SANT LONGOWAL INSTITUTE OF ENGINEERING & TECHNOLOGY

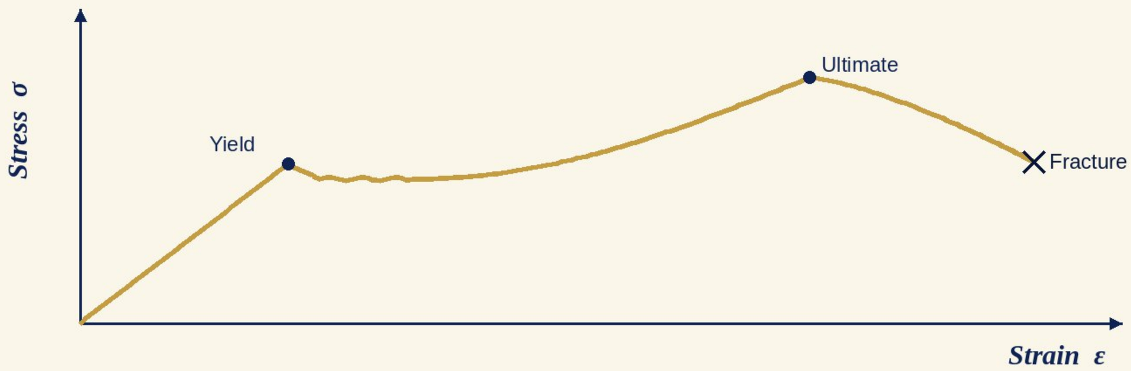
Longowal — 148106, Punjab, India
(Deemed-to-be-University, established by an Act of Parliament, under MoE, Govt. of India)

LABORATORY MANUAL

Strength of Materials

Subject Code: PCME-525

Degree Programme — Mechanical Engineering



Department of Mechanical Engineering

Strength of Materials Laboratory

Academic Session 2025 – 2026

संस्थान कुलगीत

जयति जयति विधा-संस्थान !

रावी-व्यास कल-कल अनुगुंजित

सृजन-मंत्र देता अविराम !!

'योग-कर्म-कौशल' नित मन में,

गुरु-वाणी अमृत कण-कण में,

ज्ञान-ज्योति जागृत जीवन में,

सन्त ह्रदय दर्पण अभिराम !

सृजन-मंत्र देता अविराम!! जयति जयति.........

गौरव संस्कृति, दर्शन उज्ज्वल,

प्रगति-सन्देश प्रचारित पल-पल,

यांत्रिकी-शिक्षा नवयुग संबल,

युवाशक्ति चिर गरिमा-गान!

सृजन-मंत्र देता अविराम!! जयति जयति.........

शिव-कामना चहूँ दिशि रंजित,

भ्रातृ-भावना नित अभिव्यंजित,

सर्व धर्म सम्भाव विधान !!

सृजन -मंत्र देता अविराम !!

उधोग-क्रान्ति आह्वान करें हम,

नवयुग, नव निर्माण करें हम,

भू को स्वर्ग समान करें हम ,

अमृतमय शारद-वरदान!

सृजन-मंत्र देता अविराम!! जयति जयति.........

डा. योगेंद्र नाथ शर्मा

PREFACE

This laboratory manual introduces students to various methods and techniques used in material testing and the concepts of strength of materials as per the subject code PCME-525. It aims to help students analyze material behavior, improve testing processes, and enhance productivity. The knowledge and practical skills gained from this manual will enable students to master essential laboratory techniques, making them more competitive in the job market.

A brief overview of the constructional features of different strength of materials laboratory systems is also provided. This manual is specifically designed to meet the laboratory exercise requirements of degree-level students who have this subject in their course curriculum. To facilitate a better understanding, a sufficient number of schematic diagrams and sketches have been compiled from Strength of Materials laboratory books and online sources.

Although the experiments and activities in this laboratory manual have been thoroughly tested, students must strictly follow the specified procedures and adhere to safety norms while performing experiments. The key learning outcomes of this manual include:

- Analyzing stress-strain relationships and material deformation under different loading conditions.
- Understanding the fundamental concepts of elasticity, plasticity, failure mechanisms, and material strength.
- Developing skills in conducting experiments, collecting data, and interpreting results.
- Familiarizing students with standard testing equipment and procedures commonly used in the industry.

We gratefully acknowledge the motivation, support, and facilities provided by Prof. Shankar Singh, Head of the Mechanical Engineering Department, in bringing this manual to its present form.

Dr. Rakesh Kumar

Lab-Incharge

(Strength of materials lab.)

FOREWORD

The Laboratory Manual for the Strength of Materials Lab is intended to serve the needs of degree-level students in the Mechanical Engineering Department as well as the Institute. This manual is expected to facilitate the smooth conduct of practical classes. The **Strength of Materials Laboratory** plays a crucial role in understanding the **fundamental mechanical properties** of materials, helping students apply theoretical concepts to real-world engineering applications. The laboratory is designed to provide **hands-on experience** in testing the mechanical behavior of different materials under various loading conditions, ensuring a comprehensive learning experience. The Strength of Materials Lab bridges the gap between **theory and practice**, allowing students to **observe material behavior firsthand**. By performing these experiments, students develop a deep understanding of **material properties, structural stability, and mechanical performance**. The practical knowledge gained in this lab is essential for careers in **mechanical, civil, and structural engineering**, as well as **material science and manufacturing industries**.

This manual serves as a **comprehensive guide** for students, ensuring they are well-prepared to conduct experiments efficiently while adhering to **safety guidelines and standardized procedures**. The hands-on experience provided in this lab enhances problem-solving skills, critical thinking, and technical expertise, making students better equipped for the **real-world challenges of engineering**.

I would like to express my sincere appreciation to the highly motivated laboratory team, including the Lab In-charge and Technician, for their efforts in compiling and presenting this manual for the benefit of the students

HOD

Mechanical Engineering Department

GENERAL INSTRUCTION

1. All students must wear a protective uniform, shoes, and an identity card before entering the laboratory.

2. Before starting an experiment, students should clearly understand the principle behind it.

3. Students must bring a completed record and a corrected observation book of the previous experiment.

4. Do not operate any instrument or machine without prior permission from a staff member.

5. All instruments are costly; handle them with care to avoid damage and potential fines.

6. Take utmost care to prevent any injuries while working in the laboratory. In case of an accident, immediately report it to the staff members.

7. One student from each batch must sign the instrument issue register while receiving the instrument.

****

List of Experiments

Strength of Materials lab: PCME-525

L	T	P	Credits	Weekly Load
0	0	2	1	2

Course Outcomes:

After successful completion of course, the students should be able to

CO1: Apply the basic concepts and principles of strength of materials.

CO2: Calculate stresses and deformations of the objects under different loadings.

CO3: Analyse and design structural members subjected to tension, compression, torsion, bending and combined stresses using the fundamental concepts of stress, strain and elastic behaviour of materials.

CO4: Utilize appropriate materials in design considering engineering properties, sustainability, cost and weight.

CO5: Perform engineering work in accordance with ethical and economic constraints related to the design of structures and machine parts.

