout.
- Cross sections of the shaft, which are plane before twist, remain plane after twist.

- All radii which are straight before twist remain straight after twist.
- The maximum torque transmitted by a circular shaft, is obtained from the maximum shear stress induced at the outer surface of the solid shaft.

EXPERIMENTAL PROCEDURE:

- Measure the diameter of the given specimen using vernier caliper.
- Measure the length of the specimen accurately after securing the specimen into the machine.
- Set the initial torque and angle of twist to zero.
- Note the values of the torque for every 10° angle of twist.
- Note the values of torque till the specimen fails.
- Using the formulae determine the modulus of rigidity, modulus of rupture, maximum stress induced, torsional rigidity and polar moment of inertia of the given specimen.

- **TABULATION:**

Sl.no	Torque (Nm)	Angle of twist		Torsion of rigidity (Nmm^2)	Maximum shear stress induced (N/mm^2)
		Degree	Radian		

Calculation:

RESULT:

1. Modulus of rigidity = __________N/mm^2
2. Torsional rigidity at torque ______Nm = ________ N/mm^2
3. Maximum shear stress induced at torque ______Nm = ________ N/mm^2

REVIEW QUESTIONS:

1. Describe twisting moment.

Torsion is the twisting of a beam under the action of a torque (twisting moment). It is systematically applied to screws, nuts, axles, drive shafts etc, and is also generated more randomly under service conditions in car bodies, boat hulls, aircraft fuselages, bridges, springs and many other structures and components.

2. Define torsional rigidity.

Torsional rigidity is a measure of an object's resistance to twisting when subjected to a torque or twisting moment

3. Name some engineering components/ parts, which are subjected to torsion when they are in actual service.

1. Drive shaft. 2. Propeller shaft. 3. Flywheel. 4. Coupling. 5. Axle. 6. Crank and drive shaft.

4. What is polar moment of inertia?

The polar moment of inertia (denoted as J) is a geometric property of a cross-section that measures its resistance to torsion (twisting) about its central axis. It is used in the analysis of shafts and structural components subjected to torsional loads.

5. Differentiate polar moment of inertia and mass moment of inertia.

Polar moment of Inertia: Measures a cross-section's resistance to torsion about a axis.
Mass moment of inertia: Measures a body's resistance to rotational motion about axis.

6. When the shaft is subjected to torsion, where the induced shear stress will be high?

When a shaft is subjected to torsion, the shear stress is highest at the outer surface of the shaft and is zero at the center.

Ex.No.	IZOD IMPACT TEST ON METALSPECIMEN
Date:	

AIM:

To determine the impact strength of the given material using izod impact test.

APPARATUS REQUIRED:

1. Vernier caliper
2. Scale
3. Impact machine setup.

THEORY:

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

PROCEDURE:

1. With the striking hammer (pendulum) in safe test position, firmly hold the steel specimen in impact testing machine’s vice in such a way that the notch 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. At its topmost height after breaking the specimen, the indicator stops moving, while the pendulum falls back. Note the indicator at that topmost final position.

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

FORMULA USED:

Impact Energy = (Energy observed / Cross sectional area) (J/mm^2)

TABULATION

S.No	Material Used	Energy absorbed by force (A) J	Energy spent to break the specimen (B) J	Energy absorbed by the specimen (A-B) J	Impact Strength J/mm^2

CALCULATION:

Specimen size:

RESULT:

The Impact strength of given material is found out to be ________________________

REVIEW QUESTION:

1. Define strain energy.

The energy stored in a material when it deforms due to an applied force.

2. Discriminate Izod and Charphy impact test

Specimen position

The Izod test is performed vertically, while the Charpy test is performed horizontally.

Striking point

In the Izod test, the hammer strikes the upper tip of the specimen, while in the Charpy test, the hammer strikes the notch at the opposite direction.

3.What is the angle of Charpy and Izod?

The notch angle of the Charphy and Izod impact test specimen is 45°. In Charpy test, the Charpy geometry consists of a simply supported beam with a centrally applied load on the reverse side of beam from the notch.

4.Define resilience

Resilience is a material's ability to absorb and release energy when it's deformed elastically

5.List the types of fracture occurred on ferrous material.

(i) Ductile fracture

(ii) Brittle fracture

Ex.No.	CHARPY IMPACT TEST ON METALSPECIMEN
Date:	

AIM:

To determine the impact strength of the given material using Charpy impact test.

