



## SRI SHANMUGHA COLLEGE OF ENGINEERING AND TECHNOLOGY

(Approved by AICTE, Affiliated to Anna University and Accredited by NAAC & NBA (ECE)

Pullipalayam, Morur (P.O), Sankari (T.k), Salem (D.T) – 637 304

### DEPARTMENT OF MECHANICAL ENGINEERING



***CE8381 - Strength of Materials Laboratory***

## ***Mission and vision of the institute***

### **VISION**

To be an institute of repute in the field of engineering and technology by implementing the best educational practices akin to global standards for fostering domain knowledge and developing research attitude among students to make them globally competent.

### **MISSION**

Achieving excellence in Teaching Learning process using state-of-the-art resources

Extending opportunity to upgrade faculty knowledge and skills

Implementing the best student training practices for requirements of industrial scenario of the state

Motivating faculty and students in research activity for real time application

## **Vision and Mission of the Department**

### **VISION**

To prepare competent mechanical engineers capable of working in an interdisciplinary environment contributing to society through innovation, leadership and entrepreneurship

### **MISSION**

**M1:** To offer quality education which enables them in professional practice and career

**M2:** To provide learning opportunities in the state-of-the-art research facilities to create, interpret, apply and disseminate knowledge in their profession

**M3:** To prepare the students as professional engineers in the society with an awareness of environmental and ethical values

### **PROGRAMOUTCOMES (POs):**

**PO1 Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals and an engineering specialization to the solution of complex engineering problems.

**PO2 Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences and engineering sciences.

**PO3 Design/development of solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health, safety, cultural, societal and environmental considerations.

**PO4 Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis, and interpretation of data and synthesis of the information to provide valid conclusions.

**PO5 Modern tool usage:** Create, select, apply appropriate techniques, resources, modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

**PO6 The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal, cultural issues and the consequent responsibilities relevant to the professional engineering practice.

**PO7 Environment and sustainability:** Understand the impact of the professional engineering solutions in societal, environmental contexts, demonstrate the knowledge and need for sustainable development.

**PO8 Ethics:** Apply ethical principles, commit to professional ethics, responsibilities and norms of the engineering practice.

**PO9 Individual and team work:** Function effectively as an individual, as a member or leader in diverse teams and in multidisciplinary settings.

**PO10 Communication:** Communicate effectively on complex engineering activities with the engineering community with society at large being able to comprehend, write effective reports, design documentation, make effective presentations and receive clear instructions.

**PO11 Project management and finance:** Demonstrate knowledge, understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

**PO12 Life-long learning:** Recognize the need, ability to engage in independent and life-long learning in the broadest context of technological change.

### **PROGRAM SPECIFIC OUTCOMES (PSOs):**

**PSO1 Manufacturing:** Modelling, Simulation and Analysis in the field of Manufacturing.

**PSO2 Design:** Develop and implement new ideas on product design with help of modern CAD tools.

## **LABORATORY 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.**

## LIST OF EXPERIMENTS

<b>Sl.No</b>	<b>K Level</b>	<b>Experiments Name</b>	<b>Relevance to COs</b>	<b>Page No</b>
<b>1.</b>	K4	Tension test on a mild steel rod	CO1	
<b>2.</b>	K4	Double shear test on Mild steel and Aluminium rods	CO1	
<b>3.</b>	K4	Torsion test on mild steel rod	CO1	
<b>4.</b>	K4	Impact test on metal specimen	CO1	
<b>5.</b>	K4	Hardness test on metals - Brinnell and Rockwell Hardness Number	CO1	
<b>6.</b>	K4	Deflection test on beams	CO1	
<b>7.</b>	K4	Compression test on helical springs	CO1	
<b>8.</b>	K4	Strain Measurement using Rosette strain gauge	CO1	
<b>9.</b>	K4	Effect of hardening- Improvement in hardness and impact resistance of steels.	CO1	
<b>10.</b>	K4	Tempering- Improvement Mechanical properties Comparison (i) Unhardened specimen (ii) Quenched Specimen and (iii) Quenched and tempered specimen.	CO2,CO3	
<b>11.</b>	K4	Microscopic Examination of (i) Hardened samples and (ii) Hardened and tempered samples.	CO2,CO3	

**COURSE OUTCOME:**

C308.1	Ability to perform Tension, Torsion, Hardness, Compression, and Deformation test on Solid materials.
C308.2	Learn about specimen preparation for metallographic examination, microstructures and heat treatment processes.
C308.3	Gain knowledge about various characteristic of materials.

Course Outcomes	Program Outcomes													
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PO1 2	PSO 1	PSO 2
<b>C308.1</b>	3	3	1	1					2	1	1	3	2	
<b>C308.2</b>	3	3	1	1	1				2	1	1	3	2	1
<b>C308.3</b>	3	3	1	1					2	1	1	3	2	
<b>C308</b>	<b>3</b>	<b>3</b>	<b>1</b>	<b>1</b>	<b>1</b>				<b>2</b>	<b>1</b>	<b>1</b>	<b>3</b>	<b>2</b>	<b>1</b>

<b>SI. No</b>	<b>Experiments Name</b>	<b>Date /Time</b>	<b>Marks</b>	<b>Signature</b>
1	Tension test on a mild steel rod			
2	Double shear test on Mild steel and Aluminium 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.			