Pre-requisite knowledge:

CO/PO Mapping: (Strong(S) / Medium(M) / Weak(W) indicates strength of correlation)												
COs	**Program Outcomes (POs)**											
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	S	S	M	S	M	M	M	S	S	M	M	S
CO2	S	S	S	M	M	W	M	M	S	M	M	S
CO3	S	S	M	S	M	W	M	M	M	M	M	S
CO4	S	S	S	S	M	M	M	M	M	M	M	S
CO5	S	S	S	S	M	M	M	S	M	M	M	S

LIST OF PRACTICAL (PCME-525)

1. Tension test.
2. Bending tests on simply supported beam / Cantilever beam.
3. Torsion test.
4. Hardness tests (Brinell and Rockwell).
5. Tests on close coiled and open coiled helical springs.
6. Compression test on wood or concrete.
7. Impact test.
8. Shear test.
9. Fatigue Test.

AIM: - STUDY AND DEMONSTRATION OF UNIVERSAL TESTING MACHINE AND ITS ATTACHMENTS.

OBJECTIVE: - To Study the various component parts of the Universal Testing Machine (U.T.M.) & test procedures of various practical have to be performed.

APPARATUS: - Universal Testing Machine with all attachment i.e. shear test attachment, bending attachment, tension grips, compression test attachment etc.

THEORY: - The Universal Testing Machine consists of two units.

1) **Loading unit,**
2) **Control panel,**

LOADING UNIT: - The loading unit consists of a main hydraulic cylinder with a robust base. The piston moves up and down, driven by a chain connected to an electric motor, which is mounted on the left-hand side. The screw column, fixed in the base, can be rotated using the chain arrangement.

Each column passes through the main nut, which is secured to the lower crosshead. The lower table is connected to the main piston through a ball and ball seat to ensure axial loading. A connection exists between the lower table and the upper head assembly, allowing them to move up and down with the main piston.

The movement of this assembly is guided by bearings that slide over the columns. The test specimen is held in a fixture known as a Jack Job. To secure the specimen tightly, the Jack Job moves helically using a handle.

CONTROL PANEL: - The control panel consists of an oil tank equipped with a hydraulic oil level sight glass for monitoring the oil level. The pump is a displacement-type piston pump with free plungers, ensuring continuous high-pressure operation. The pump is mounted at the bottom of the oil tank, with suction and delivery valves installed near the tank.

The electric motor, which drives the pump, is mounted on four studs on the right side of the tank. A mechanism is provided to tighten or loosen the valve as needed. The control panel contains four valves that regulate the oil flow in the hydraulic system. The loading system functions as follows:

When the return valve is closed, the oil is delivered from the pump through the flow control valves into the cylinder, causing the piston to move upward.

As the pressure builds up, the specimen either breaks or reaches the maximum load capacity.

The base dynamometers control the maximum load value, consisting of a cylinder with a reciprocating piston.

The control panel is equipped with upper and lower push buttons, enabling upward and downward movement of the movable head.

The ON/OFF switch and a pilot lamp indicate the main power supply status.

METHOD OF TESTING: - Initial Adjustments:

Before starting the test, adjust the pendulum according to the test capacity, such as 8 tons, 10 tons, 20 tons, or 40 tons.

For example, if testing a 6-ton capacity specimen, using the 10-ton range on the dial will yield more accurate results compared to using the 20-ton range. The capacity range is selected using the range selector knob.

The control weights of the pendulum must be adjusted correctly.

Insert ink into the pen holder for recording test results on the drum chart.

The testing process begins based on the type of test to be performed

TENSION TEST: - Select the appropriate fixture (job) and ensure the upper and lower check adjustments are complete.

- Apply grease to the tapered surface of the specimen or groove to reduce friction.
- Grip the upper end of the test specimen securely by operating the upper crosshead grip handle.
- Keep the lower left valve fully closed.
- Open the right valve and then close it once the lower table slightly lifts.
- Adjust the lower pointer to zero using the adjusting knob to compensate for the dead weight of the lower table.
- Lock the specimen in position using the job working handle.
- Open the left control valve to begin loading.
- The dial gauge pointer will indicate the breaking load, at which the specimen fractures.
- The maximum load recorded on the dial gauge is the ultimate load.

COMPRESSION TEST:

- Fix the upper and lower pressure plates to the upper stationary head and the lower table, respectively.
- Place the specimen on the lower plate to ensure a secure grip.
- Adjust the zero position by lifting the lower table.
- Perform the test in the same manner as described in the Tension Test.

FLEXURAL OR BENDING TEST:

- Position the bending table on the lower table, ensuring that its central position aligns with the central location value of the lower table.
- Adjust the bending supports to the required distance.
- Use the stoppers at the back of the bending table to secure it in different positions.
- Place the specimen on the bending table and apply the load using the bending attachment at the upper stationary head.

Perform the test following the same procedure as in the Tension Test.

BRINELL HARDNESS TEST: - Place the specimen on the lower table and lift it slightly.

- Adjust the zero position on the bottom side of the lower crosshead.
- Slowly increase the load until the ultimate load value is obtained.
- Gradually release the load using the left control valve.
- Measure the indentation (impression) on the specimen, ensuring that its diameter falls between 5 mm and 10 mm.
- Use a microscope to accurately measure the diameter of the impression and calculate the Brinell Hardness Number (BHN).

SHEAR TEST: - Place the shear test attachment on the lower table. The attachment consists of a cutter for shearing the specimen.

- Insert the specimen into the slots of the shear test attachment.
- Lift the lower table to adjust the zero position.
- Apply the load until the specimen shears into two or three pieces:
- If the specimen breaks into two pieces, it is classified as single shear.
- If the specimen breaks into three pieces, it is classified as double shear

STUDY OF EXTENSOMETER: - The extensometer is an attachment used in universal/tensile testing machines to measure the elongation of a test specimen under load for a set gauge length.

- Measurement range: 0.01 mm (least count) to a maximum elongation of 5 mm.
- This measurement helps in determining the proof stress at the required percentage elongation

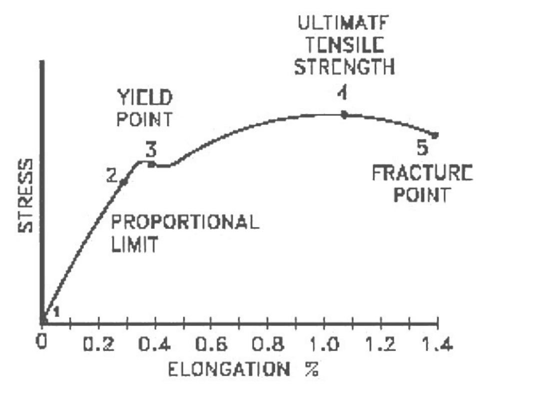
WORKING OF THE INSTRUMENT: - Set the required gauge length (between 30 mm and 200 mm) by