APPARATUS REQUIRED:

1. Vernier caliper
2. Scale
3. Impact machine setup.

Theory:

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

PROCEDURE:

1. With the striking hammer (pendulum) in safe test position, firmly hold the steel specimen in impact testing machines vice in such a way that the notch faces s the hammer and is half inside and half above the top surface of thevice.
2. Bring the striking hammer to its top most striking position unless it is already there, and lock it at that position.
3. Bring indicator of the machine to zero, or follow the instructions of the operating manual supplied with the machine.
4. Release the hammer. It will fall due to gravity and break the specimen through its

momentum, the total energy is not absorbed by the specimen. Then it continues to swing. At its topmost height after breaking the specimen, the indicator stops moving, while the pendulum falls back. Note the indicator at that topmost final position.

5. The specimen is placed on supports or anvil so that the blow of hammer is opposite to the notch.

FORMULA USED:

Impact Energy = (Energy observed / Cross sectional area) (J/mm^2)

TABULATION

S.No	Material Used	Energy absorbed by force (A) J	Energy spent to break the specimen (B) J	Energy absorbed by the specimen (A-B) J	Impact Strength J/mm^2

CALCULATION:

Specimen size:

RESULT:

The Impact strength of given material is found out to be ________________________

REVIEW QUESTION:

1. Define strain energy.

The energy stored in a material when it deforms due to an applied force.

2. Discriminate Izod and Charphy impact test

Specimen position

The Izod test is performed vertically, while the Charpy test is performed horizontally.

Striking point

In the Izod test, the hammer strikes the upper tip of the specimen, while in the Charpy test, the hammer strikes the notch at the opposite direction.

3.What is the angle of Charpy and Izod?

The notch angle of the Charphy and Izod impact test specimen is 45°. In Charpy test, the Charpy geometry consists of a simply supported beam with a centrally applied load on the reverse side of beam from the notch.

4.Define resilience

Resilience is a material's ability to absorb and release energy when it's deformed elastically

5.List the types of fracture occurred on ferrous material.

(i) Ductile fracture

(ii) Brittle fracture

Ex.No.	**HARDNESS TEST ON METALS- BRINELL HARDNESS NUMBER (BHN)**
Date:	

AIM:

To find the Brinell Hardness Number for the given metal specimen.

EQUIPMENTS REQUIRED:

1. Brinell Hardness Testing Machine
2. Metal Specimens
3. Brinell Microscope.

FORMULAE USED:

1. Brinell Hardness Number (BHN) = $P/(A)$
2. Surface area of Indentation (A)= $(\pi D)/(2) \times (D - \sqrt{D^2 - d^2})$

Where,

P = Load applied in kgf.

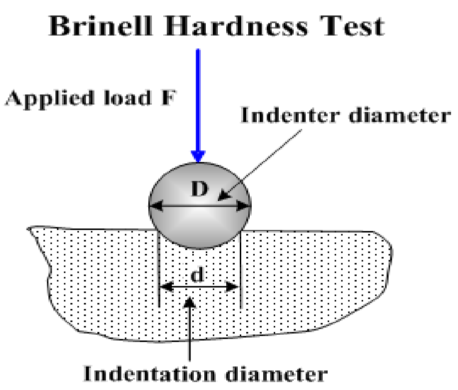
D = Diameter of the indenter in mm.

D = Diameter of the indentation in mm.

THEORY:

The hardness of the materials is often equated with the wear resistance and durability. It serves as a measure of abrasion resistance and strength. Hardness may be defined as resistance of metal to plastic deformation usually by indentation. However, the term may also refer to stiffness or temper or resistance to scratch, abrasion or cutting. There are three general types of hardness measurements depending upon the way the test is conducted.

1. Scratch hardness measurement.
2. Rebound hardness measurement.
3. Indentation Hardness measurement.



Procedure:

- Test piece is placed upon the machine. The dial may be showing any reading.
- Hand wheel is turned; thereby raising the test piece up against the steel ball indenter till the needle of the small dial is against the red mark. This applies minor load.
- Major load is applied by pressing the crank provided on the right-hand side of the machine. Time is given as 30 sec to make the load reach specimen fully.
- When the penetration is completed, the crank is turned in the reverse direction thereby with drawing the minor load but the leaving the major load applied.
- The pointer moves further and becomes stand still. This reading is taken as Rockwell Hardness Number – C scale.(HRC)
- Hand wheel is rotated and the test piece is lowered.

