



**SRM VALLIAMMAI ENGINEERING COLLEGE**

(An Autonomous Institution)

SRM NAGAR, KATTANKULATHUR-603203



**DEPARTMENT OF MECHANICAL ENGINEERING**

**1909406-STRENGTH OF MATERIALS LABORATORY**

**Regulation-2019  
Academic Year 2022-23**

**LAB MANUAL**

**(Fourth semester B.E. Mechanical Engineering students)**

**OBJECTIVES:**

1. Performing various destructive testing on metal samples.
2. Analyzing the effect of torsion on metal rods.
3. Performing various hardness tests
4. Understanding the effects of hardening on metal specimens.
5. 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
  - (i) Unhardened specimen
  - (ii) Quenched Specimen and
  - (iii) Quenched and tempered specimen.
11. Microscopic Examination of
  - (i) Hardened samples and
  - (ii) Hardened and tempered samples.

**OUTCOME:**

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

1. Ability to perform various destructive testing on metal samples.
2. Analyze the effect of torsion on metal rods.
3. Ability to perform various hardness tests.

4. Ability to understand the effects of hardening on metal specimens.
5. Analyze the effects of tempering on metal specimens

**LIST OF EQUIPMENT FOR BATCH OF 30 STUDENTS**

<b>S.No.</b>	<b>NAME OF THE EQUIPMENT</b>	<b>Quantity</b>
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

1. When you handle chemicals wear eye protection (chemical splash goggles or full face shield).
2. When you work with furnaces for heat treatment procedures or other thermally activated equipment you should use special gloves to protect your hands.
3. Students should wear durable clothing that covers the arms, legs, torso and feet. (Note: sandals, shorts, tank tops etc. have no place in the lab. Students inappropriately dressed for lab, at the instructors discretion, be denied access)
4. To protect clothing from chemical damage or other dirt, wear a lab apron or lab coat. Long hair should be tied back to keep it from coming into contact with lab chemicals or flames.
5. In case of injury (cut, burn, fire etc.) notify the instructor immediately.
6. In case of a fire or imminently dangerous situation, notify everyone who may be affected immediately; be sure the lab instructor is also notified.
7. If chemicals splash into someone's eyes act quickly and get them into the eye wash station, do not wait for the instructor.
8. In case of a serious cut, stop blood flow using direct pressure using a clean towel, notify the lab instructor immediately.
9. Eating, drinking and smoking are prohibited in the laboratory at all times.
10. Never work in the laboratory without proper supervision by an instructor.
11. Never carry out unauthorized experiments. Come to the laboratory prepared. If you are unsure about what to do, please ask the instructor.
12. Always remember that HOT metal or ceramic pieces look exactly the same as COLD pieces are careful what you touch.
13. Know the location and operation of fire alarms, fire extinguisher, first aid kit and telephone

## LABARATORY CLASSES - INSTRUCTIONS TO STUDENTS

1. Students must attend the lab classes with ID cards and in the prescribed uniform.
2. 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.
3. Students must check if the components, instruments and machinery are in working condition before setting up the experiment.
4. 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.
5. 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.
6. Students may contact the lab in charge immediately for any unexpected incidents and emergency.
7. The apparatus used for the experiments must be cleaned and returned to the technicians, safely without any damage.
8. Make sure, while leaving the lab after the stipulated time, that all the power connections are switched off.

### 9. 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 1**

**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 voce** means answering all the questions given in the manual pertaining to the experiments.

**Full marks will be awarded if the students performs well in each case of the above component**

**NOTE 2**

Incompletion or repeat of experiments means not getting the correct value of the required parameters and not getting the correct shape of the characteristics of the first attempt. In such cases, it will be marked as **“IC” in the red ink** in the status column of the mark allocation table given at the end of every experiment. The students are expected to repeat the incomplete the experiment before coming to the next lab. Otherwise the marks for IC component will be reduced to **zero**.

**NOTE 3**

Absenteeism due to genuine reasons will be considered for doing the **missed experiments**.

In case of power failure, extra classes will be arranged for doing those experiments only and assessment of all other components preparedness; viva voce etc. will be completed in the regular class itself.

**NOTE 4**

The end semester practical internal assessment marks will be based on the average of all the experiments.

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**Ex.No:1****TENSION TEST ON MILD STEEL ROD****AIM:**

To conduct tension test on the given mild steel rod for determining the yield stress, ultimate stress, breaking stress, percentage of reduction in area, percentage of elongation over a gauge length and young s modulus.

**APPARATUS REQUIRED:**

1. Verniercaliper.
2. Scale.

**THEORY:**

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

Usually a tension testis conducted at room temperature and the tensile load is applied slowly. During this test either round of flat specimens may be used. The round specimens may have smooth, shouldered or threaded ends. The load on the specimen is applied mechanically or hydraulically depending on the type of testing machine.



**FORMULA USED:**

$$1. \text{ Original area of the rod } (A_O) = (3.14/4) \times (d_O)^2 \quad \text{mm}^2$$

$$2. \text{ Neck area of the rod } (A_N) = (3.14/4) \times (d_N)^2 \quad \text{mm}^2$$