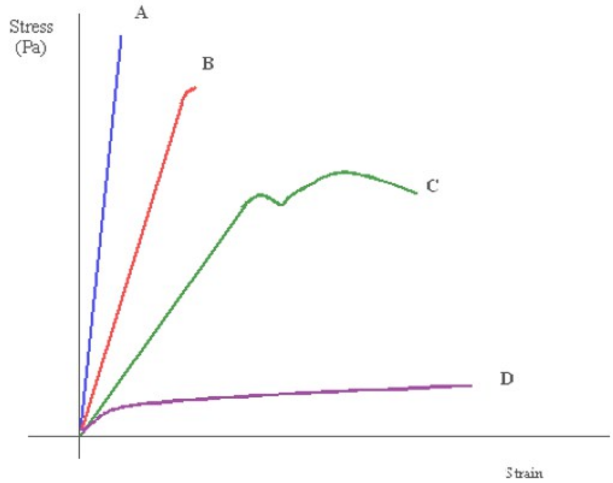
- adjusting the upper knife edges. A scale is provided for precise adjustments.
- Secure the specimen in the upper and lower jaws of the Tensile/Universal Testing Machine.
- Position the extensometer on the specimen.
- Adjust the upper clamp to press the upper knife edges onto the specimen.
- The extensometer is now fixed to the specimen using spring pressure.
- Set the zero position on both dial gauges using the zero adjust screws.
- Start loading the specimen and take readings of:
- Load on the machine at a required elongation.
- Elongation at a required load.
- Calculate the mean value of both dial gauge readings for accurate elongation measurement

TECHNICAL DATA: -

Measuring Range: 0 – 3 mm Least Count: 0. 01 mm Gauge Length adjustable from: 30 - 120 mm Specimen Size: 1 to 20 mm Round or Flats up to 20 x 20 mm

A) Stress-strain graph for Mild Steel





B) Stress-strain graph for Different materials

Curve A: Brittle Materia

- This curve represents a brittle material, which is also strong because it undergoes little strain for a high stress.
- The fracture of a brittle material occurs suddenly and catastrophically, with minimal or no plastic deformation.
- Brittle materials fail under tension, as stress concentrations form around cracks, leading to crack propagation.
- Under compressive loading, cracks propagate less, making brittle materials stronger in compression than in tension.

Curve B: Strong but Not Ductile Material

- This curve represents a strong material with low ductility, such as steel wires.
- Steel wires stretch very little before breaking, leading to sudden failure.
- Under tensile stress, a steel wire stores a significant amount of elastic strain energy.
- If the wire snaps, the stored energy is suddenly released, causing a dangerous "whiplash" effect.

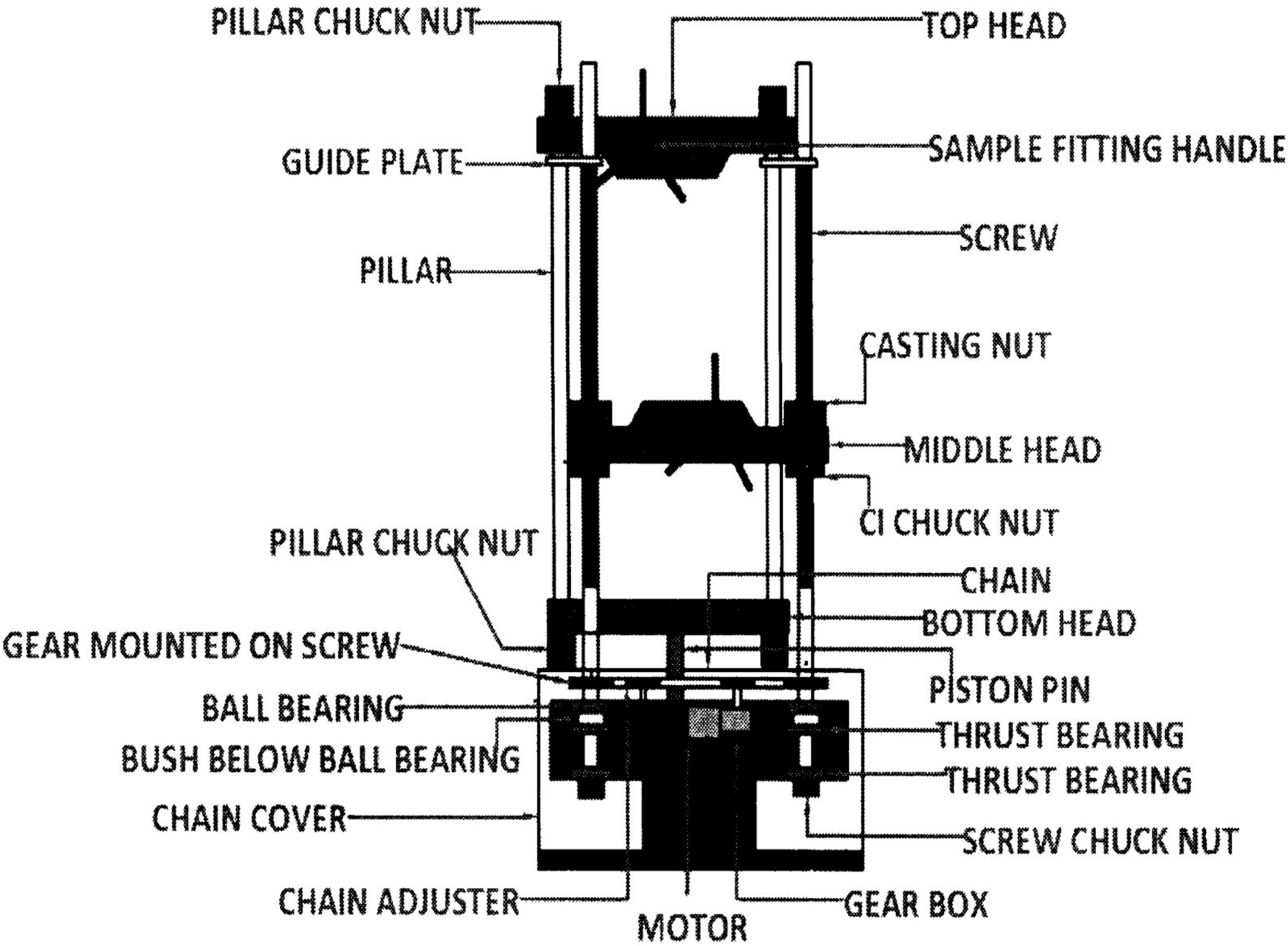
Curve C: Ductile Material

- This curve represents a ductile material, which undergoes significant plastic deformation before failure.
- Ductile materials exhibit both elastic and plastic behavior, allowing them to withstand high strain before breaking.
- Such materials are preferred for structural applications because they provide visible warning signs before failure.

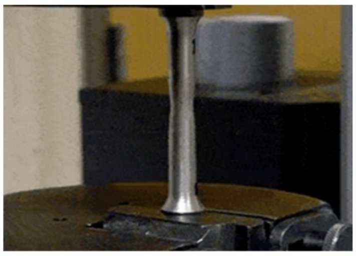
Curve D: Plastic Material

- This curve represents a plastic material, characterized by large strain for a small applied stress.
- Once deformed, the material does not return to its original shape after the load is removed.
- This behavior is typical of polymers and soft metals, which show permanent deformation even under relatively low stress