Tabulation:

Sl.No.	Specimen Material	Load in (kgf)	Diameter of ball (mm)	Indentation Diameter (mm)			Average of Indentation Diameter (mm)	Brinell Hardness Number (BHN)

CALCULATION:

RESULT:

1. The Brinell Hardness for specimen-1 (   ) =   kg/mm²
2. The Brinell Hardness for specimen-2 (   ) =   kg/mm²
3. The Brinell Hardness for specimen-3 (   ) =   kg/mm²

REVIEW QUESTION:

1. Define Hardness of the material.

Hardness is a material's resistance to permanent deformation, such as indentation, scratching, or wear.

2. Why is the hardness of a material important

The hardness of a material is important because it determines the material's ability to resist deformation, such as scratching, indentation, wear, and abrasion. It is a critical property for selecting materials in engineering and manufacturing applications.

3. Name the Engineering components required high hardness value

- **Nuts and bolts:** Commonly tested using the Rockwell C method, which applies a 150 kgf load with a diamond
- **Hand tools:** Commonly tested using the Rockwell C method
- **Seat belt buckles**: Commonly tested using the Rockwell C method
- **Chains:** Commonly tested using the Rockwell C method
- **Springs:** Commonly tested using the Rockwell C method
- **Axles:** Commonly tested using the Rockwell C method
- **Bearings:** Commonly tested using the Rockwell C method
- **Blades:** Commonly tested using the Rockwell C method

4.Discriminate Brinell and Rockwell hardness.

Brinell test is better suited for materials with a rough or uneven surface, such as castings or forgings, and it involves measuring the diameter of the indentation left by a ball. It is commonly used in larger or coarser materials.

Rockwell test is faster, easier to perform, and can test a wider variety of materials (including metals, plastics, and thin materials). It measures the depth of indentation and uses a variety of scales for different material types, with Rockwell C scale being common for harder materials.

Ex.No.	HARDNESS TEST ON METALS- ROCKWELL HARDNESS NUMBER
Date:	

AIM:

To determine the Rockwell Hardness number for the given metal specimen.

EQUIPMENTS REQUIRED:

- Rockwell Hardness Testing Machine.
- Metal Specimen.

THEORY:

The hardness of the materials is often equated with the wear resistance and durability. It serves as a measure of abrasion resistance and strength. Hardness may be defined as resistance of metal to plastic deformation usually by indentation. However, the term may also refer to stiffness or temper or resistance to scratch, abrasion or cutting. There are three general types of hardness measurements depending upon the way the test is conducted.

- Scratch hardness measurement.
- Rebound hardness measurement.
- Indentation Hardness measurement.

In scratch hardness method, the materials are rated on their ability to scratch one another and mineralogists use it. In rebound hardness measurement, a standard body is usually dropped on to the material surface and the hardness is measured in terms of the height of its rebound. The general means of judging the hardness is the resistance of a material to indentation.

Indentation hardness may be measured by various hardness test such as Brinell, Rockwell, etc. Rockwell hardness testing differs from Brinell testing. In Rockwell testing, the indenters and loads are smaller and therefore the resulting indentation on the specimen is smaller and shallower. The Rockwell machine gives arbitrary direct reading, Unlike Brinell testing,

PROCEDURE:

- Clean the surface of the specimen with an emery sheet.
- Place the specimen on the testing platform.
- Raise the platform until the longer needle comes to rest
- Release the load.
- Apply the load and maintain until the longer needle comes to rest
- After releasing the load, note down the dial reading.

- The dial reading gives the Rockwell hardness number of the specimen.
- Repeat the same procedure three times with specimen. Find the average. This gives the Rockwell hardness number of the given specimen.

Tabulation:

Sl.No.	Specimen Material	Load in (kgf)	Diameter of ball (mm)	Indentation Diameter (mm)			Average of Indentation Diameter (mm)	Brinell Hardness Number (BHN)

CALCULATION:

RESULT:

1. The Rockwell Hardness for specimen-1 (   ) =   kg/mm²
2. The Rockwell Hardness for specimen-2 (   ) =   kg/mm²
3. The Rockwell Hardness for specimen-3 (   ) =   kg/mm²

REVIEW QUESTION:

1. Define Hardness of the material.

Hardness is a material's resistance to permanent deformation, such as indentation, scratching, or wear.

2. Why is the hardness of a material important

The hardness of a material is important because it determines the material's ability to resist deformation, such as scratching, indentation, wear, and abrasion. It is a critical property for selecting materials in engineering and manufacturing applications.