Where,

$d_O$ =original area of cross section in mm

$d_N$  =diameter of the rod at the neck in  
mm

$$3. \text{ Percentage reduction in area} = [ ( A_o - A_N ) / A_o ] * 100$$

Where,

$A_O$ =original cross sectional area of the rod in mm

$A_N$ =Neck area of the rod in mm

$$4. \text{ Percentage of Elongation} = [ ( L_o - L ) / L ] * 100$$

Where,

$L_O$ =Final gauge length of the rod in mm

$L$ =Original gauge length of the rod in mm

$$5. \text{ Yield stress} = \text{N/mm}^2$$

$$6. \text{ Ultimate stress} = \text{N/mm}^2$$

$$7. \text{ Breaking stress} = \text{N/mm}^2$$

$$8. \text{ Young s modulus} = \text{N/mm}^2$$

Where,

$P$ =Load in N

$L$ =Original length in mm

$A_O$ =Original cross sectional area of the rod in mm

$L_o - L$  =Extension of the rod in mm

**PROCEDURE:**

1. Measure the diameter of the rod using Vernier caliper.
2. Measure the original length of the rod.
3. Select the proper jaw inserts and complete the upper and lower chuck assemblies.
4. Apply some graphite grease to the tapered surface of the grip surface for the smooth motion.
5. Operate the upper cross head grip operation handle and grip fully the upper end of the test piece.
6. The left valve in UTM is kept in fully closed position and the right valve in normal open position.
7. Open the right valve and close it after the lower table is slightly lifted.

8. Adjust the load to zero by using large push button (This is necessary to remove the dead weight of the lower table, upper cross head and other connecting parts of the load).
9. Operate the lower grip operation handle and lift the lower cross head up and grip fully the lower part of the specimen. Then lock the jaws in this position by operating the jaw locking handle.
10. Turn the right control valve slowly to open position (anticlockwise) until we get a desired loadings rate.
11. After that we will find that the specimen is under load and then unclamp the locking handle.
12. Now the jaws will not slide down due to their own weight. Then go on increasing the load.
13. At a particular stage there will be a pause in the increase of load. The load at this point is noted as yield point load.
14. Apply the load continuously, when the load reaches the maximum value. This is noted as ultimate load.
15. Note down the load when the test piece breaks, the load is said to be a breaking load.
16. When the test piece is broken close the right control valve, take out the broken pieces of the test piece. Then taper the left control valve to take the piston down.

### **GRAPH**

Draw a graph between Elongations (X-axis) and load (Y-axis).

### **OBSERVATIONS**

- |   |   |     |
|---|---|-----|
| 1. Original gauge length of the rod ( $L_0$ ) | = | mm. |
| 2. Original diameter of the rod ( $d_0$ )     | = | mm. |
| 3. Final length of the rod                    | = | mm. |
| 4. Load at yield point                        | = | kN. |
| 5. Ultimate load                              | = | kN. |
| 6. Breaking load                              | = | kN. |
| 7. Diameter at the neck (DN)                  | = | mm. |
| 8. Gauge in length                            | = | mm. |

**TABULATION:**

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

**RESULT:**

1. Final length of the rod = \_\_\_\_\_ mm.
2. Diameter at the neck(DN) = \_\_\_\_\_ mm.
3. Percentage reduction in area= \_\_\_\_\_%
4. Percentage of Elongation = \_\_\_\_\_%
5. Yield stress = \_\_\_\_\_ N/mm<sup>2</sup>
6. Ultimate stress = \_\_\_\_\_ N/mm<sup>2</sup>
7. Breaking stress = \_\_\_\_\_ N/mm<sup>2</sup>
8. Young's modulus = \_\_\_\_\_ \*10<sup>5</sup> N/mm<sup>2</sup>

## VIVA QUESTION & ANSWER

### **1. Define stress.**

When an external force acts on a body, it undergoes deformation. At the same time the body resists deformation. The magnitude of the resisting force is numerically equal to the applied force. This internal resisting force per unit area is called stress.  $\text{Stress } \sigma = \text{Force/Area, } P/A \text{ Unit } N/mm^2$

### **2. Define strain**

When a body is subjected to an external force, there is some change of dimension in the body. Numerically the strain is equal to the ratio of change in length to the original length of the body

$$\text{Strain} = \text{Change in length/Original length}$$
$$e = \delta L/L$$

### **3. State Hooke's law.**

It states that when a material is loaded, within its elastic limit, the stress is directly proportional to the strain.

$$E = \sigma/e$$

$$E = \text{Stress/Strain, unit is } N/mm^2$$

Where, E -Young's modulus  $\sigma$  -Stress e -Strain

### **4. Define Poisson's ratio.**

When a body is stressed, within its elastic limit, the ratio of lateral strain to the longitudinal strain is constant for a given material. Poisson's ratio ( $\mu$  or  $1/m$ ) = Lateral strain /Longitudinal strain

### **5. What is compound bar?**

A composite bar composed of two or more different materials joined together such that system is elongated or compressed in a single unit.

### **6. Define-elastic limit**

Some external force is acting on the body, the body tends to deformation. If the force is released from the body its regain to the original position. This is called elastic limit

### **7. Define – Young's modulus**

The ratio of stress and strain is constant with in the elastic limit.  $E = \text{Stress/Strain}$

### **8. Define Bulk-modulus**

The ratio of direct stress to volumetric strain.  $K = \text{Direct stress/Volumetric strain}$

### **9. Define-lateral strain**

The strain right angle to the direction of the applied load is called lateral strain.