DIAGRAM OF MACHINE

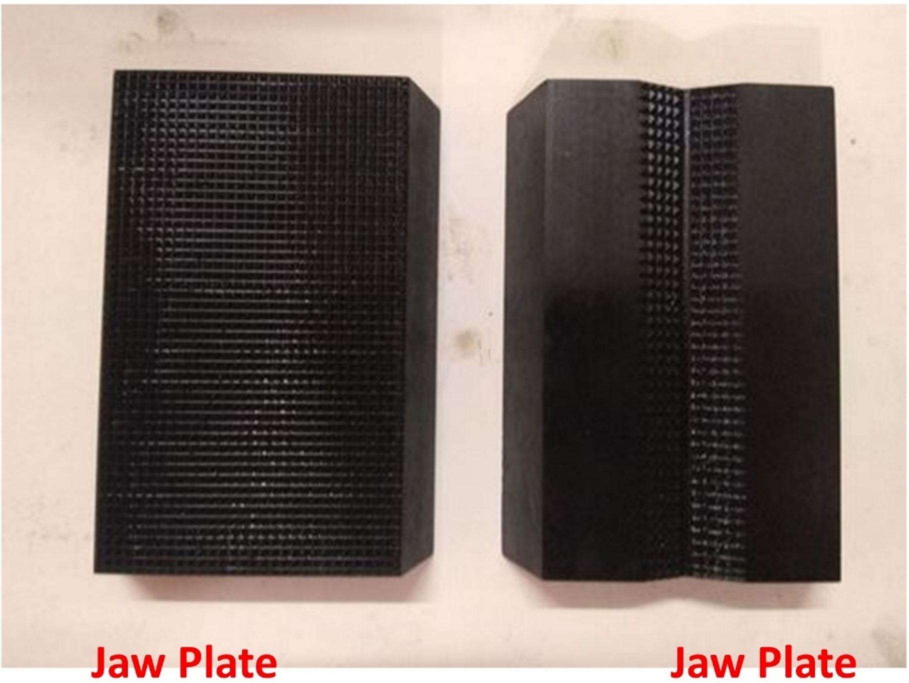


BRINELL HARDNESS TEST ATTACHMENT



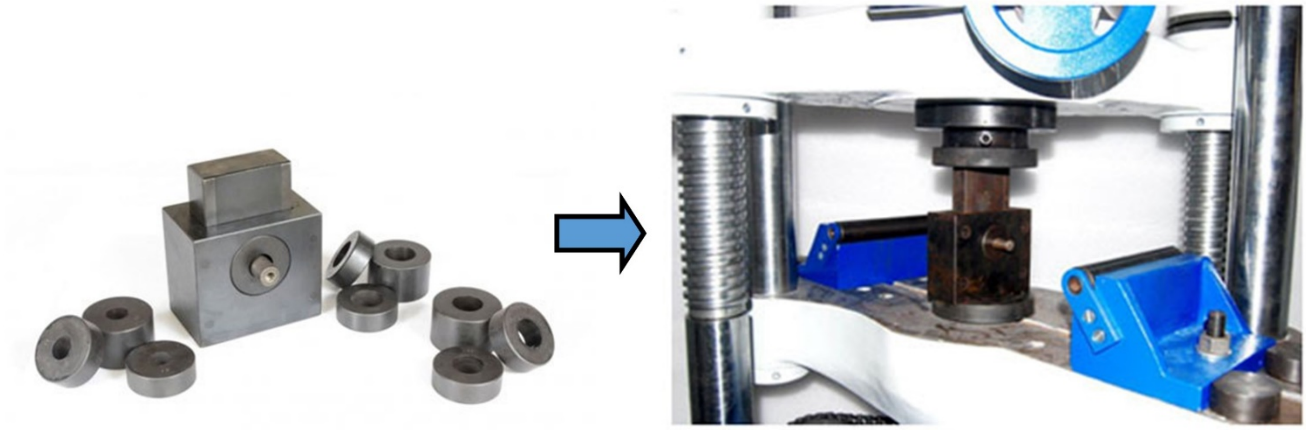
TENSION TEST

JAW HOLDER ARRANGEMENT

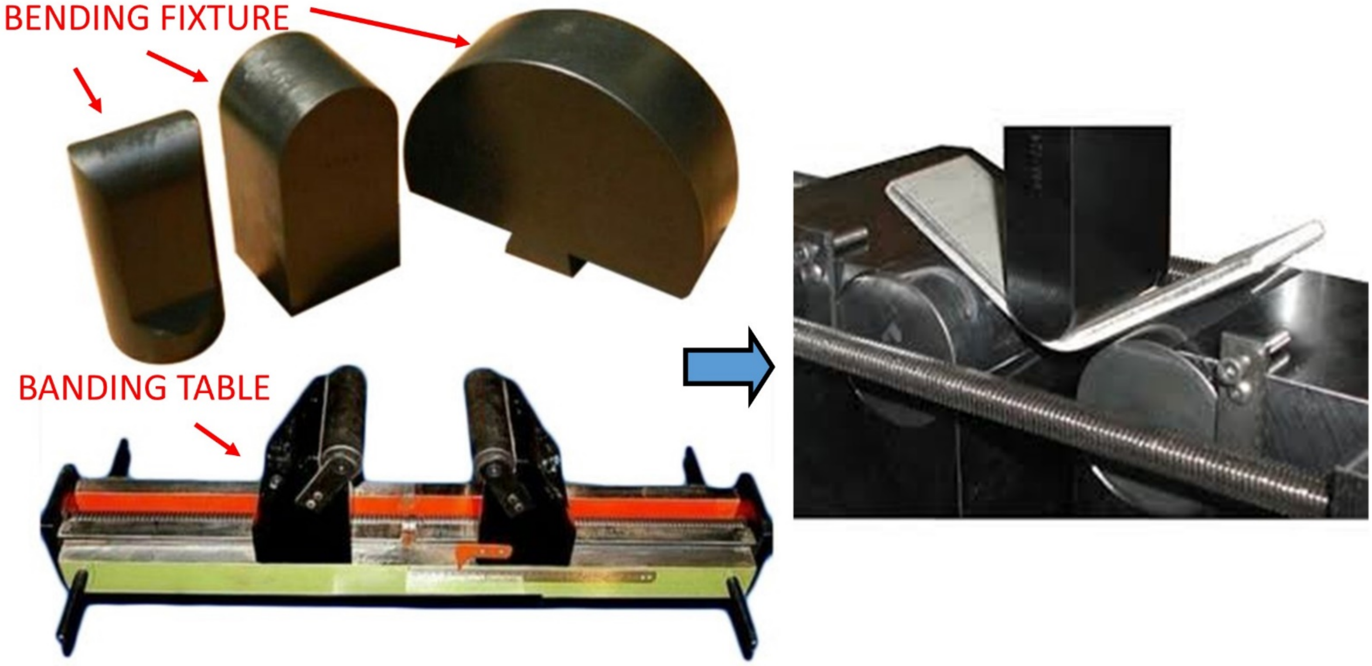


Jaw Plate (for plane sample)