3. Name the Engineering components required high hardness value

- **Nuts and bolts:** Commonly tested using the Rockwell C method, which applies a 150 kgf load with a diamond
- **Hand tools:** Commonly tested using the Rockwell C method
- **Seat belt buckles**: Commonly tested using the Rockwell C method
- **Chains:** Commonly tested using the Rockwell C method
- **Springs:** Commonly tested using the Rockwell C method
- **Axles:** Commonly tested using the Rockwell C method
- **Bearings:** Commonly tested using the Rockwell C method
- **Blades:** Commonly tested using the Rockwell C method

4.Discriminate Brinell and Rockwell hardness.

Brinell test is better suited for materials with a rough or uneven surface, such as castings or forgings, and it involves measuring the diameter of the indentation left by a ball. It is commonly used in larger or coarser materials.

Rockwell test is faster, easier to perform, and can test a wider variety of materials (including metals, plastics, and thin materials). It measures the depth of indentation and uses a variety of scales for different material types, with Rockwell C scale being common for harder materials.

Ex.No.	COMPRESSION TEST ON HELICALSPRINGS
Date:	

AIM:

To determine Stiffness, Modulus of rigidity, and Shear stress for the given open coiled helical spring.

APPARATUS REQUIRED:

1. Spring testing machine
2. Steel rule
3. open coiled spring
4. Vernier caliper

FORMULAE USED:

1. Stiffness, s = W/δ N/mm
2. Modulus of rigidity, C = $(8sD^3 n)/d^4$ N/ mm²
3. Maximum Shear stress induced on the spring, τ = $8WD/(\pi d)^3$ N/ mm²

Where,

W = Applied load (N)

δ = Deflection (mm)

D = Mean Diameter of spring coil (mm)

d = Diameter of spring wire (mm)

n = Number of coils

THEORY:

Springs are the elastic bodies which absorb energy due to resilience. The absorbed energy may be released as and when required. A spring is capable of absorbing greatest amount of energy for the given stress, without getting permanently distorted, is known as bet spring. The two important types of springs are

1. Leaf springs
2. Helical springs

Leaf springs which consist of several parallel strips of a metal having different lengths and same width, placed one over the other. These springs are used to absorb shocks in railway wagons, coaches, and road vehicles (such as cars, Lorries etc.).

Helical springs are the thick springs wires coiled into a helix. They are two types:

- Close coiled helical springs
- Open coiled helical springs

In close coiled helical springs, helix angle is very small or in other words the pitch between two adjacent turns is small. An open-coiled helical spring is a compression spring, that resists a compressive force applied axially. Compression springs are usually coiled as a constant-diameter cylinder.

TABULATION:

S. No	Load **Kg**	Scale reading (mm)		Deflection reading (mm)	Rigidity modulus (N/ mm^2)	Stiffness (N/mm)

PROCEDURE:

1. By using the micrometer measure the diameter of the wire of the spring
2. By using the vernier caliper measure the diameter of the spring coil
3. Count the number of turns
4. insert 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. Find the slope of the curve, which gives the stiffness of the spring.

OBSERVATION:

To determine the wire diameter, and coil diameter of spring (each 3 readings)

Least count of Vernier =

S.No	Main Scale Reading (MSR) (mm)	Vernier scale reading (VSR)	R x LC in mm	Total reading MSR= (VSR x LC) (mm)

CALCULATION:

RESULT:

1. Stiffness, s = ______________________________ N/mm
2. Modulus of rigidity, C = _______________________N/ mm^2
3. Maximum Energy stored = ____________________

REVIEW QUESTIONS:

1. Describe about stiffness

Stiffness is typically defined as the force required to produce a unit displacement in an object. In simpler terms, the greater the stiffness, the less an object will deform when a force is applied.

2. What is the effect on stiffness, if a spring is cut into two halves?

When a spring is cut into two halves, its stiffness changes. The effect depends on whether the spring is in series or parallel configuration, but for a simple case of a spring being cut into two halves in series.

3. What is the effect on net stiffness, if two springs are connected in parallel?

When two springs are connected in parallel, their net stiffness is the sum of the individual stiffnesses. This is because the force applied to the system is distributed between the two springs, and both springs stretch (or compress) by the same amount under the same load.

$K_{net}=k1+k2$

k1 = Stiffness of the first spring

k2 = Stiffness of the second spring

4. What is the effect on net stiffness, if two springs are connected in series?

$$\frac{1}{k_{\text{net}}} = \frac{1}{k_1} + \frac{1}{k_2}$$

Where:

- k_1 = Stiffness of the first spring
- k_2 = Stiffness of the second spring

5. What is solid length of the spring?

The solid length of a spring refers to the length of the spring when it is in its compressed or coiled state, with all the coils touching each other, meaning the spring is fully compressed and there is no space between the coils. This length is essentially the minimum length of the spring, as it represents the situation where the spring is not under any external force and the coils are in direct contact.