### **10. Define-longitudinal strain**

When a body is subjected to axial load P, The length of the body is increased. The axial deformation of the length of the body is called longitudinal strain

**Ex.No.2****TORSION TEST ON MILD STEEL SPECIMEN****AIM:**

To conduct the torsion test on the given specimen for the following

1. Modulus of rigidity
2. Shear stress

**APPARATUS REQUIRED:**

1. Vernier caliper
2. Scale

**FORMULA USED:**

$$1. \text{ Modulus of rigidity, } C = \frac{TL}{J\alpha}$$

N/mm

<sup>2</sup>Where,

$\alpha$  = angle of degree

$$2. \text{ Shear stress (t) } = TR/LN/\text{mm}^2$$

**PROCEDURE:**

1. Measure the diameter and length of the given rod.
2. The rod is fixing in to the grip of machine.
3. Set the pointer on the torque measuring scale.
4. The handle of machine is rotate in one direction.
5. The torque and angle of test are noted for five degrees.
6. Now the handle is rotated in reverse direction and rod is takeout

**THEORY:**

A torsion test is quite intruded in determining the values of modulus of rigidity of metallic specimen the values of modulus of rigidity can be found out through observation made during experiment by using torsion equation

$$T/G = C\alpha/L$$

**OBSERVATION:**

**Diameter of the Specimen** = **Mm**

**Gauge length of the Specimen** = **Mm**

**TABULATION:**

S.NO	ANGLE OF TWIST	Twist in Rod	Torque		Modulus of Rigidity (N/mm <sup>2</sup> )	Shear Stress (N/mm <sup>2</sup> )
			N-M	N-MM		

**RESULT:**

Thus the torsion test on given mild steel specimen is done and the values of modulus of rigidity and shear stress are calculated.

VIVA QUESTION & ANSWER**1. Define Torsion**

When a pair of forces of equal magnitude but opposite directions acting on body, it tends to twist the body. It is known as twisting moment or torsion moment or simply as torque. Torque is equal to the product of the force applied and the distance between the point of application of the force and the axis of the shaft.

**2. What are the assumptions made in Torsion equation**

The material of the shaft is homogeneous, perfectly elastic and obeys Hooke's Law. Twist is uniform along the length of the shaft. The stress does not exceed the limit of proportionality. The shaft circular in section remains circular after loading. Strain and deformations are small.

**3. Define polar modulus**

It is the ratio between polar moment of inertia and radius of the shaft.  $= J/R$  polar moment of inertia =  $J$  Radius  $R$

**4. Write the polar modulus for solid shaft and circular shaft.**

polar moment of inertia =  $J$  Radius  $R$   $J = D^4 / 32$

**5. Why hollow circular shafts are preferred when compared to solid circular shafts?**

The torque transmitted by the hollow shaft is greater than the solid shaft. For same material, length and given torque, the weight of the hollow shaft will be less compared to solid shaft.

**6. Write torsion equation**

$T/J = C\theta/L = q/R$   $T$ -Torque,  $\theta$ -angle of twist in radians  $J$ -Polar moment of inertia  $C$ -Modulus of rigidity  $L$ -Length  $q$ -Shear stress  $R$ -Radius

**7. Write down the expression for power transmitted by a shaft**

$P = 2\pi NT/60$   $N$ -speed in rpm  $T$ -torque

**8. Write down the expression for torque transmitted by hollow shaft**

$T = (1/16) (D^4 - d^4) / d^3$   $T$ -torque  $q$ -Shear stress  $D$ -outer diameter  $d$ -Inner diameter

**9. Write down the equation for maximum shear stress of a solid circular section in diameter 'D' when subjected to torque 'T' in a solid shaft.**

$T = 1/16 D^3$  Where  $T$ -torque,  $q$ -Shear stress and  $D$ -diameter

**10. Define torsional rigidity**

Product of rigidity modulus and polar moment of inertia is called torsional rigidity

**Ex.No:3****IMPACT TEST ON METALSPECIMEN****AIM:**

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

**APPARATUS REQUIRED:**

1. Vernier caliper
2. Scale

**THEORY:**

An impact test signifies toughness of material that is ability of material to absorb energy during plastic deformation. Static tension tests of un-notched specimens do not always reveal the susceptibility of a metal to brittle fracture. This important factor is determent by impact test. Toughness takes into account both the material. Several engineering material have to with stand impact or suddenly 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 notched bar test are most extensively used. Therefore, the impact test measures the energy necessary to fracture a standard notched bar by applying an impulse load. The test measures the notch toughness of material under shocking 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 same material under different conditions. This test can also be used to assess the ductile brittle transition temperature of the material occurring due to lowering of temperature.

**FORMULA USED:**

$$\text{Impact strength} = \frac{\text{energy absorbed}}{\text{Cross sectional area}} \text{J/mm}^2$$

**PROCEDURE:**

1. Raise the swinging pendulum weight and lock it.
2. Release the trigger and allow the pendulum to swing.
3. This actuates the pointer to move in the dial.
4. Note down the frictional energy absorbed by the bearings.
5. Raise the pendulum weight again and lock it in position.



6. Place the specimen in between the simple anvil support keeping the "U" notch in the direction opposite to the striking edge of hammer arrangement.
7. Release the trigger and allow the pendulum to strike the specimen at its midpoint.
8. Note down the energy spent in breaking (or) bending the specimen.
9. Tabulate the observation.

**OBSERVATION:**

Area of cross section of the given material:

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 <sup>2</sup>

**Result:**

The impact strength for the given material is \_\_\_\_\_ J/mm<sup>2</sup>

## VIVA QUESTION & ANSWER

### **1. Give example for gradually applied load and suddenly applied load.**

#### Example for gradually applied load

When we lower a body with the help of a crane, the body first touches the platform on which it is to be placed. On further releasing the chain, the platform goes on loading till it is fully loaded by the body. This is the case of gradually applied load.

#### Example for suddenly applied load

When we lower a body with the help of a crane, the body is first of all, just above the platform on which it is to be placed. If the chain breaks at once at this moment the whole load of the body begins to act on the platform. This is the case of suddenly applied load.

### **2. What is resilience?**

The strain energy stored by the body within elastic limit, when loaded externally is called resilience.

### **3. Define strain energy.**

Strain energy is the energy absorbed or stored by a member when work is done on it to deform it.