**DEPARTMENT OF MECHANICAL ENGINEERING**

**LABORATORY MANUAL**

**CE8381 – STRENGTH OF MATERIALS LAB**

<b>YEAR / SEMESTER</b>	<b>:</b>	<b>II / IV</b>
<b>DEPARTMENT</b>	<b>:</b>	<b>Mechanical</b>
<b>ACADEMIC YEAR</b>	<b>:</b>	<b>2018 – 2019 EVEN</b>
<b>REGULATION</b>	<b>:</b>	<b>2017</b>

## **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.

## **STRENGTH OF MATERIALS LABORATORY**

### **GENERAL INSTRUCTION**

**The following instructions should be strictly followed by the students in the strength of Materials Laboratory.**

1. All the students are expected to come to the lab, with shoe, uniform etc., whenever they come for the laboratory class.
2. For each lab class, all the students are expected to come with observation note book, record note book, pencil, eraser, sharpener, scale, divider, graph sheets, French curve etc.
3. While coming to each laboratory class, students are expected to come observation note book prepared for the class.
4. All the students are expected to complete their laboratory work including calculations and get it corrected in the laboratory class itself.
5. While coming to the next lab classes are expected to submit the record note for correction.
6. All the equipments, tools accessories and expensive. Therefore, students are expected to handle the instruments with utmost care during the experiment.
7. The tools and accessories required for conducting the experiments can be obtained from the technician and the same should be returned as soon as the experiment over.
8. Breakage amount will be collected from the student(S) for causing damage to the instruments / equipments due to wrong operation or carelessness.

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## **TENSION TEST ON MILD STEEL ROD**

**Ex. No.:**

**Date:**

**Aim:**

To conduct a tension test on given mild steel specimen for finding the following:

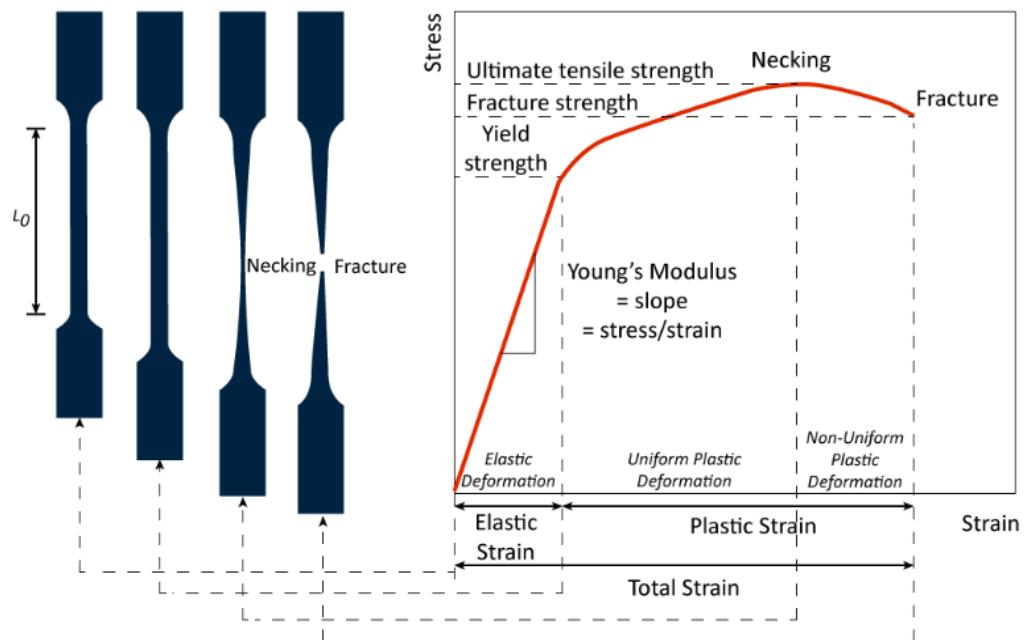
1. Yield stress
2. Ultimate stress
3. Nominal breaking stress
4. Actual breaking stress
5. Percentage Elongation in length
6. Percentage Reduction in area.

**Apparatus Required:**

1. Universal Testing machine (UTM)
2. Mild steel specimen
3. Scale
4. Vernier caliper
5. Dot Punch
6. Hammer

**Procedure:**

1. Measure the length (L) and diameter (d) of the given specimen.
2. Mark the centre of the specimen using dot punch.
3. Mark two points P and Q at a distance of 150mm on either side of the centre mark so that the distance between P and Q will be equal to 300mm.
4. Mark two point A and B at a distance of 2.5 times the rod distance on the either side of the centre mark so that the distance between A & B will be equal to 5 times the rod diameter and is known as initial gauge length of rod. ( $l_i$ ).
5. Insert the specimen in the middle cross head and top cross head grip of the machine so that the two points A and B coincide with grips.
6. Apply the load gradually and continue the applications of load. After sometime, there will be slightly pause in the increase of load. The load at this point is noted as yield point ( $P_y$ ).
7. Apply load continuously till the specimen fails and note down the ultimate load ( $P_u$ ) and breaking load ( $P_b$ ) from the digital indicator.
8. Remove the specimen from the machine and join the two pieces of the specimens.
9. Measure the distance between the two points A and B. This distance is known as final gauge length ( $l_f$ ) of the specimen.
10. Measure the diameter of the rod at neck ( $d_n$ ).
11. Determine the yield stress, ultimate stress, nominal breaking stress, actual breaking stress, percentage elongation in length and percentage reduction in area using the following formula.



Mild Steel Specimen

**Observation:**

1. Material of the specimen	=	
2. Length of the specimen, L	=	mm
3. Diameter of the specimen, d	=	mm
4. Initial gauge length of the specimen $l_i$	=	mm
5. Final gauge length of the specimen $l_f$	=	mm
6. Diameter at neck $d_n$	=	mm
7. Yield load. $P_y$	=	KN
8. Ultimate load, $P_u$	=	KN
9. Breaking load, $P_b$	=	KN

**Calculations:**

- 1) Yield stress  $\sigma_y = \frac{\text{Yield load } (P_y)}{\text{Initial Area } (A_i)}$
- 2) Ultimate stress  $\sigma_u = \frac{\text{Ultimate load } (P_u)}{\text{Initial Area } (A_i)}$
3. Nominal breaking stress,  $\sigma_{bn} = \frac{\text{Breaking load } (P_b)}{\text{Initial Area } (A_i)}$
4. Actual breaking stress,  $\sigma_{bn} = \frac{\text{Breaking load } (P_b)}{\text{Neck Area } (A_n)}$
5. % Elongation in length =  $\left( \frac{\text{Final gauge length } (l_f) - \text{Initial gauge length } (l_i)}{\text{Initial gauge length } (l_i)} \right) \times 100$
- 6% Reduction in area =  $\left( \frac{\text{Initial area } (A_i) - \text{Neck area } (A_n)}{\text{Initial gauge length } (l_i)} \right) \times 100$

Where  $A_i = \text{Initial Area} = \pi d^2 / 4$   
 $A_n = \text{Area at neck} = \pi d_n^2 / 4$ .