6. How will you find work done on the spring?

The work done on a spring is determined by the force applied to it and the displacement it undergoes. For a spring, the relationship between force and displacement follows Hooke's Law:

$F=k\cdot\delta$

Where:

- F = Force applied to the spring (N)
- k= Spring constant or stiffness (N/m)
- δ = Displacement (or elongation/compression) of the spring (m)

7. Define spring index.

The spring index is a term used in the design and analysis of springs to describe the ratio of the coil diameter to the diameter of the wire used to make the spring. It is an important factor because it helps determine the geometry of the spring.

8. List the types of spring

Helical Spring, Leaf Spring, Spiral Spring, Disc Spring.

Ex.No.	DEFLECTION TEST ON BEAM
Date:	

AIM:

To determine the Young’s modulus of the given specimen by conducting bending test.

APPARATUS AND SPECIMEN REQUIRED:

- Bending Test Attachment
- Specimen for bending test
- Dial gauge
- Scale
- Pencil /Chalk

PROCEDURE:

- Measure the length (L) of the given specimen.
- Mark the center of the specimen using pencil /chalk
- Mark two points A & B at 350mm on either side of the center mark. The distance between A & B is known as span of the specimen(l)
- Fix the attachment for the bending test in the machine properly.
- Place the specimen over the two supports of the bending table attachment such that the points A &B coincide with center of the supports. While placing, ensure that the tangential surface nearer to heart will be the top surface and receives the load.
- Measure the breadth (b) and depth (d) of the specimen using scale.
- Place the dial gauge under this specimen at the centre and adjust the dial gauge reading to zero position.
- Place the load cell at top of the specimen at the centre and adjust the load indicator in the digital box to zero position.
- Select a strain rate of 2.5mm / minute using the gear box in the machine.
- Apply the load continuously at a constant rate of 2.5mm/minute and note down the deflection for every increase of 0.25 tone load up to a maximum of 6 sets of readings.
- Calculate the Young s modulus of the given specimen for each load using the following formula:

  Young s modulus **$E = PL^3/48I\delta$**

  Where,

  P = Load in N

L = Span of the specimen in mm

I = Moment of Inertia in mm4 (bd3/12)

b = Breadth of the beam in mm.

d = Depth of the beam in mm

δ = Actual deflection in mm.

OBSERVATION:

. Material of the specimen	=	mm
. Length of the specimen	=	mm
3. Breadth of the specimen, b	=	mm
4. Depth of the specimen, d	=	mm
. Span of the specimen	=	mm
. Least count of the dial gauge (LC)	=	mm

TABULATION:

S.No	Load		Deflection in mm			Young's Modulus in (N/mm^2)
	kg	N	Loading	Unloading	Mean	
					Average	

RESULT:

Young's Modulus of the given specimen = ____________________(N/mm^2)

REVIEW QUESTIONS:

1.List the types of loads.

(i) Point load. (ii) Uniformly distributed load. (iii) Uniformly varying load.

2. Summarize the types of beams.

- Simply Supported Beam
- Cantilever Beam
- Fixed Beam
- Continuous Beam
- Overhanging Beam

3. Explain Theory of simple bending

The theory of simple bending explains how a beam bends when subjected to a transverse load (a load perpendicular to its axis). It assumes that the beam is subjected to pure bending—meaning there is no shear force acting along its length, only a bending moment.

4. In which point the bending moment is maximum in the beam?

The bending moment in a beam is maximum at the point where the shear force changes sign or shear force is zero.

5. Summarize the assumption for theory of simple bending.

- Material is Homogeneous and Isotropic
- Beam is Initially Straight and Has Uniform Cross-Section
- Plane Sections Remain Plane After Bending
- Elastic Limit is Not Exceeded
- No Shear or Axial Forces
- Stress Distribution is Linear
- Neutral Axis Remains Neutral

Ex.No.	DOUBLE SHEAR TEST ON MILD STEEL AND ALUMINUMRODS
Date:	

AIM:

To conduct shear test on given specimen under double shear.

EQUIPMENTS REQUIRED:

- UTM with double shear chuck
- Vernier Caliper
- Test Specimen

DESCRIPTION:

In actual practice when a beam is loaded the shear force at a section always comes to play along with bending moment. It has been observed that the effect of shearing stress as compared to bending stress is quite negligible. But sometimes, the shearing stress at a section assumes much importance in design calculations.

Universal testing machine is used for performing shear, compression, and tension. There are two types of UTM.