### **4. Distinguish between suddenly applied and impact load.**

When the load is applied all of a sudden and not step wise is called is suddenly applied load. The load which falls from a height or strike and body with certain momentum is called falling or impact load..

### **5. Define proof resilience?**

The maximum strain energy stored in a body up to elastic limit is known as proof resilience.

### **6. Define strain energy density.**

Strain energy density as the maximum strain energy stored in a material within the elastic limit per unit volume. It is also known as modulus of resilience.

### **7. What is meant by fracture?**

Fracture refers to the breaking of a component into two or more pieces either during service or during fabrication.

### **8. What are the four types of fractures?**

Four types of fractures are

- i) Brittle fracture
- ii) Ductile fracture
- iii) Fatigue fracture and
- iv) Creep fracture.

### **9. What is ductile fracture?**

Ductile fracture is the rupture of a material after a considerable of plastic deformation.

### **10. What is fatigue fracture?**

Materials subjected to extended cyclic loading may result in delayed fracture called fatigue fracture.

**Ex.No:4****COMPRESSION TEST ON HELICAL SPRINGS****AIM:**

To determine the stiffness of spring, modulus of rigidity of the spring wire and maximum strain energy stored.

**EQUIPMENTS REQUIRED:**

1. Spring testing machine
2. A open coil spring
3. Vernier caliper

**FORMULAE:**

$$1. \text{ deflection} = \frac{64 WR^3 n \sec \alpha [\cos^2 \alpha / N + 2 \sin^2 \alpha / E]}{d^2} \quad \text{N/mm}^2$$

W=Load applied in Newton

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

n= No of Coils

$\alpha$  = Helix angle of spring

N=Modulus of rigidity of spring Material

E=Young s modulus of the spring material

$$2. \tan \alpha = \text{pitch} / 2\pi R$$

$$3. \text{ Pitch} = (L-d) / n$$

Where,

d=Dia of spring wire in mm

L=Length of spring in mm

N=no of turns in spring

$$4. \text{ Stiffness of spring (K)} = W / \delta$$

Where,

$\delta$  =Deflection of spring in mm

W=Load applied in Newton

$$5. \text{ Maximum energy stores} = 0.5 \times W_{\max} \times x_{\max}$$

Where,

$W_{\max}$  =Maximum load applied

$x_{\max}$  =Maximum deflection



**OBSERVATION:**

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

Least count of Vernier =

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

**RESULT:**

Under compression test on open coil helical spring

- Rigidity Modulus (N)=
- Stiffness of spring(K)=
- Maximum energy stored=

## VIVA QUESTION & ANSWER

### 1. What is a spring?

A spring is an elastic member, which deflects, or distorts under the action of load and regains its original shape after the load is removed.

### 2. State any two functions of springs.

1. To measure forces in spring balance, meters and engine indicators.
2. To store energy.

### 3. What are the various types of springs?

- i. Helical springs
- ii. Spiral springs
- iii. Leaf springs
- iv. Disc spring or Belleville springs

### 4. Classify the helical springs.

1. Close – coiled or tension helical spring.
2. Open –coiled or compression helical spring.

### 5. What is spring index (C)?

The ratio of mean or pitch diameter to the diameter of wire for the spring is called the spring index.

### 6. What is solid length?

The length of a spring under the maximum compression is called its solid length. It is the product of total number of coils and the diameter of wire.  $L_s = nt \times d$  Where,  $nt$  = total number of coils.

### 7. Define spring rate (stiffness).

The spring stiffness or spring constant is defined as the load required per unit deflection of the spring.  $K = W/y$  Where  $W$  –load and  $y$  – Deflection

### 8. Define pitch.

Pitch of the spring is defined as the axial distance between the adjacent coils in uncompressed state. Mathematically  $\text{Pitch} = \text{free length} / n - 1$

### 9. Define helical springs.

The helical springs are made up of a wire coiled in the form of a helix and are primarily intended for compressive or tensile load.

### 10. What are the differences between closed coil & open coil helical springs?

The spring wires are coiled very closely, each turn is nearly at right angles to the axis of helix the wires are coiled such that there is a gap between the two consecutive turns. Helix angle is less than  $10^\circ$  Helix angle is large ( $>10^\circ$ )

**Ex.No:5-(a) HARDNESS TEST ON METALS- ROCK WELL HARDNESS NUMBER****AIM:**

To determine the Rockwell hardness number of the given specimen.

**APPARATUS REQUIRED:**

1. Emery paper
2. Penetrator

**THOERY:**

In Rock well hardness test consists in touching an indenter of standard cone or ball into the surface of a test piece in two operations and measuring the permanent increase of depth of indentation of this indenter under specified condition. From it Rockwell hardness is deduced. The ball (B) is used for soft materials (e.g. mild steel, cast iron, Aluminum, brass. Etc.) And the cone (C) for hard ones (High carbon steel. etc.)

HRB means Rockwell hardness measured on **B scale**

HRC means Rock well hardness measured on **C**

**scale PROCEDURE:**

1. Clean the surface of the specimen with an emery sheet.
2. Place the specimen on the testing platform.
3. Raise the platform until the longer needle comes to rest
4. Release the load.
5. Apply the load and maintain until the longer needle comes to rest
6. After releasing the load, note down the dial reading.
7. The dial reading gives the Rockwell hardness number of the specimen.
8. Repeat the same procedure three times with specimen.
9. Find the average. This gives the Rockwell hardness number of the given specimen.