**Result:**

Tension test for the given specimen was conducted and the results are as follows:

1. Yield stress, $\sigma_y$	=	N/mm <sup>2</sup>
2. Ultimate stress, $\sigma_u$	=	N/mm <sup>2</sup>
3. Nominal breaking stress, $\sigma_{bn}$	=	N/mm <sup>2</sup>
4. Actual breaking stress, $\sigma_{bn}$	=	N/mm <sup>2</sup>
5. Percentage Elongation in length	=	
6. Percentage Reduction in area	=	

## **TEST FOR TORSION ON MILD STEEL ROUND ROD**

**Experiment No:**

**Date:**

### **AIM:**

To conduct torsion test on mild steel round rod and to determine the value of modulus of rigidity and maximum shear stress.

### **APPARATUS REQUIRED:**

- a. Torsion testing machine
- b. Vernier caliper
- c. Steel rule
- d. Specimen

### **FORMULAE USED:**

$$\text{Modulus of Rigidity, } (C) = \frac{T \times L}{J \times \theta} \text{ N/mm}^2$$

$$\text{Maximum Shear Stress, } (\tau) = \frac{T \times R}{J} \text{ N/mm}^2$$

Where,

T → Torque, N-mm

J → Polar Moment of Inertia, mm<sup>4</sup>

L → Gauge Length, mm

θ → Angle of Twist, Radians

R → Mean radius of shaft, mm

### **PROCEDURE:**

1. Before testing, adjust the measuring range according to the capacity of the test piece.
2. Hold the specimen in driving chuck and driven chuck with the help of handles.
3. Adjust the angle measuring dial at zero position, black pointer at the starting position and pen in its required position.
4. Bring the red dummy pointer in line with the black pointer.
5. Start the machine and now the specimen will be subjected to torsion.
6. Take down the value of torque from the indicating dial for particular value of angle of twist (for every 5° of rotation).
7. Repeat the experiment until the specimen breaks into two pieces. Note the value of torque at this breaking point.
8. Tabulate the readings and draw graph between angle of twist and torque.
9. Find the value of T/θ from the graph and find the value of modulus of rigidity.
10. Find the maximum shear stress.

**OBSERVATION & TABULATION:**

i. Gauge Length (L) = \_\_\_\_\_ mm

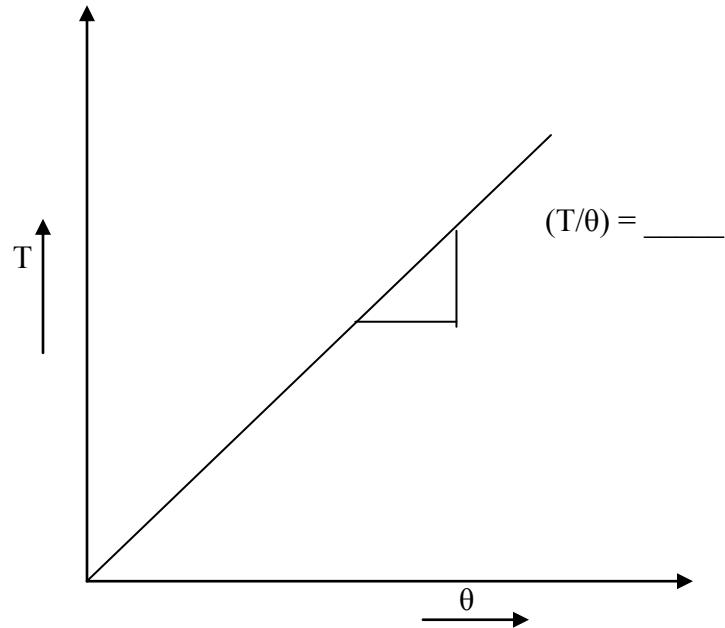
ii. Mean Diameter of Specimen(d):

Vernier Caliper Reading: L.C. = \_\_\_\_\_ mm

Sl. No.	M.S.R. (mm)	V.S.R. (Div)	Observed Reading = M.S.R. + (V.S.R. x L.C.)	Correct Reading = Observed Reading ± Z.C.
Mean				

Mean Diameter of the specimen (d) = \_\_\_\_\_ mm.

Sl. No.	Angle of Twist ( $\theta$ ) (Radians)	Torque (T) (N - mm)

**GRAPH:**

**CALCULATIONS:**

- i. Polar Moment of Inertia (J) =  $(\pi/32) \times d^4$
- ii. Modulus of Rigidity, (C) =  $\frac{T \times L}{J \times \theta}$  N/mm<sup>2</sup>
- iii. Maximum Shear Stress, ( $\tau$ ) =  $\frac{T \times R}{J}$  N/mm<sup>2</sup>

**RESULT**

For the given mild steel round rod specimen

$$\text{Modulus of Rigidity, (C)} = \underline{\hspace{2cm}} \text{ N/mm}^2$$

$$\text{Maximum Shear Stress, } (\tau) = \underline{\hspace{2cm}} \text{ N/mm}^2$$

## CHARPY IMPACT TEST

**Ex. No.:**

**Date:**

**Aim:**

To determine the impact strength of the given specimen by conducting charpy impact test.