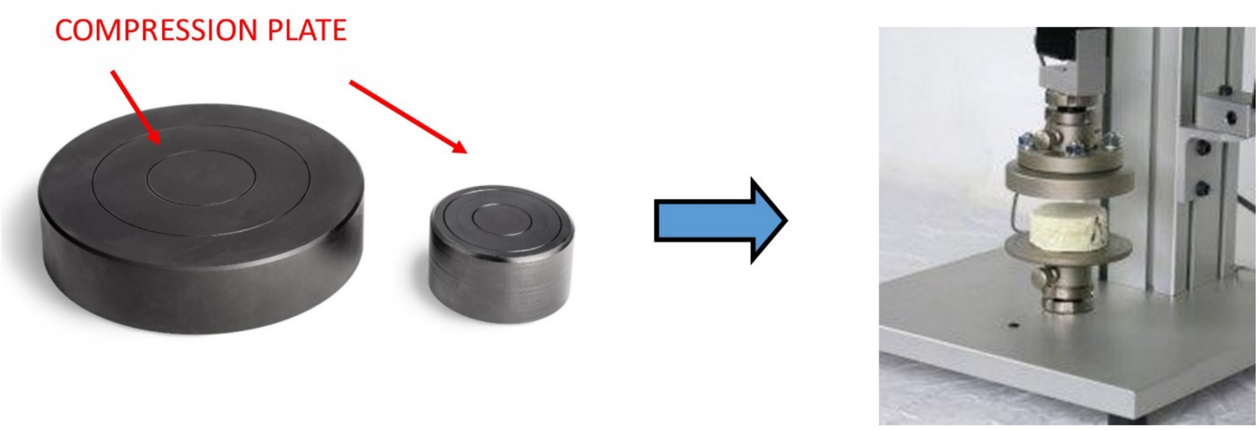
Jaw Plate (For Round Sample)



SHEAR TEST ATTACHMENT



FLEXURAL OR BENDING TEST ATTACHMENT



COMPRESSION TEST ATTACHMENT

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3. ASTM E8/E8M-22. Standard Test Methods for Tension Testing of Metallic Materials. ASTM International, West Conshohocken, PA.
4. IS 1608 (Part 1): 2018. Metallic Materials - Tensile Testing - Method of Test at Room Temperature. Bureau of Indian Standards, New Delhi.
5. Beer, F. P., Johnston, E. R., DeWolf, J. T., & Mazurek, D. F. (2020). Mechanics of Materials, 8th ed. McGraw-Hill Education.

AIM: TO CONDUCT A TENSILE TEST ON A GIVEN SPECIMEN

OBJECTIVE: To conduct a tensile test on a mild steel specimen and determine the following:

1. Limit of proportionality
2. Elastic limit
3. Yield strength
4. Ultimate strength
5. Young's modulus of elasticity
6. Percentage elongation
7. Percentage reduction in area.

APPARATUS:

1. Universal Testing Machine (UTM)
2. Mild steel specimens
3. Graph paper
4. Scale
5. Vernier Caliper

M/C SPECIFICATIONS:

Hydro-Mech. U.T.M
Capacity: 600 KN.
Model: UT-60(Enkay).
Mfd. By: M/S, Enkay Enterprises B-143/1 , Maya Puri Industrial Area Phase -1 ,New Delhi-110064

&

Computerized Universal Testing Machine
Capacity: 600 KN.
Model: - AEC 1112-60T , Sr.No.. - 2K19J26
Mfd. By: M/s Ashian engineers Company India, Ashian, 831, Westend Mall , District Center, Janakpuri, New Delhi- 110058

THEORY: -

- The tensile test is one of the most commonly applied mechanical tests. In this test, the ends of the test specimen are securely fixed into grips, which are connected to both a straining device and a load-measuring device.
- If the applied load is small, the deformation of the material remains entirely elastic. In this case, the solid returns to its original shape immediately after the load is removed. However, if the applied load exceeds a certain limit, the material undergoes permanent deformation.
- The initial portion of the stress-strain curve, where deformation is fully recoverable after unloading, is termed the elastic region. The remaining portion of the curve, where the material undergoes permanent deformation, is known as the plastic region.
- The stress level below which deformation remains entirely elastic is called the yield strength of the material. In some materials, the onset of plastic deformation is marked by a sudden drop in load, indicating the presence of both an upper and a lower yield point. However, other materials do not exhibit a sharp yield point and transition smoothly into plastic deformation.

- During plastic deformation, as the specimen undergoes further elongation, strain hardening occurs. However, at larger extensions, strain hardening cannot fully compensate for the decrease in cross-sectional area. As a result, the load reaches a maximum value before starting to decrease.

- At this stage, the material reaches its ultimate strength, which is defined as:
- Ultimate Strength = Maximum Load/Original Cross-Sectional Area
- Further loading eventually leads to the formation of a "neck", where a localized reduction in cross-sectional area occurs, followed by fracture or rupture of the specimen

PROCEDURE: -

2. The gauge length (the marked section on the specimen using a preset punch), or
3. The total length of the specimen.
4. Secure the specimen in the grips of the testing machine and attach the strain-measuring device properly.
5. Begin applying the load and record the load versus elongation data at regular intervals.
6. Increase the frequency of readings as the yield point is approached to capture accurate deformation data.
7. Measure elongation values using a divider and a ruler for precise results.
8. Continue the test until fracture occurs.
9. After fracture, carefully join the two broken halves of the specimen together and measure the final length and diameter to determine permanent deformation

OBSERVATION: -

A) Material: -

i) Original dimensions

Length = ------------

Diameter = ---------

Area = ------

ii) Final Dimensions:

Length = ------------

Diameter = ---------

Area = -------

OBSERVATION TABLE: -

To plot the stress - strain curve determine the following

Sr. No	Load (N)	Original Gauge length	Extension (mm)	Stress =Load/Area (N/mm^2)	Strain = Increase in length / Original length
1.					
2.					
3.					
4.					
5.					

1. Elastic limit $= \frac{Load\ at\ proportinality}{Original\ Cross\ Section\ Area}$ N/mm^2
2. Yield strength $= \frac{Yield\ Load}{Original\ Cross\ Section\ Area}$ N/mm^2
3. Ultimate strength $= \frac{Maximum\ Tensile\ Load}{Original\ Cross\ Section\ Area}$ N/mm^2
4. Young's modulus of elasticity $= \frac{Stress\ at\ proportional\ limit}{Corresonding\ Strain}$ N/mm^2
5. Percentage elongation $= \frac{Final\ Length\ at\ fracture - Original\ Length}{Original\ Length}$ %
6. Percentage reduction in area $= \frac{Original\ Area - Area\ at\ fracture}{Original\ Area}$ %

RESULT: -

a) Average Breaking Stress =
b) Ultimate Stress =
c) Average % Elongation =

PRECAUTIONS: -

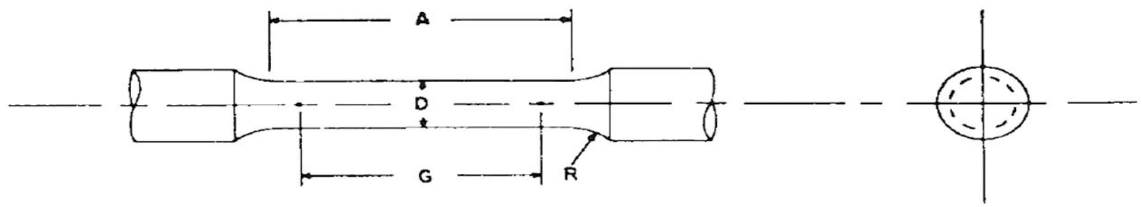
Precautions for Conducting a Tensile Test on a Given Specimen-

1. Ensure the specimen is free from defects, rust, or surface irregularities before testing.
2. Measure the original dimensions of the specimen (length, diameter, and gauge length) accurately using a vernier caliper or micrometer.
3. Secure the specimen properly in the grips of the Universal Testing Machine (UTM) to prevent slippage during the test.
4. Align the specimen correctly along the axis of loading to ensure uniform force distribution and avoid bending stresses.
5. Check and calibrate the testing machine before performing the test to ensure accurate results.
6. Apply the load gradually and uniformly to avoid sudden shocks that may cause premature failure.
7. Monitor the load and elongation readings carefully throughout the test for precise data collection.
8. Do not exceed the elastic limit of the specimen unless required to study plastic deformation and fracture.
9. Take readings at regular intervals, especially near the yield point for better accuracy.
10. Follow all safety precautions while operating the machine, including wearing protective gear (gloves, safety goggles, etc.).
11. Ensure that all observers maintain a safe distance from the machine to avoid injury in case of specimen failure.