**TABULATION**

S.No.	Material	Scale	Load (kgf)	Rockwell hardness Number			Rockwel l hardness Number (Mean)
				1	2	3	

**RESULT:**

Rockwell hardness number of the given material is \_\_\_\_\_

**Ex.No:5-(b) HARDNESS TEST ON METALS- ROCK WELL HARDNESS NUMBER****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:**

$$\text{Brinell Hardness Number (BHN)} = 2P / \{ \pi D [D - (D^2 - d^2)^{1/2}] \}$$

Where,

P = Load applied in Kgf.

D = Diameter of the indenter in mm.

d = Diameter of the indentation in mm.

**DESCRIPTION:**

It consists of pressing a hardened steel ball into a test specimen. In this usually a steel ball of Diameter D under a load „P is forced in to the test piece and the mean diameter d of the indentation left in the surface after removal of load is measured. According to ASTM specifications a 10 mm diameter ball is used for the purpose. Lower loads are used for measuring hardness of soft materials and vice versa. The Brinell hardness is obtained by dividing the test load „P by curved surface area of indentation. This curved surface is assumed to be portion of the sphere of diameter „D.

**TEST REQUIREMENTS:**

1. Usual ball size is 10 mm  $\pm$  0.0045 mm. Sometimes 5 mm steel ball is also used. It shall be hardened and tempered with a hardness of at least 850 VPN. (Vickers Pyramid Number). It shall be polished and free from surface defects.
2. Specimen should be smooth and free from oxide film. Thickness of the piece to be tested shall not be less than 8 times from the depth of indentation.
3. Diameter of the indentation will be measured in two directions normal to each other with an accuracy of  $\pm$  0.25% of diameter of ball under microscope provided with cross tables and calibrated measuring screws.

**PRECAUTIONS:**

1. Brinell test should be performed on smooth, flat specimens from which dirt and scale



have been cleaned.

2. The test should not be made on specimens so thin that the impression shows through the metal, nor should impressions be made too close to the edge of the specimen.

**PROCEDURE:**

1. Specimen is placed on the anvil. The hand wheel is rotated so that the specimen along with the anvil moves up and contact with the ball.
2. The desired load is applied mechanically (by gear driven screw) and the ball presses into the specimen.
3. The diameter of the indentation made in the specimen by the pressed ball is measured by the use of a micrometer microscope, having transparent engraved scale in the field of view.
4. The indentation diameter is measured at two places at right angles to each other, and the average of two readings is taken.
5. The Brinell Hardness Number (BHN) which is the pressure per unit surface area of the indentation is noted down.

**OBSERVATION:**

S.No.	Material	Load in Kgf	Diameter Of the Indenter in mm	Diameter of the indentation in mm			Brinell Hardness Number(BHN )
				1	2	3	

**RESULT:**

Thus the Brinell hardness of the Given Specimen is

1. MildSteel =----- BHN
2. Aluminium= \_\_\_\_\_ BHN
3. Brass = -----BHN

### VIVA QUESTION & ANSWER

#### 1. Define buckling factor and buckling load.

**Buckling factor:** It is the ratio between the equivalent length of the column to the minimum radius of gyration.

**Buckling load:** The maximum limiting load at which the column tends to have lateral displacement or tends to buckle is called buckling or crippling load. The buckling takes place about the axis having minimum radius of gyration, or least moment of inertia

#### 2. Define safe load.

It is the load to which a column is actually subjected to and is well below the buckling load. It is obtained by dividing the buckling load by a suitable factor of safety (F.O.S).

$$\text{Safe load} = \text{Buckling load} / \text{Factor of safety}$$

#### 3. State Hooke's law.

It states that when the material is loaded, within its elastic limit, the stress is directly proportional to the strain.

$$\text{Stress} \propto \text{Strain}$$

#### 4. Define Factor of Safety.

It is defined as the ratio of ultimate tensile stress to the permissible stress (working stress).

#### 5. State the tensile stress & tensile strain.

When a member is subjected to equal & opposite axial pulls the length of the member is increased. The stress is included at any cross section of the member is called Tensile stress & the corresponding strain is known as Tensile strain.

#### 6. Brinell hardness

The Brinell hardness test is commonly used to determine the hardness of materials like metals and alloys.

The test is achieved by applying a known load to the surface of the tested material through a hardened steel ball of known diameter.

The diameter of the resulting permanent impression in the tested metal is measured and the Brinell Hardness Number is calculated as

$$BHN = 2P / (\pi D (D - (D^2 - d^2)^{1/2})) \quad (1)$$

where

*BHN* = Brinell Hardness Number

*P* = load on the indenting tool (kg)

*D* = diameter of steel ball (mm)

*d* = measure diameter at the rim of the impression (mm)

#### 7. Rockwell hardness

The **Rockwell scale** is a hardness scale based on indentation hardness of a material. The Rockwell test determines the hardness by measuring the depth of penetration of an indenter under a large load compared to the penetration made by a preload.<sup>[1]</sup> There are different scales, denoted by a single letter, that use different loads or indenters. The result is a dimensionless number noted as HRA, where A is the scale letter.

#### 8. Vickers Hardness:

The unit of hardness given by the test is known as the Vickers Pyramid Number (HV) or Diamond Pyramid Hardness (DPH). The HV number is then determined by the ratio  $F/A$ , where  $F$  is the force applied to the diamond in kilograms-force and  $A$  is the surface area of the resulting indentation in square millimeters.

#### 9. What is Hardness

Hardness is a measure of how resistant solid matter is to various kinds of permanent shape change when a compressive force is applied. Some materials, such as metal, are harder than others. Macroscopic hardness is generally characterized by strong intermolecular bonds, but the behavior of solid materials under force is complex; therefore, there are different measurements of hardness: *scratch hardness*, *indentation hardness*, and *rebound hardness*.