- Screw type
- Hydraulic type.

Hydraulic machines are easier to operate. They have a testing unit and control unit connected to each other with hydraulic pipes. It has a reservoir of oil, which is pumped into a cylinder, which has a piston. By this arrangement, the piston is made to move up. Same oil is taken in a tube to measure the pressure. This causes movement of the pointer, which gives reading for the load applied.

DETAILS OF UTM:

- Capacity: 400 KN.
- Range: 0 - 400KN.

PROCEDURE:

- Measure the diameter of the hole accurately.
- Insert the specimen in position and grip one end of the attachment in the upper portion and the other end in the lower portion.
- Switch on the main switch on the universal testing machine.
- Bring the drag indicator in contact with the main indicator.
- Gradually move the head control lever in left hand direction till the specimen shears.
- Note down the load at which specimen shears.

- Stop the machine and remove the specimen.

OBSERVATION:

- Diameter of the specimen(d)= mm
- Cross sectional area in double shear, (A) =

$$A_{total} = 2 \times \frac{\pi d^2}{4}$$

- Shear Load taken by specimen at the time of failure(P)= KN.

- Shear strength = (Maximum shear force / Area of the specimen)

RESULT:

Shear strength of given material is ______________________________(N/mm^2)

REVIEW QUESTIONS:

1.Define shear stress.

Shear stress is a critical concept in engineering and material science, as it helps analyze the ability of materials to resist deformation or failure under sliding forces.

2.Write the expression for shear modulus of the beam

The shear modulus is mathematically expressed as:

$$G = \frac{\tau}{\gamma}$$

Where:

- G = **Shear modulus** (Pa or N/m^2)
- τ = **Shear stress** (Pa or N/m^2)
- γ = **Shear strain** (radians, unitless)

3.Describe shear stress distribution.

In **torsional loading**, shear stress distribution is **radial** and **linear** across the circular cross-section.

Formula:

$$\tau = \frac{T \cdot r}{J}$$

Where:

- T = **Torque** (N·m)
- r = **Radial distance** from the center (m)
- J = **Polar moment of inertia** (m^4)
- **Maximum shear stress** (τ_{max}) occurs at the **outer surface** ($r = R$):

$$\tau_{max} = \frac{T \cdot R}{J}$$

Ex.No.	EFFECT ON HARDENING- IMPROVEMENT IN HARDNESS AND IMPACT RESISTANCE OF STEEL
Date:	

AIM

To find hardness number and impact strength for unhardened, hardened specimen or quenched and tempered specimen and compare mechanical properties.

MATERIAL AND EQUIPMENT

Unhardened specimen, Hardened or Quenched and tempered specimen, muffle furnace, Rockwell testing machine, impact testing machine.

PROCEDURE:

HARDENING:

It is defined as a heat treatment process in which the steel is heated to a temperature within or above its critical range, and held at this temperature for a considerable time to ensure thorough penetration of the temperature inside the component and allowed to cool by quenching in water, oil, or brine solution.

Case (I) - Unhardened specimen

- Choose the indenter and load for given material.
- Hold the indenter in indenter holder rigidly
- Place the specimen on the anvil and raise the elevating screw by rotating the hand wheel up to the initial load.
- Apply the major load gradually by pushing the lever and then release it as before.
- Note down the readings in the dial for corresponding scale.
- Take min 5 readings for each material.

Case (II) - For Hardened specimen

- Keep the specimen in muffle furnace at temperature of 700˚ to 850˚ for 2hours
- The specimen is taken from muffle furnace and quenched in water or oil.
- Then above procedure is followed to test hardness

Case (III) - For Tempered specimen

- Keep the specimen in muffle furnace at temperature of 650˚ for 2hours
- Allow the specimen for air cooling after taking from muffle furnace
- Then same procedure is followed foe the specimen

OBSERVATION:

Rockwell Hardness Test

Cases for hardness=

Cross sectional area=

S.No	Material	Temperature (˚C)	Load (kgf)	Indenter detail	Scale	RHN			
						Trial 1	Trail 2	Trail 3	Mean
1.	Deep case-un hardened steel								
2.	Deep case-Hardened steel								
3.	Mild steel-hardened steel								
4.	Mild steel- un hardened steel								

CHARPY TEST:

S.No	Material and Condition	Energy absorbed (Joules)	Cross-sectional area below the notch (mm^2)	Impact strength (J/mm^2)
1.	Mild steel-unhardened			
2.	Quenched			

RESULT:

Hardness

- Deep case-hardened steel =
- Unhardened =
- Quenched =
- Mild steel =
- Unhardened =
- Quenched =

Impact strength

- Deep case-hardened steel =
- Unhardened =
- Quenched =

REVIEW QUESTIONS:

1**.Define case hardening**

Case hardening is a heat treatment process that increases the surface hardness of a material (typically steel) while maintaining a tougher, ductile core. This is achieved by introducing carbon or nitrogen into the surface layer of the material, forming a hard outer "case" while leaving the inner core softer and more resilient. The result is a material that is wear-resistant and hard on the outside, but tough and strong internally.