**Apparatus and specimen required:**

1. Impact testing machine with attachment for charpy test.
2. Charpy specimen
3. Vernier caliper
4. Scale.

**Procedure:**

1. Measure the length ( $l$ ), breadth ( $b$ ), & depth ( $d$ ) of the given specimen.
2. Measure the position of notch (i.e. groove) from one end ( $l_g$ ), depth of groove ( $d_g$ ) and top width of the groove ( $w_g$ ) in the given specimen.
3. Lift the pendulum and keep it in the position meant for charpy test.
4. Adjust the pointer to coincide with initial position (i.e. maximum value) in charpy scale.
5. Release the pendulum using the lever and note down the initial reading in the charpy scale.
6. Repeat the step 3 and 4.
7. Place the specimen centrally over the supports such that the groove is opposite to the striking face.
8. Release the pendulum again using the lever and note down the final reading in the charpy scale.
9. Find the impact strength of the given specimen by using the following relation:  
Impact strength = (Final charpy scale reading – Initial charpy scale reading)

**Observation:**

- |   |   |      |
|---|---|------|
| 1. Material of the given specimen             | = |      |
| 2. Type of notch (i.e. groove)                | = |      |
| 3. Length of the specimen, $l$                | = | mm   |
| 4. Breadth of the specimen, $b$               | = | mm   |
| 5. Depth of the specimen, $d$                 | = | mm   |
| 6. Position of groove from one end, ( $l_g$ ) | = | mm   |
| 7. Depth of groove ( $d_g$ )                  | = | mm   |
| 8. Width of groove ( $w_g$ )                  | = | mm   |
| 9. Initial charpy scale reading               | = | kg.m |
| 10. Final charpy scale reading                | = | kg.m |

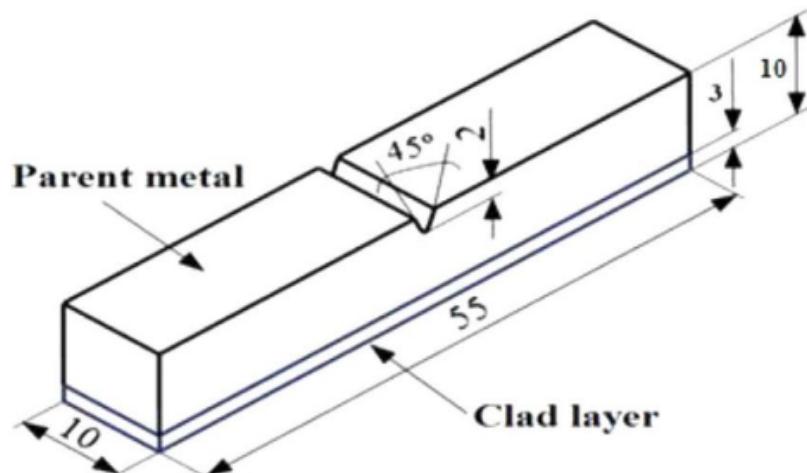
**Result:**

The impact strength of the given specimen is ----- Kg.m

## CHARPY IMPACT TESTING MACHINE



## SPECIMEN - CHARPY TEST



## **IZOD IMPACT TEST**

**Ex. No.:**

**Date:**

**Aim:**

To determine the impact strength of the given specimen by conducting Izod impact test.

**Apparatus and specimen required:**

1. Impact testing machine with attachment for Izod test.
2. Given specimen
3. Vernier caliper
4. Scale.

**Procedure:**

1. Measure the length ( $l$ ), breadth ( $b$ ), & depth ( $d$ ) of the given specimen.
2. Measure the position of notch (i.e. groove) from one end ( $l_g$ ), depth of groove ( $d_g$ ) and top width of the groove ( $w_g$ ) in the given specimen.
3. Lift the pendulum and keep it in the position meant for charpy Izod test.
4. Adjust the pointer to coincide with initial position (i.e. maximum value) in the izod scale.
5. Release the pendulum using the lever and note down the initial reading in the izod scale.
6. Repeat the step 3 and 4.
7. Place the specimen vertically upwards such that the shorter distance between one end of the specimen and groove will be protruding length and also the groove in the specimen should face the striking end of the hammer.
8. Release the pendulum again using the lever and note down the final reading in the izod scale.
9. Find the impact strength of the given specimen by using the following relation:  
Impact strength = (Final izod scale reading – Initial izod scale reading)

**Observation:**

- |   |        |
|---|--------|
| 1. Material of the given specimen             | =      |
| 2. Type of notch (i.e. groove)                | =      |
| 3. Length of the specimen, $l$                | = mm   |
| 4. Breadth of the specimen, $b$               | = mm   |
| 5. Depth of the specimen, $d$                 | = mm   |
| 6. Position of groove from one end, ( $l_g$ ) | = mm   |
| 7. Depth of groove ( $d_g$ )                  | = mm   |
| 8. Width of groove ( $w_g$ )                  | = mm   |
| 9. Initial charpy scale reading               | = kg.m |
| 10. Final charpy scale reading                | = kg.m |

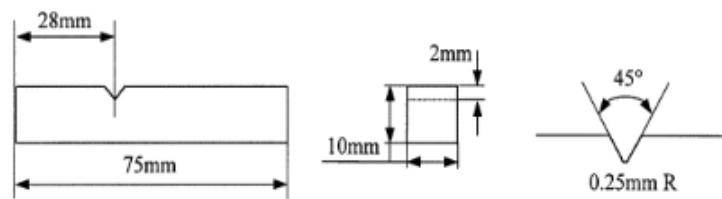
**Result:**

The impact strength of the given specimen is ----- Kg.m

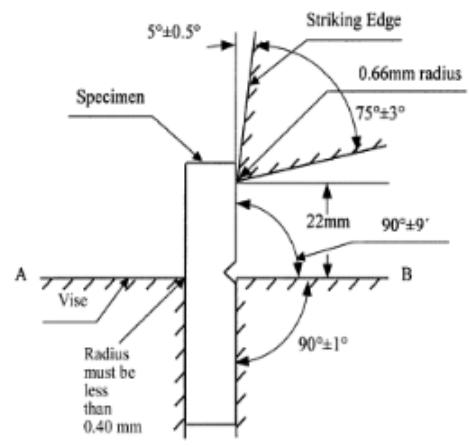
## IZODE IMPACT TESTING MACHINE



## SPECIMEN - IZODE TEST



(a) test specimen



(b) specimen-holding fixture

## **ROCKWELL HARDNESS TEST**

**Ex. No.:**

**Date:**

**Aim:**

To determine the Rockwell hardness number for the given specimen.