#### 10. Types of measuring hardness

- Scratch hardness
- Indentation hardness
- Rebound hardness

**Ex.No.6****DEFLECTION TEST ON BEAM****AIM:**

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

**APPARATUS AND SPECIMEN REQUIRED:**

1. Bending Test Attachment
2. Specimen for bending test
3. Dial gauge
4. Scale
5. Pencil /Chalk

**PROCEDURE:**

1. Measure the length (L) of the given specimen.
2. Mark the center of the specimen using pencil /chalk
3. Mark two points A & B at a distance of 350mm on either side of the center mark. The distance between A & B is known as span of the specimen(l)
4. Fix the attachment for the bending test in the machine properly.
5. 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.
6. Measure the breadth (b) and depth (d) of the specimen using scale.
7. Place the dial gauge under this specimen at the centre and adjust the dial gauge reading to zero position.
8. Place the load cell at top of the specimen at the centre and adjust the load indicator in the digital box to zero position.
9. Select a strain rate of 2.5mm / minute using the gear box in the machine.
10. 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.
11. Calculate the Young's modulus of the given specimen for each load using the following formula:

$$\text{Young's modulus, } E = \frac{Pl^3}{48I\delta}$$

Where,

P = Load in N

L = Span of the specimen in mm

I = Moment of Inertia in  $\text{mm}^4$  ( $bd^3/12$ )

b = Breadth of the beam in

mm. d = Depth of the beam in

mm

$\delta$  = Actual deflection in mm.

12. Find the average value of young s modulus that will be the Young s modulus of the given specimen.

**OBSERVATION:**

- |                                       |   |    |
|---------------------------------------|---|----|
| 1. Material of the specimen           | = |    |
| 2. Length of the specimen             | = | mm |
| 3. Breadth of the specimen, b         | = | mm |
| 4. Depth of the specimen, d           | = | mm |
| 5. Span of the specimen               | = | mm |
| 6. Least count of the dial gauge, LC= |   | mm |

**TABULATION:**

S.No	Load in		Deflection in mm			Young's Modulus in $\frac{\text{N}}{\text{mm}^2}$
	kg	N	Loading	Unloading	Mean	
<b>Average</b>						

**Result:**

The young's modulus of the given specimen =-----N/mm<sup>2</sup>

## VIVA QUESTION & ANSWER

### 1. What are the methods for finding out the slope and deflection at a section?

The important methods used for finding out the slope and deflection at a section in a loaded beam are

1. Double integration method
2. Moment area method
3. Macaulay's method

The first two methods are suitable for a single load, where as the last one is suitable for several loads.

### 2. Why moment area method is more useful, when compared with double integration?

Moment area method is more useful, as compared with double integration method because many problems which do not have a simple mathematical solution can be simplified by the ending moment area method.

### 3. Explain the Theorem for conjugate beam method?

Theorem I: "The slope at any section of a loaded beam, relative to the original axis of the beam is equal to the shear in the conjugate beam at the corresponding section" Theorem II: "The deflection at any given section of a loaded beam, relative to the original position is equal to the Bending moment at the corresponding section of the conjugate beam"

### 4. Define method of Singularity functions?

In Macaulay's method a single equation is formed for all loading on a beam, the equation is constructed in such way that the constant of Integration apply to all portions of the beam. This method is also called method of singularity functions.

### 5. What are the points to be worth for conjugate beam method?

1. This method can be directly used for simply supported Beam
2. In this method for cantilevers and fixed beams, artificial constraints need to be supplied to the conjugate beam so that it is supported in a manner consistent with the constraints of the real beam.

### 6. What are the types of beams?

1. Cantilever beam
2. Simply supported beam
3. Fixed beam
4. Continuous beam
5. over hanging beam

### 7. What are the types of loads?

1. Concentrated load or point load
2. Uniform distributed load
3. Uniform varying load

### 8. In which point the bending moment is maximum?

When the shear force change of sign or the shear force is zero

### 9. Write the assumption in the theory of simple bending?

1. The material of the beam is homogeneous and isotropic.
2. The beam material is stressed within the elastic limit and thus obey Hooke's law.
3. The transverse section which was plane before bending remains plains after bending also.
4. Each layer of the beam is free to expand or contract independently about the layer, above or below.
5. The value of E is the same in both compression and tension.

### 10. Write the theory of simple bending equation?

$M/I = F/Y = E/R$  M -Maximum bending moment I -Moment of inertia F -Maximum stress induced Y -Distance from the neutral axis E - Young's modulus R - Radius of curvature

**Ex.No:7****DOUBLE SHEAR TEST ON MILD STEEL AND ALUMINUMRODS****AIM:**

To conduct shear test on given specimen under double shear.

**EQUIPMENTS REQUIRED:**

1. UTM with double shear chuck
2. Vernier Caliper
3. 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.

1. Screw type
2. 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.

**PRECAUTION:**

The inner diameter of the hole in the shear stress attachment is slightly greater than that of the specimen.



**PROCEDURE:**

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

**OBSERVATION:**

Diameter of the specimen(d)=----- mm

Cross sectional area in double shear, (A) =  $2 \times d^2 / 4$  mm<sup>2</sup>

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

Shear strength =  $\frac{\text{Maximum shear force}}{\text{Area of the specimen}}$

**RESULT:**

Shear strength of the given material = ----- N /mm<sup>2</sup>

**VIVA QUESTION & ANSWER****1. State the main assumptions while deriving the general formula for shear stresses.**

The material is homogeneous, isotropic and elastic. The modulus of elasticity in tension and compression are same. The shear stress is constant along the beam width. The presence of shear stress does not affect the distribution of bending stress.

**2. Define: Shear stress distribution**

The variation of shear stress along the depth of the beam is called shear stress distribution.