2. **What is meant by quenching?**

Quenching is a heat treatment process used to rapidly cool a heated metal, typically steel or alloys, to increase its hardness and strength. The process involves heating the metal to a specific temperature (usually in the austenitic phase) and then quickly cooling it, typically in water, oil, or air.

3.**Define annealing**

Annealing is a heat treatment process used to soften a material, typically metal, by heating it to a specific temperature and then cooling it slowly. This process helps to reduce the material's hardness, increase its ductility, relieve internal stresses, and improve its machinability.

4. Define crystallization temperature

Crystallization temperature refers to the specific temperature at which a material (typically a metal or alloy) begins to solidify or crystallize from its liquid phase into a solid phase as it cools.

5. What is the effect on grain size of the material during age hardening?

During age hardening, the material undergoes changes in its microstructure, including the formation of fine precipitates within the solid solution, which impede dislocation movement and result in increased hardness and strength.

Ex.No.	TEMPERING- IMPROVEMENT MECHANICAL PROPERTIES COMPARISON
Date:	

AIM:

To perform the heat treatment tempering on the given material C-40 steel.

APPARATUS REQUIRED:

1. Muffle furnace: tongs
2. Given material: C-40steel
3. Quenching medium: water

PROCEDURE:

Quenching:

It is an operation of rapid cooling by immersing a hot piece into a quenching bath.

Tempering:

- It is defined as the process of reheating the hardened specimen to some temperature before the critical range followed by any rate of cooling such a reheating permits the trapped temperature to transform and relieve the internal stresses.
- The given specimen is subjected to Rockwell hardness test and Rockwell hardness number is measured before hardening that the specimen is subjected to rough grinding.
- The specimen is placed inside the combustion chamber of muffle furnace and is noted up to 830˚C.
- Then the specimen is soaked for 10 minutes at the same temperature830˚C.
- After soaking it is taken out from the furnace and it is quenched in the water.
- The specimen is cooled, now the tempering is completed.

TABULATION:

S.NO	SPECIMEN MATERIAL	LOAD (Kgf)	PENETRATOR	SCALE	RHN

CALCULATION:

RESULT:

The heat treatment tempering on the given material C-40 steel and its Rockwell hardness number is measured

1.Rockwell hardness number before tempering =

2.Rockwell hardness number after tempering =

REVIEW QUESTIONS:

1. What is meant by Annealing?

The material is heated to a specific temperature (usually above its recrystallization temperature), held at that temperature for a while, and then slowly cooled, usually in the furnace or air.

2. Describe the term Tempering

The quenched material is reheated to a lower temperature (typically between 150°C to 650°C), held at that temperature for a certain period, and then cooled slowly.

Effect: Reduces brittleness and adjusts hardness, improving toughness and strength.

3. Define the term Normalizing

Process: The material is heated above its critical temperature and then allowed to cool in air (faster than in annealing).

Effect: Results in a more uniform and refined grain structure compared to annealing, improving toughness and strength.

6. Describe about Case Hardening.

Process: The surface is subjected to carbon (via carburizing) or nitrogen (via nitriding) diffusion, followed by quenching.

Effect: Hardens the outer surface of the material while the core remains softer and more resistant to shock.

5. Induction Hardening:

Process: The material is heated by electromagnetic induction, and then rapidly quenched.

Effect: Hardens the surface while leaving the inner core unaffected, offering a balance between hardness and toughness.

6. What is meant by Nitriding?

Process: The material is heated in an atmosphere containing nitrogen or ammonia, allowing nitrogen atoms to diffuse into the surface.

Effect: Produces a very hard, wear-resistant surface, often used for steels and alloys that require resistance to corrosion and wear.

7. Softening:

Process: The material is heated to a temperature where it becomes more ductile and easier to work. Effect: Reduces hardness and increases ductility.

Ex.No.	MICROSCOPIC EXAMINATION OF HARDENED, HARDENED AND TEMPERED SAMPLES
Date:	

AIM:

To examine the microstructure of a given plain carbon steel sample before and after heat treatment.