**Apparatus Required:**

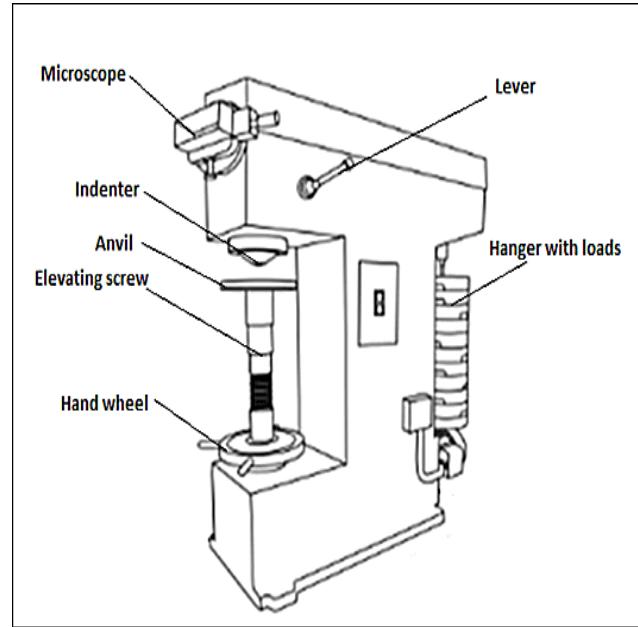
1. Rockwell hardness testing machine
2. Indentor
3. Test specimen
4. Stop watch

**Procedure:**

1. Identify the material of the given specimen
2. Know the major load, type of indenter and scale to be used for the given test specimen from the following table.

Sl.No.	Material type	Major load	Indenter	Scale
1	Hardened steel	150kg	Diamond cone 120°	C
2	Mild steel	100kg	1.58mm dia, steel ball	B
3	Aluminum	100kg	1.58mm dia. Steel ball	B
4	Brass	100kg	1.58mm dia. Steel ball	B
5	Copper	100kg	1.58mm dia. Steel ball	B

3. Fix the indentor and place the given specimen on the anvil of the machine.
4. Select the major load from the knob available on the right of the machine.
5. Raise the anvil using the rotating wheel till the specimen touches the indentor and then slowly turns the wheel till the small pointer on the dial reaches the red mark position. Now the specimen is subjected to a minor load of 10kg.
6. Push the loading handle in the forward direction to apply the major load to the specimen and allow the load to act on the specimen for 15 seconds.
7. Release the major load by pushing the loading handle in the backward direction and keep the minor 10kg load still on the specimen.
8. Read the Rockwell hardness number either from 'C' or 'B' scale, as the case may be, directly on the dial and record it.
9. Release the minor load of 10kg by rotating the hand wheel and lowering the screw bar.
10. Repeat the experiment to obtain at least 3 different sets of observations for the given specimen by giving a gap of at least 3mm between any two adjacent indentations and 1.5mm from the edge.
11. Find the average value, which will be the rockwell hardness number for the given specimen.



### **Rockwell hardness test equipment**

Observation:

Sl.No.	Material	Major load	Indentor	Scale	Rockwell hardness number (RHC..... or RHB)
Average					

Result:

The Rockwell hardness number for the given specimen = RHC ----- (or) RHB -----

## **BRINELL HARDNESS TEST**

**Ex. No.:**

**Date:**

**Aim:**

To determine the Brinell hardness number for the given specimen.

Apparatus Required:

1. Brinell hardness testing machine
2. Microscope
3. Indenter
4. Test specimen
5. Stop watch

Procedure:

1. Identify the material of the given specimen
2. Know the value of  $P/D^2$  and diameter of the indenter (D) type to be used for the given test specimen from the following table.

Sl.No.	Material type	$P/D^2$ value in kg/mm <sup>2</sup>	Diameter of steel ball (D) indenter in mm
1	Steel and cast iron	30	2.5
2	Copper and Aluminum Alloys	10	2.5
3	Copper and Aluminum	5	2.5
4	Lead, Tin and Alloys	1	2.5

Where, P = Major load in kg.

3. Calculate the major load to be applied for the given test specimen by knowing the value of  $PD^2$  and D.
4. Select the major load from the knob available on the right of the machine.
5. Fix the indenter and place the given specimen on the anvil of the machine.
6. Raise the anvil using the rotating wheel till the specimen touches the indenter and then slowly turns the wheel till the small pointer on the dial reaches the red mark position. Now the specimen is subjected to a minor load of 10kg.
7. Apply the major load to the specimen by pushing the loading – handle in the forward direction and allow the load to act on the specimen for 15 seconds.
8. Release the major load by pushing the loading handle in the backward direction.
9. Release the minor load of 10kg by rotating the hand wheel and lowering the screw bar.
10. Measure the diameter of indentation (d) using the microscope.

11. Calculate the Brinell hardness number for the given specimen using the following formula:

$$\text{Brinell hardness number} = \frac{\text{Load in kg}}{\text{Spherical area of Indentation of mm}^2}$$

$$= \frac{P}{\pi D/2 [d - \sqrt{D^2 - d^2}]} \text{ kg/mm}^2$$

Where, P = Major load in kg.