VIVA QUESTION-

1. What is a tensile test, and why is it performed?
2. What properties of a material can be determined from a tensile test?
3. What is the difference between yield strength and ultimate tensile strength?
4. What is the significance of the gauge length in a tensile test?
5. Why is it important to measure the initial dimensions of the specimen before testing?
6. What type of stress is induced in the specimen during a tensile test?
7. What is the purpose of using an extensometer in a tensile test?
8. How is the elastic limit of a material determined in a tensile test?
9. What is strain hardening, and how is it observed in a tensile test?
10. What is the significance of the stress-strain curve in a tensile test?

E 8M – 04



Dimensions, mm					
	Standard Specimen	Small-Size Specimens Proportional To Standard			
	12.5	9	6	4	2.5
G—Gage length	62.5 ± 0.1	45.0± 0.1	30.0 ± 0.1	20.0± 0.1	12.5 ± 0.1
D—Diameter (Note 1)	12.5 ± 0.2	9.0 ± 0.1	6.0 ± 0.1	4.0 ± 0.1	2.5 ± 0.1
R—Radius of fillet, min	10	8	6	4	2
A—Length of reduced section, min (Note 2)	75	54	36	24	20

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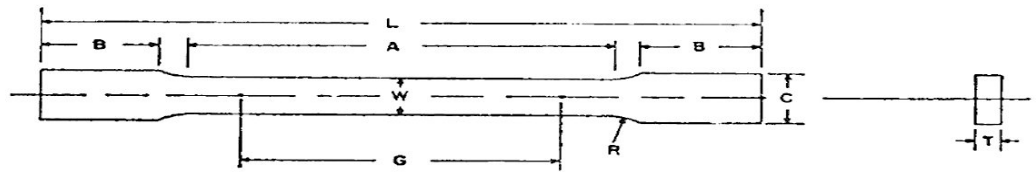
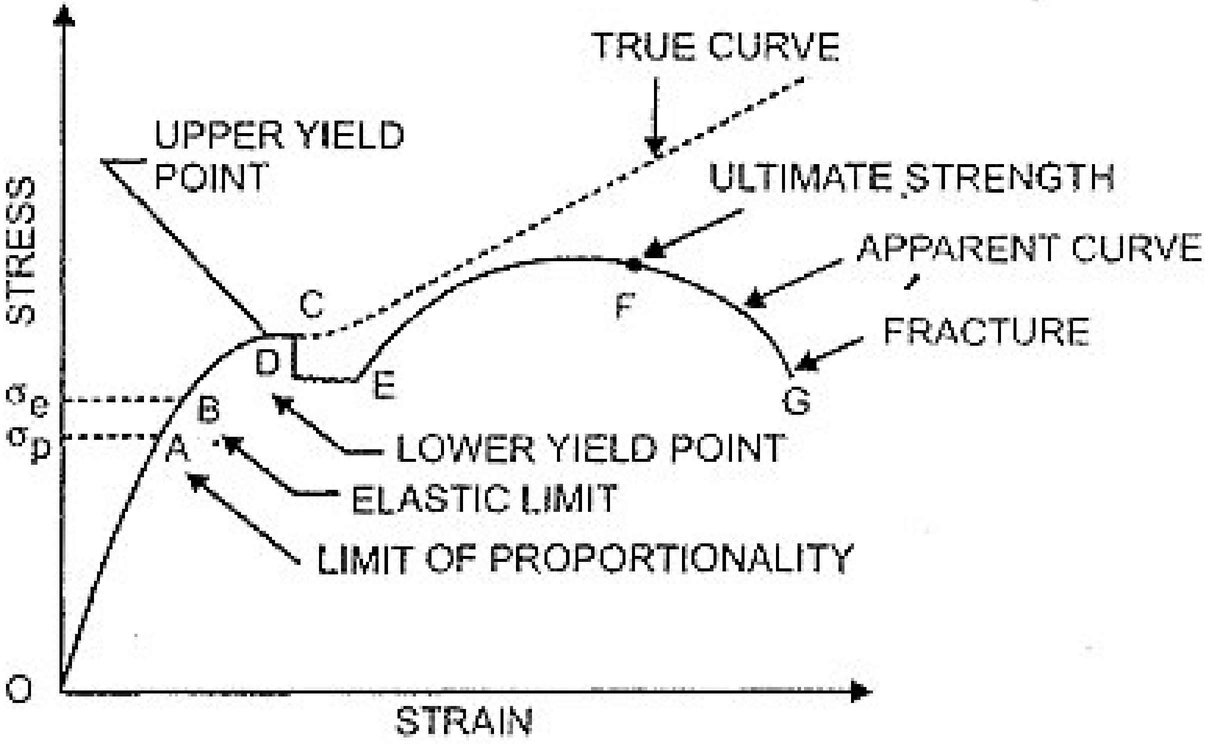
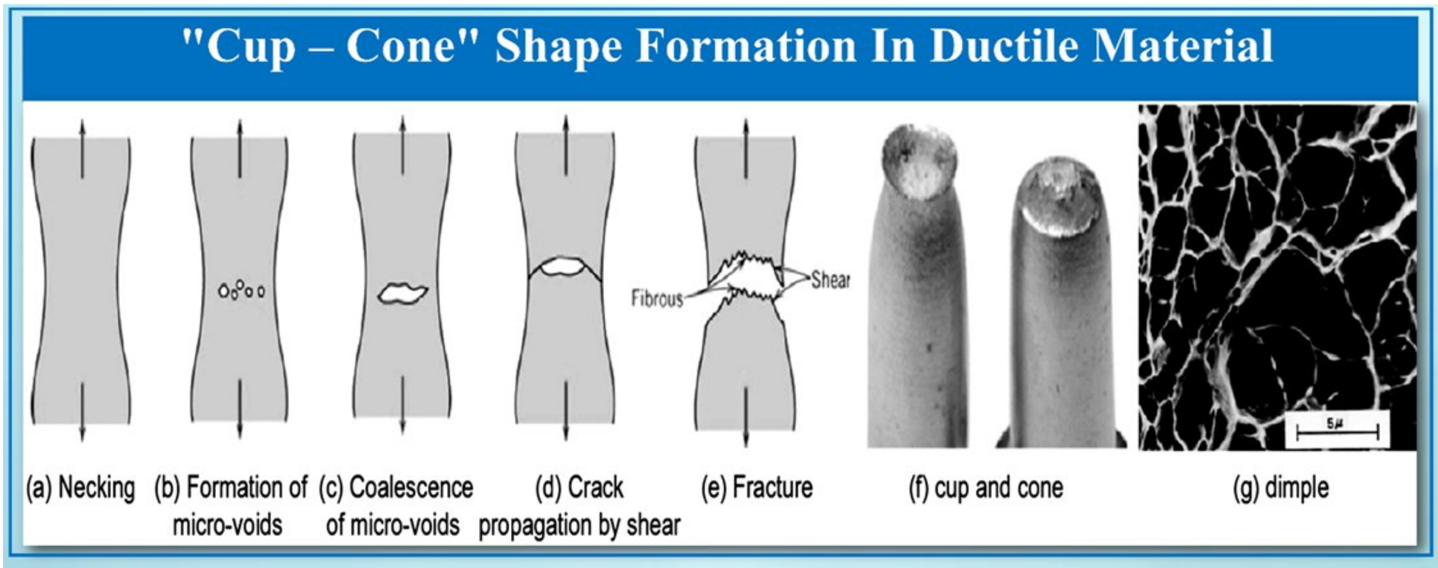