**3. What is the ratio of maximum shear stress to the average shear stress for the rectangular section?**

$Q_{max}$  is 1.5 times the  $Q_{avg}$ .

**4. What is the ratio of maximum shear stress to the average shear stress in the case of solid circular section?**

$Q_{max}$  is  $4/3$  times the  $Q_{ave}$ .

**5. What is the shear stress distribution value of Flange portion of the I-section?**

$q = f/2I \cdot (D^2/4 - y^2)$  D-depth y-Distance from neutral axis

**6. What is the value of maximum of minimum shear stress in a rectangular cross section?**

$Q_{max} = 3/2 \cdot F / (bd)$

**7. What is the shear stress distribution for I-section?**

The shear stress distribution I-section is parabolic, but at the junction of web and flange, the shear stress changes abruptly. It changes from  $F/8I [D^2 - d^2]$  to  $B/b \times F/8I [D^2 - d^2]$  where D = overall depth of the section d = Depth of the web b = Thickness of web B = Overall width of the section.

**8. How will you obtain shear stress distribution for unsymmetrical section?**

The shear stress distribution for Unsymmetrical sections is obtained after calculating the position of NA.

**9. Where the shear stress is max for Triangular section?**

In the case of triangular section, the shear stress is not max at N.A. The shear stress is max at a height of  $h/2$

**10. Where shear stress distribution diagram draw for composite section?**

The shear stress distribution diagram for a composite section, should be drawn by calculating the shear stress at important points.

## **Ex.No.8 Effect on Hardening- Improvement in Hardness and impact resistance of steel**

### **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**

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

#### **Case (II) - For Hardened specimen**

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

#### **Case (III) - For Tempered specimen**

1. Keep the specimen in muffle furnace at temperature of 650° for 2 hours
2. Allow the specimen for air cooling after taking from muffle furnace
3. Then same procedure is followed for the specimen

**OBSERVATION:**

**ROCKWEL HARDNESS TEST:**

Cases for hardness =

Cross sectional area =

S.No	Material	Temperature (°C)	Load (kgf)	Indenter detail	Scale	RH N			
						Trial 1	Trail 2	Trail 3	Mean
1	Deep case Hardened steel								
2.	Deep case Hardened steel								
3.	Mild steel								
4.	Mild steel								

**CHARPY TEST:**

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

**RESULT:****1. Hardness in**

- (i) Deep case hardened steel (a)
  - Unhardened = (b)
  - Quenched =
- (ii) Mild steel
  - (a) Unhardened = (b)
  - Quenched =

**2. Impact strength in**

- (i) Deep case hardened steel (a)
  - Unhardened = (b)
  - Quenched =

**VIVA QUESTION & ANSWER**

1. What is austenite?  
Phase in certain steels, characterized as a solid solution, usually of carbon or iron carbide, in the gamma form of iron. Such steels are known as "austenitic". Austenite is stable only above 1333°F. In a plain carbon steel, but the presence of certain alloying elements, such as nickel and manganese, stabilizes the austenitic form, even at normal temperatures.
2. What is austenitic steel?  
Steel, because of the presence of alloying elements, such as manganese, nickel, chromium, etc., shows stability of Austenite at normal temperatures.
3. How bainite is formed?  
A slender, needle-like (acicular) microstructure appearing in spring steel strip characterized by toughness and greater ductility than tempered Martensite. Bainite is a decomposition product of Austenite best developed at interrupted holding temperatures below those forming fine pearlite and above those giving Martensite.
4. Which steel is called as carbon steel?  
Common or ordinary steel as contrasted with special or alloy steels, which contain other alloying metals in addition to the usual constituents of steel in their common percentages.
5. State the meaning of carburizing.  
(Cementation) It is the process of adding carbon to the surface of iron-base alloys by absorption through heating the metal at a temperature below its melting point in contact with carbonaceous solids, liquids or gasses. It is the oldest method of case hardening.
6. What is meant by case hardening?  
Carburizing and subsequently hardening by suitable heat-treatment, all or part of the surface portions of a piece of iron-base alloy.
7. What is a cast steel?  
Any object made by pouring molten steel into molds
8. What is grain boundary?  
Bounding surface between crystals. When alloys yield new phases (as in cooling), grain boundaries are the preferred location for the appearance of the new phase. Certain deteriorations, such as season cracking and caustic embrittlement, occur almost exclusively at grain boundaries.
9. What is meant by graphitizing?  
A heating and cooling process by which the combined carbon in cast iron or steel is transformed, wholly or partly, to graphitic or free carbon.
10. Define the term hardenability.  
The ability of a metal, usually steel, to harden in depth as distinguished from the terms hardness, malleability, and similar properties of both metals and their alloy.

**Ex.No:9      TEMPERING- IMPROVEMENT MECHANICAL PROPERTIES  
COMPARISON**

**AIM:**

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

**APPARATUS REQUIRED:**

1. Muffle furnace: tongs
2. Given material: C-40 steel
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 permit the trapped temperature to transform and relieve the internal stresses.

1. 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.
2. The specimen is placed inside the combustion chamber of muffle furnace and is noted up to 830°C.
3. Then the specimen is soaked for 10 minutes at the same temperature 830°C.
4. After soaking it is taken out from the furnace and it is quenched in the water.
5. The specimen is cooled, now the tempering is completed.
6. Again the specimen is subjected to Rockwell hardness test and Rockwell hardness number is measured.