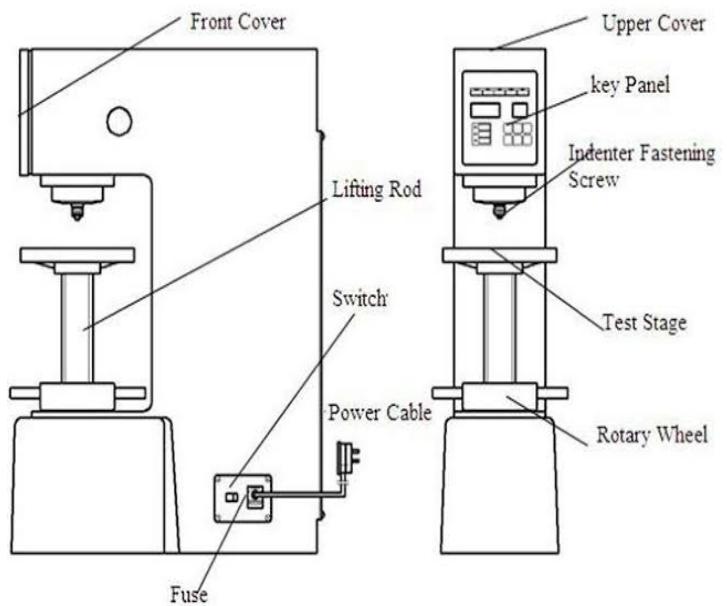
D = Diameter of indenter in mm.

d = diameter of indentation in mm.

12. Repeat the experiment to obtain at least 3 different sets of observations for the given specimen by giving a gap of at least 3mm between any two adjacent indentations and 1.5mm from the edge.

11. Find the average value, which will be the Brinell hardness number for the given specimen.

### BRINELL HARDNESS TEST



**Observation:**

Sl.No.	Material	P/D <sup>2</sup> value in kg/mm <sup>2</sup>	Major load (P) in kg	Diameter of steel ball indentor (D) in mm.	Dia of indentation (d) in mm	Brinell hardness number (BHN) in kg/mm <sup>2</sup>
Average						

**Result:**

The Brinell hardness number for the given specimen = ----- kg/mm<sup>2</sup>

## **DEFLECTION TEST ON BEAMS**

**Ex. No.:**

**Date:**

**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 centre of the specimen using pencil / chalk
3. Mark two points A & B at a distance of 350mm on either side of the centre 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 centre 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 tonne 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:

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

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.

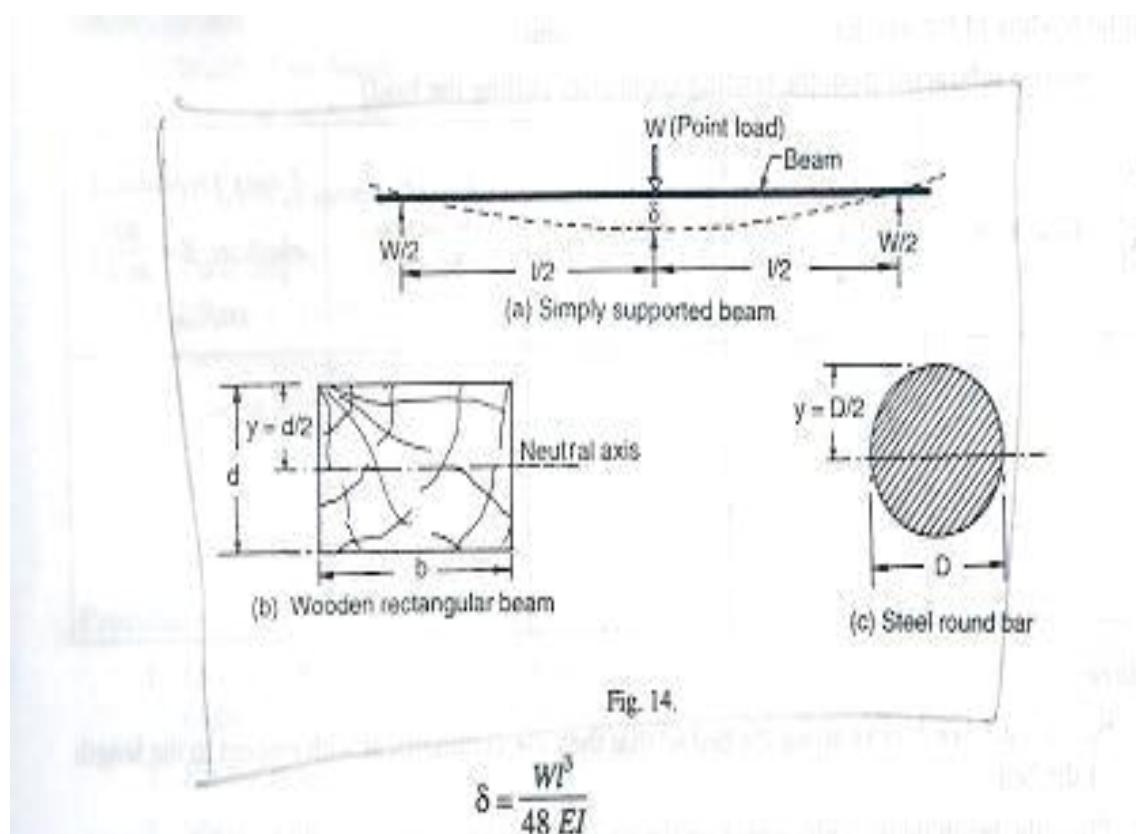
**Observation:**

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

Sl.No.	Load in		Deflection in mm		Young's Modulus in N/mm <sup>2</sup>
	T	N	observed	Actual	
Average					

**Result:**

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



$$\delta = \frac{Wl^3}{48EI}$$

**DEFLECTION TEST – SPECIMEN SETUP**

## **TEST ON COMPRESSION SPRING**

**Ex. No.:**

**Date:**

**Aim:**

To determine the modulus of rigidity and stiffness of the given compression spring specimen.