Dimensions, mm			
Nominal Width	Standard Specimens		Subsize Specimen
	Plate-Type 40 mm	Sheet-Type 12.5 mm	6 mm
G— Gage length (Note 1 and Note 2)	200.0 ± 0.2	50.0 ± 0.1	25.0 ± 0.1
W— Width (Note 3 and Note 4)	40.0 ± 2.0	12.5 ± 0.2	6.0 ± 0.1
T— Thickness (Note 5)		thickness of material	
R— Radius of fillet, min (Note 6)	25	12.5	6
L— Overall length, (Note 2, Note 7 and Note 8)	450	200	100
A— Length of reduced section, min	225	57	32
B— Length of grip section, (Note 8)	75	50	30
C— Width of grip section, approximate (Note 4 and Note 9)	50	20	10

1. After the test, measure the final dimensions of the broken specimen (elongated length and neck diameter) for further analysis. Measure deflection on scale accurately & carefully



Stress-strain diagram for mild steel.



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4. IS 1608 (Part 1): 2018. Metallic Materials - Tensile Testing - Method of Test at Room Temperature. Bureau of Indian Standards, New Delhi.
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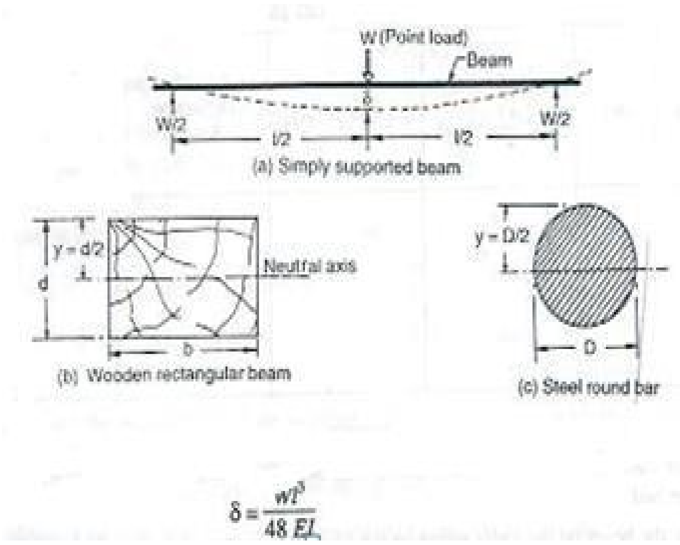
AIM: DETERMINE THE DEFLECTION AND BENDING STRESS OF A SIMPLY SUPPORTED BEAM SUBJECTED TO CONCENTRATED LOAD AT THE CENTER.

APPARATUS:

Required Equipment:

- Beam Apparatus – Used to support the test specimen and apply bending loads.
- Bending Fixture – Holds the beam in place and applies a controlled bending force.
- Vernier Caliper – Measures precise dimensions of the test piece, such as width and thickness.
- Meter Rod – Used for measuring beam length and displacement.
- Test Piece (Specimen) – The material sample being tested under bending loads.
- Dial Gauge – Measures small deflections and deformations in the beam with high accuracy..

DIAGRAM:



THEORY:

Three-Point Bending Test Procedure

The bending test is performed on a beam using a three-point loading system. The bending fixture is supported on the platform of the hydraulic cylinder in the Universal Testing Machine (UTM).The applied load is transmitted through the middle crosshead of the machine. At a specific load, the deflection at the center of the beam is measured using a dial gauge

The deflection at the beam center is given by the formula: $\delta = \frac{WL^3}{48EI}$,

where:

δ = Deflection at the center of the beam
P = Applied load
L = Length of the beam between supports
E = Modulus of elasticity of the material
I = Moment of inertia of the beam cross-section

Procedure: Bending Test

- Measure the length, width, and thickness of the test piece using a vernier caliper.
- Place the bending fixture on the lower crosshead of the testing machine.
- Position the test piece on the rollers of the bending fixture.
- Mount the dial gauge on a stand, ensuring that its spindle contacts the test piece.
- Start the testing machine and record the load and corresponding dial gauge readings at regular intervals.
- Plot a graph between load (force applied) and deflection (displacement of the test piece).

Observations Section:

1. Least count of the vernier caliper = _______
2. Length of the beam (L) = _______ mm
3. Width of the beam (b) = _______ mm
4. Thickness of the beam (t) = _______ mm

TABLE:

S.No	Load 'W' in N	Deflection 'δ' in mm.	Young's Modulus 'E' N/mm^2
1.			
2.			
3.			
4.			
5.			

CALCULATIONS:

$$I = \frac{bt^3}{12}$$

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

Precautions:

1. Measure the length of the simply supported beam accurately.
2. Ensure that the spindle of the dial gauge is in proper contact with the beam at the bottom of the loading point.
3. Place the loading hanger at a known, pre-determined distance.
4. Eliminate all possible errors while taking readings.
5. Ensure that the beam is positioned perfectly horizontal before starting the test.

RESULT:

The Bending strength of given specimen ……... N/mm^2

1. What are the different types of beams?

2. What is deflection?
3. Write the equation for the slope of a cantilever beam with a point load.
4. Write the equation for the deflection of a simply supported beam with a point load at the center.
5. How many types of bending exist?
6. Define bending moment.
7. What is the difference between bending moment and shear force?
8. Explain the significance of the moment of inertia in beam bending.
9. What is the modulus of elasticity, and how does it affect beam deflection?
10. What are the different types of supports used in beams?
11. What is the difference between a cantilever beam and a simply supported beam?
12. State the assumptions made in the bending theory of beams.
13. What is meant by pure bending?
14. Differentiate between elastic and plastic bending.
15. Explain the term 'neutral axis' in beam bending.
16. What is the section modulus, and why is it important in beam design?
17. What are the different methods used to determine beam deflection?
18. What is the significance of the slope in beam analysis?
19. How does the load position affect the deflection of a beam?
20. Explain the concept of shear stress distribution in beams.
21. What is the difference between symmetric and unsymmetric bending?
22. What happens when a beam is subjected to an eccentric load?
23. What are the different failure modes in beam bending?
24. Why do we use moment-area methods for beam deflection calculations?
25. How does the cross-sectional shape of a beam affect its bending strength?