APPARATUS REQIRED:

- Belt grinder
- Simple disc polishing machine Stretching agent
- Emery sheet Muffle furnace

THEORY:

Sample specimen:

i) Unbalanced specimen

ii) Harden specimen

iii) Tempered specimen

Steel can be heat treated to high temperature to achieve the requirement harden and strength. The high operating stress need the high strength of hardened structure similarly tools such as like knives etc. as quenched hardened steels are so, brittle than even slight compact cause fracture. The heat treatment that reduces the brittleness of steel without significantly lowering the hardness and strength. Hardened steel must be tempered before use.

Hardening:

- To increase the strength and hardness
- To improve the mechanical properties
- Hardening temperature-9000ºC
- Holding time-1hr
- Quenching medium - Water.

Tempering:

- To reduce the stress
- To reduce the brittleness
- Tempering temperature-320ºC
- Holding time-1 hr
- Quenching medium-Air

The specimen and is heated at a temperature which is determined using the microstructure the specimen quenching into oil. The given three samples are subjected to the study of microstructure of the hardened metal. The micro structure of the unhardened sample is studied and hardness is found. The furnace which is maintained at temperature at 900ºC for hardening. The sample is added to get austenite structure. The third sample is subjected to tempering process of is hold at 830 is furnace for this and quenched in air. The micro structure of the third specimen is studied and hardness is formed.

PROCEDURE:

1. Specimen is heated to temperature which is determined using the microscopic structure the specimen is quenched in oil.
2. The given samples are subjected to the study of micro structure and hardness.
3. The microstructure of the hardened sample is subjected and hardness is found.
4. The remaining two specimens is quenched into the furnace which is maintained at the temperature 9000 c for hardening process.
5. The specimen is then taken from the furnace and immediately.

TABULATION:

SAMPLES	SAMPLE-1 (Before hardening)	SAMPLE-1 (After hardening)	SAMPLE-2 (after tempering)
MICROSTRUCTURE	STRUCTURE 1	STRUCTURE 2	STRUCTURE 3
HARDENING			

OBSERVATION:

- Specimen:
- Magnification:
- Composition:
- Hardness test:
- Load:
- Indenter:

RESULT:

Thus, the microstructure and the hardness of the given sample are studied and treatment is tabulated.

REVIEW QUESTIONS:

1. Describe about microstructure of a material.

The microstructure of a material refers to the structure and arrangement of its constituent phases, grains, and other microscopic features (such as inclusions, precipitates, and dislocations) as observed under a microscope at various magnifications. It plays a crucial role in determining the physical, mechanical, and thermal properties of a material.

2. Describe the Effect of age hardening on microstructure of Material

The process involves three main stages: solution treatment, quenching, and aging. Age hardening affects the microstructure of the material, primarily by altering the distribution, size, and morphology of precipitates within the matrix.

3. List the types of microstructures of material.

- Crystalline Microstructure
- Amorphous (Non-crystalline) Microstructure
- Polycrystalline Microstructure
- Dual-Phase Microstructure
- Martensitic Microstructure
- Pearlite Microstructure
- Ferrite Microstructure
- Cementite (Fe_3C) Microstructure

4. Describe about amorphous microstructure structure

An amorphous structure refers to a type of material where the atoms or molecules are arranged in a random or disordered pattern, rather than in a regular, repeating structure. Unlike crystalline materials, which have a well-defined lattice structure, amorphous materials lack long-range atomic order. The atomic arrangement is more akin to that of a liquid than a solid, even though the material may be in a solid state.

5. Describe about Ferrite Microstructure.

Ferrite is a phase in steel and iron alloys that has a body-centered cubic (BCC) crystal structure. It is one of the primary components of steel, particularly in low-carbon steels. Ferrite is known for being soft, ductile, and magnetic, and it plays a crucial role in the overall properties of steels, especially those with low carbon content.

CO - PO and CO - PSO MAPPING

ME3468	PROGRAM OUTCOMES												PSO's		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4
CO1	3	2	1	3	3	1	1		3			2	2	2		
CO2	3	2	1	3	3	1	1		3			2	3	2		
CO3	3	2	2	3	2	1	1		3			2	3	2		
CO4	3	2	1	3	3	1	1		3			2	2	2		
CO5	3	2	1	3	3	1	1		3			2	3	2		
Average	**3**	**2**	**1.2**	**3**	**2.8**	**1**	**1**		**3**				**2.6**	**2**		

(1–LOW, 2– MEDIUM, 3–HIGH)