**Apparatus and specimen required:**

1. Spring test machine
2. Compression spring specimen
3. Vernier caliper

**Procedure:**

1. Measure the outer diameter (D) and diameter of the spring coil (d) for the given compression spring.
2. Count the number of turns i.e. coils (n) in the given compression specimen.
3. Place the compression spring at the centre of the bottom beam of the spring testing machine.
4. Rise the bottom beam by rotating right side wheel till the spring top touches the middle cross beam.
5. Note down the initial reading from the scale in the machine.
6. Apply a load of 25kg and note down the scale reading. Increase the load at the rate of 25kg upto a maximum of 100kg and note down the corresponding scale readings.
7. Find the actual deflection of the spring for each load by deducting the initial scale reading from the corresponding scale reading.
8. Calculate the modulus of rigidity for each load applied by using the following formula:

$$\text{Modulus of rigidity, } N = \frac{64PR^3n}{d^4\delta}$$

Where, P = Load in N

R = Mean radius of the spring in mm ( $D - d / 2$ )

d = Diameter of the spring coil in mm

$\delta$  = Deflection of the spring in mm

D = Outer diameter of the spring in mm.

9. Determine the stiffness for each load applied by using the following formula:

$$\text{Stiffness, } K = P/\delta$$

10. Find the values of modulus of rigidity and spring constant of the given spring by taking average values.

**Observation:**

1. Material of the spring specimen =  
2. Outer diameter of the spring, D = mm  
3. Diameter of the spring coil, d = mm  
4. Number of coils / turns, n = Nos.  
5. Initial scale reading = cm = mm

Sl.No.	Applied Load in		Scale reading in		Actual deflection in mm	Modulus of rigidity in N/mm <sup>2</sup>	Stiffness in N/mm
	kg	N	cm	mm			
Average							

**Result:**

The modulus of rigidity of the given spring = ----- N/mm<sup>2</sup>  
The stiffness of the given spring = ----- N/mm<sup>2</sup>

## **DOUBLE SHEAR TEST ON STEEL BAR**

**Ex. No.:**

**Date:**

**Aim:**

To determine the maximum shear strength of the given bar by conducting double-shear test.

**Apparatus and specimen required:**

1. Universal Testing machine (UTM)
2. Mild steel specimen
3. Device for double shear test
4. Veriner caliper / screw gauge

**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 stresses 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.

**Procedure:**

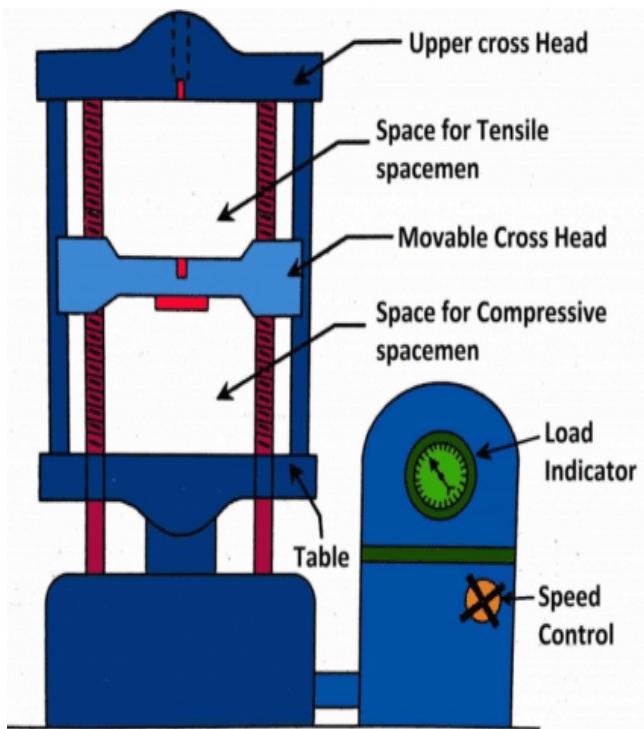
1. Measure the diameter (d) of the given specimen.
2. The inner diameter of the hole in the shear stress attachment is slightly greater than that of the specimen.
3. Fit the specimen in the double shear device and place whole assembly in the UTM.
4. Apply the load till the specimen fails by double – shear.
5. Note down the load at which the specimen fails (P).
6. Calculate the maximum shear strength of the given specimen by using the following formula:  
Maximum shear strength = 
$$\frac{\text{Load at failure (P) in N}}{2 \times \text{cross-sectional area of the bar in mm}^2}$$

**Observation:**

1. Material of the specimen =
2. Diameter of the specimen, d = mm
3. Cross sectional area in double shear, (A) =  $2 \times \pi d^2/4 \text{ mm}^2$
4. Shear Load taken by specimen at the time of failure (P) = ----- KN

**Result:**

The maximum shear strength of the given specimen = ----- N/mm<sup>2</sup>

**UNIVERSAL TESTING MACHINE**

## **STRAIN MEASUREMENT ON CANTILEVER BEAM**

**Ex. No.:**

**Date:**

### **Aim:**

To determine the Strain of the cantilever beam subjected to Point load at the free end and to plot the characteristic curves.

### **Apparatus required**

Cantilever Beam Straingauge Trainer Kit  
Weights and Multimeter

### **Formula used**

$$\text{Strain, } S = 6PL / BT^2E$$

Where,

P=Load applied in Kg.

L = Effective length of the beam in cm.

B = Width of the beam in cm.

T = thickness of the beam in cm.

E = young's modulus =  $2 \times 10^9 \text{ Kg/cm}^2$ .

S = Micro strain.