**TABULATION:**

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

**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 =



VIVA QUESTION & ANSWER

1. What are the factors affecting diffusion?
  - i) Temperature : increases the rate of diffusion
  - ii) crystal structure : crystal with low packing factor increase the rate of diffusion
  - iii) Grain size : fine grain material has more diffusion rate
  - iv) Concentration : value of diffusion coefficient varies with concentration
2. Distinguish between hardening and annealing.  
 Hardening gives hardness to a material so that its yield strength, corrosion resistance, wear resistance and cutting ability are increased. Annealing gives softness and ductility to the materials and also refines the grain size and removes the internal stresses.
3. What are the uses of Vickers hardness test?
  - i) The material is tested without any destructions so it's a nondestructive testing. After testing the material or product can be used or sold.
  - ii) Only smaller loads are applied. That would not produce cracks or fractures inside the specimen.
  - iii) Micro hardness of the surface hardened materials can be determined accurately.
4. What is meant by heat treatment? What are the different methods of heat treatment?  
 Heating and cooling a solid metal or alloy in such a way as to obtain desired conditions or properties is called heat treatment. There are different methods of strengthening and hardening by heat treatment. They are
  - i) Age hardening (precipitation hardening)
  - ii) Annealing
  - iii) Normalizing
  - iv) Tempering and
  - v) Case hardening
5. What is age hardening or precipitation hardening?  
 By uniformly dispersing extremely small particles within the original phase matrix the strength and hardness of metal alloys may be enhanced; this process of heat treatment is called precipitation hardening or age hardening.
6. What is overaging?  
 For some alloys, aging occurs spontaneously at room temperature over extended time periods. With increase of time the strength increases and after reaching a maximum a value, it finally diminishes. This type of reduction in yield strength and hardness that occurs after long time periods is known as overaging.
7. What is annealing and what is its purpose?  
 Annealing means heating the material to and holding at a suitable temperature and then cooling at a suitable rate. Annealing is for the purpose of
  - i) Reducing hardness
  - ii) Improving machinability
  - iii) Facilitating cold working
  - iv) Producing a desired microstructure and
  - v) Obtaining desired mechanical, physical and other properties.
8. What is normalizing?  
 Heating a ferrous alloy to a suitable temperature above the transformation range and then cooling in air to a temperature substantially below the transformation range is called normalizing.
9. What is tempering?  
 Tempering is the process of re-heating the hardened steel to some temperature below its critical temperature in order to impart toughness and to reduce brittleness. This reduces the internal stresses developed during hardening.
10. Explain austempering  
 The heat treatment for ferrous alloys in which a part is quenching from the austenitizing temperature at a rate fast enough to avoid formation of ferrite or pearlite and held at a temperature just above that of martensite formation until transformation to bainite is complete is called austempering.

## **Ex.No:10 MICROSCOPIC EXAMINATION OF HARDENED, HARDENED AND TEMPERED SAMPLES**

### **AIM:**

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

### **APPARATUS REQUIRED:**

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-9000 c

Holding time-1hr

Quenching medium - Water.

Tempering:

To reduce the stress

To reduce the brittleness

Tempering temperature-320°C

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 900 °C 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:  
 Indentor:

**RESULT:**

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

VIVA QUESTION & ANSWER

## 1. Explain martempering

The process of quenching an austenitized ferrous alloy is a medium at a temperature in the upper part of the martensite range, or slightly above that range, and holding it in the medium until the temperature throughout the alloy is substantially uniform is known as martempering. The alloy is then allowed to cool in air through the martensite range.

## 2. What is case hardening?

For many industrial applications, we need a hard wear-resistant surface called the case and a relatively soft, tough inside called the core. The process of hardening the surface (case) alone is known as case hardening.

## 3. What is sub-zero treatment of steel?

Whenever the steel is hardening some amount of austenite is always retained by it. This results in the reduction of hardness, thermal conductivity and wear resistance. The sub-zero treatment of hardened steel reduces the retained austenite. In this process the hardened steel part is cooled to sub-zero temperature (between -300 C to -1200 C).

## 4. What is "patenting"?

A special application of isothermal hardening is called patenting and is used for steel wire. Steel wire with 0.40 – 1.10% carbon is quenched from the hardening temperature in a bath of molten lead to about 4000 C to 5000 C. A structure results with possesses good ductility in addition to a hardness.

## 5. Define the term age hardening.

The term as applied to soft or low carbon steels, relates to slow, gradual changes that take place in properties of steels after the final treatment. These changes, which bring about a condition of increased hardness, elastic limit, and tensile strength with a consequent loss in ductility, occur during the period in which the steel is at normal temperatures.

## 6. What is meant by aging?

Spontaneous change in the physical properties of some metals, which occurs at atmospheric temperatures after final cold working or after a final heat treatment. Frequently synonymous with the term "Age-Hardening."

## 7. What is air air hardening steel?

Alloy steel which may be hardened by cooling in air from a temperature above the transformation range. Such steels attain their martensitic structure without going through the quenching process. Additions of chromium, nickel, molybdenum and manganese are effective toward this end.

## 8. What is annealing?

A heating and cooling operation implying usually a relatively slow cooling. Annealing is a comprehensive term. The process of such a heat treatment may be: to remove stresses; to induce softness; to alter ductility; toughness; electrical magnetic, or other physical properties; to refine the crystalline structure; to remove gases; to produce a definite micro-structure. In annealing, the temperature of the operation and the rate of cooling depend upon the material being heat treated and the purpose of the treatment.

## 9. State the Abbreviation of A.S.T.M.

Abbreviation for American Society for Testing Material. An organization for issuing standard specifications on materials, including metals and alloys.

## 10. What is austempering?

A trade name for a patented heat treating process that consists of quenching a ferrous alloy from temperature above the transformation ranges, in a medium having a rate of heat abstraction sufficiently high to prevent the formation of high-temperature transformation products and in maintaining the alloy, until transformation is complete, at a temperature below that of pearlite formations and above that of martensite formation.