### **Theory:**

When the material is subjected to any external load, there will be small change in the Mechanical properties like thickness of the material or change in the length depending upon the nature of load applied to the material. The change in mechanical properties will remain till the load is released. The change in the property is called Strain (or) material gets strained.

$$\text{Strain } S = \partial L / L$$

Since the change in length is very small, it is difficult to measure  $\partial L$ , so the strain is measured in micro strain. Since it is difficult to measure the length, Resistance strain gauge are used to measure strain in the material directly. Strain gauges are bonded directly on the material using special adhesive s. As the material get strained due to load applied the resistance of the strain gauge changes proportional to the load applied. This change in resistance is used to convert mechanical property into electrical signal which can be easily measured and stored for analysis.

The change in the resistance of the strain gauge depends on the sensitivity of the strain gauge which is expressed in terms of a gauge factor,  $S_g$

$$S_g = \Delta R / R$$

The output  $\Delta R/R$  of a strain gauge is usually converted into voltage signal with a Wheatstone bridge. If a single gauge is used in one arm of Wheatstone bridge and equal but fixed resistors is used in the other arm, the output voltage is  $E_o = E_i / 4(\Delta R_g / R_g)$

$$E_o = 1/4(E_i S_g \Delta)$$

The input voltage is controlled by the gauge size and the initial resistance of the gauge. As a result, the output voltage  $E_o$  usually ranges between 1 to  $10 \Delta V$  / micro units of strain.

**Procedure:**

1. The instrument is switched on ( i.e.,). The display glows to indicate the instrument is ON.
2. The Instrument is allowed to be in ON position for 10 minutes for initial warm-up.
3. From the selector switch, FULL or HALF bridge configuration is selected.
4. The potentiometer is adjusted for ZERO till the displays reads '000'
5. 1 Kg load is applied on the pan of the cantilever the CAL Potentiometer is adjusted till the display reads 377 micro strains. When the weights are removed the display should come to ZERO, in case of any variation, ZERO Potentiometer is adjusted again and the procedure is repeated again. Now the instrument is calibrated to read micro strains.
6. Then the loads are applied on the pan in steps of 100 gm up to 1kg. When the cantilever is strained, instrument displays exact micro strain.
7. The readings are noted down in the tabular column . Percentages error in readings, hysteresis and accuracy of the instrument can be calculated by comparing with the theoretical results.

**Observation:**

Sl.N o.	Weigh t (gms)	Actual readings (using formula) Micro strains	Display readings		Error %
			While loading micro strains	While unloading micro strains	
1	100				
2	200				
3	300				
4	400				
5	500				
6	600				
7	700				
8	800				
9	900				
10	1000				

$$\% \text{ ERROR} = \frac{(\text{Actual reading} - \text{Display reading}) \times 100}{\text{Max Weight (gms)}}$$

**Result:**

Thus the strain of the cantilever beam subjected to free end loading, is obtained in micro strains and the characteristics curves – Load Vs Strain, Output Voltage Vs Strain and Actual Vs Display readings are plotted.

## **TEMPERING- IMPROVEMENT MECHANICAL PROPERTIES COMPARISON**

**Ex. No.:**

**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-40 steel
3. Quenching medium: water
4. Rockwell test setup

**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 are heating 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)	Penetration	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 =

## **MECHANICAL PROPERTIES FOR UNHARDEDENED OR HARDEDENED SPECIMEN**

**Ex. No.:**

**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 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  $700^{\circ}$  to  $850^{\circ}$  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  $650^{\circ}$  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:****Rockwell hardness test:**

Cases for hardness =

Cross sectional area=

S.No	Material	temperature	Load (Kgf)	Indente r detail	scale	RHN			
						Trial 1	trail 2	Trail 3	Mean
1	Deep casehardened steel								
2	Deep casehardened steel								
3	Mild steel								
4	Mild steel								

**CHARPY TEST**

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

**Result:**

Thus the hardening – heat treatment process is carried out.

## **MICROSCOPIC EXAMINATION OF (i) HARDENED SAMPLES AND (ii) HARDENED AND TEMPERED SAMPLES.**

**Ex. No.:**

**Date:**

### **Aim:**

To prepare a specimen for microscopic examination.

### **Tools required:**

Linisher – polisher grades of emery sheets (rough and Fine), disc polisher, metallurgical microscopes.

### **Procedure**

The specimen preparation consists of following stages:

- i) Rough grinding
- ii) Intermediate Polishing
- iii) Fine Polishing
- iv) Etching

#### (i) Rough grinding:

It is first necessary for specimen to obtain a reasonable flat surface. This is achieved by using a motor driven energy belt called Linisher-Polisher. The specimen should be kept over the moving belt which will abrade the specimen and make the surface flat. In all grinding and polishing operations, the specimen should be moved perpendicular the existing scratches, so that the deeper scratches will be replaced to a shallower one. This operation is done until the specimen is smooth, free from rust, burs, troughs and deep scratches.

#### (ii) Intermediate Polishing:

It is carried out using energy paper of progressively fine grades. The emery paper should be of good quality. The different grades of emery paper used are 120,240,320,400 and 1/0,2/0,3/0,4/0 (Grain size from coarse to fine). The emery paper should be kept against the specimen and moved gently until a fine matrix of uniformly spaced scratches appears on the object. Final grade is then chosen and the specimen is turned perpendicular to the previous direction. This operation is usually done dry.

#### (iii) Fine Polishing:

An approximate flat scratch free surface is obtained by the use of wet rotary wheel covered with abrasive of alumina powder of 0.05 microns. In this operation, water is used as lubricant and carrier of the abrasive fine scratches and very thin layer produced due to previous operations.

(iv) Etching:

The polished surface is washed with water and etching is done by rubbing the polished surface gently with cotton wetted with etching reagent. After etching the specimen is again washed and then dried, it is then placed under the metallurgical microscope to view the microstructure of it. Thus the specimen is identified.

**Result:**

Thus the specimen was prepared for microscope observation for its identification.

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