APPLICATIONS:

1. for construction of bridges

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4. ASTM E290-22. Standard Test Methods for Bend Testing of Material for Ductility. ASTM International.
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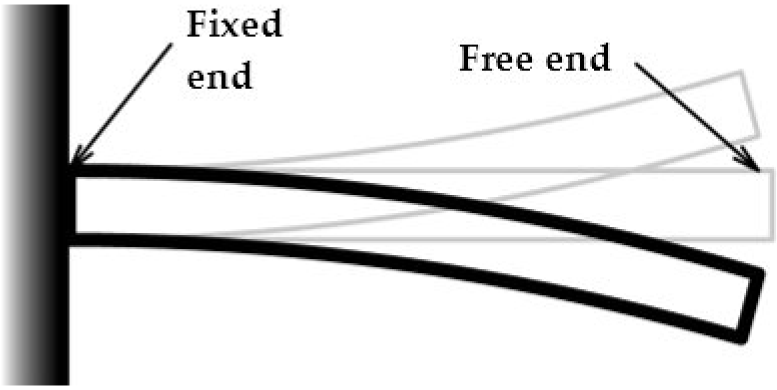
AIM: DETERMINE THE DEFLECTION AND BENDING STRESS OF CANTILEVER BEAM.

APPARATUS:

1. **Beam Apparatus** – Used to support the cantilever beam and measure deflection.
2. **Bending Fixture** – Holds the beam securely and applies the bending force.
3. **Vernier Caliper** – Measures precise dimensions of the test piece, such as width and thickness.
4. **Meter Rod** – Used for measuring beam length and deflection.
5. **Test Piece (Specimen)** – The beam specimen subjected to loading.
6. **Dial Gauge** – Measures the deflection of the beam with high accuracy

.

DIAGRAM:



THEORY:

A cantilever beam is a beam that is fixed at one end and free at the other. It is subjected to bending loads, which cause deflection and bending stress.
Consider a cantilever beam of length L that is fixed at one end while the other end remains free. The moment of inertia of the beam about its neutral axis is denoted as
I, and the Young's modulus of the beam material is E.
When a load is applied at the free end or along its length, the beam undergoes bending and deflection, which can be analyzed using bending theory and deflection equations
Moment of inertia about the neutral axis

$$I = \frac{bh^3}{12}$$

Deflection at the end where point load is acting = δ

The deflection at the end (Max deflection) δ is related to the load 'W', length 'L' moment of Inertia 'I' and Young's Modulus 'E' through the equation.

$$\delta = \frac{WL^3}{3EI}$$

PROCEDURE:

1. Clamp the Beam horizontally on the clamping support at one end.
2. Measure the length of cantilever L (distance from clamp end to loading point)
3. Fix the dial gauge under the beam at the loading point to Read down-ward Moment and set o zero.
4. Hang the loading Pan at the free end of the cantilever.

5. Load the cantilever with different loads (W) and note the dial gauge readings (δ)
6. Change the length of cantilever for two more different lengths repeat the Experiment.
7. Change the position of cantilever and repeat he experiment for the other value of I for rectangular cross-section.

TABLE:

S.No	Load 'W' in N	Deflection 'δ' in mm.	Young's Modulus 'E' N/mm^2
1.			
2.			
3.			
4.			
5.			

CALCULATIONS:

$$I = \frac{bh^3}{12}$$

$$\delta = \frac{WL^3}{3EI}$$

1. PRECAUTIONS:
2. Measure the length of the cantilever beam accurately before starting the experiment.
3. Ensure that the spindle of the dial gauge is in proper contact with the beam at the bottom of the loading point.
4. Place the loading hanger at a known, pre-determined distance along the cantilever beam.
5. Eliminate all possible errors while taking readings to ensure accurate results.
6. Do not exceed the elastic limit of the beam to avoid permanent deformation.
7. Ensure that the beam is positioned perfectly horizontal before applying the load.

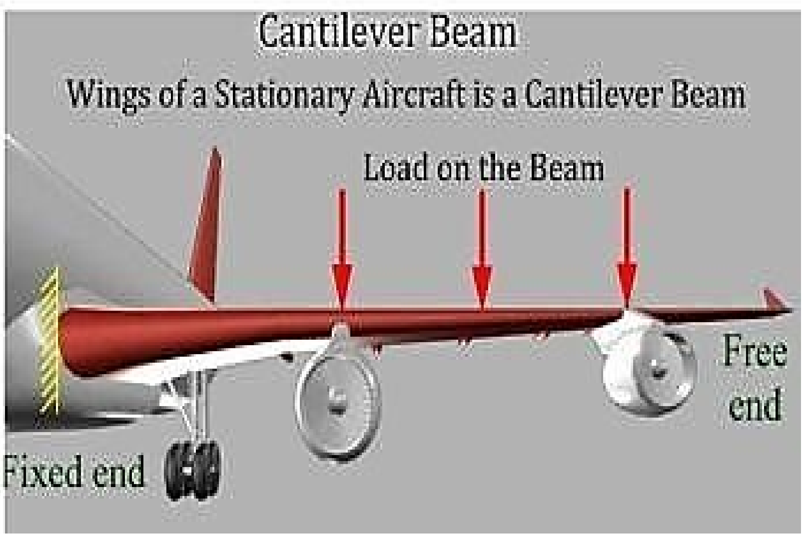
RESULT: The Bending strength of given specimen =…………… N/mm^2

VIVA QUESTIONS:

1. What is a cantilever beam?
2. What is the deflection formula for a cantilever beam?
3. What is the difference between a cantilever beam and a simply supported beam?
4. What are the different types of loads in beam analysis?
5. What is the meaning of the term "point of contra-flexure"?
6. What is bending stress, and how is it calculated in a cantilever beam?
7. What are the different types of supports used in beam structures?
8. Explain the significance of the moment of inertia in beam bending.
9. How does Young's modulus affect the deflection of a beam?
10. What are the assumptions made in the bending theory of beams?

APPLICATIONS:

1. In aircraft



2. Cantilever Cranes

REFERENCES:

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2. Singh, S. (2008). Strength of Materials, 4th ed. Khanna Publishers, New Delhi.
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	Sant Longowal Institute of Engineering & Technology Longowal-148106 (Govt of India)	**LAB MANUAL** Strength of Materials Lab
	Practical Experiment Instruction sheet **Experiment No.03**	Subject Code: PCME-525 Class: DEGREE Programme

AIM: - TO PERFORM THE TORSION TEST ON THE METALS.

OBJECTIVE:

To determine the **modulus of rigidity** of a **given specimen** using a **Torsion Testing Machine**

DESCRIPTION:

The torsion test is generally performed to determine the modulus of rigidity (shear modulus), torsional yield strength, and the modulus of rupture in torsion.
The modulus of rupture in torsion is the nominal surface stress corresponding to the maximum applied torque before failure.
The test provides essential insights into the shear behavior of materials under twisting loads.
The torsion formula is given by-

$$\frac{T}{J} = \frac{G\theta}{l} = \frac{\tau}{r}$$

$$\tau_s = \frac{Tr}{J}$$

Where

where:

- T = Applied Torque (N·m)
- J = Polar Moment of Inertia (mm^4)
- τ = Shear Stress (N/mm^2)
- r = Radius of the Specimen (mm)
- G = Modulus of Rigidity (N/mm^2)
- θ= Angle of Twist (radians)
- L = Gauge Length of the Specimen (mm)

$$G = \frac{Tl}{j\theta}$$

For a bar of circular cross – section

$$J = \frac{\pi r^4}{2}$$

$$G = \left(\frac{T}{\theta}\right) \cdot \left(\frac{2l}{\pi r^4}\right)$$

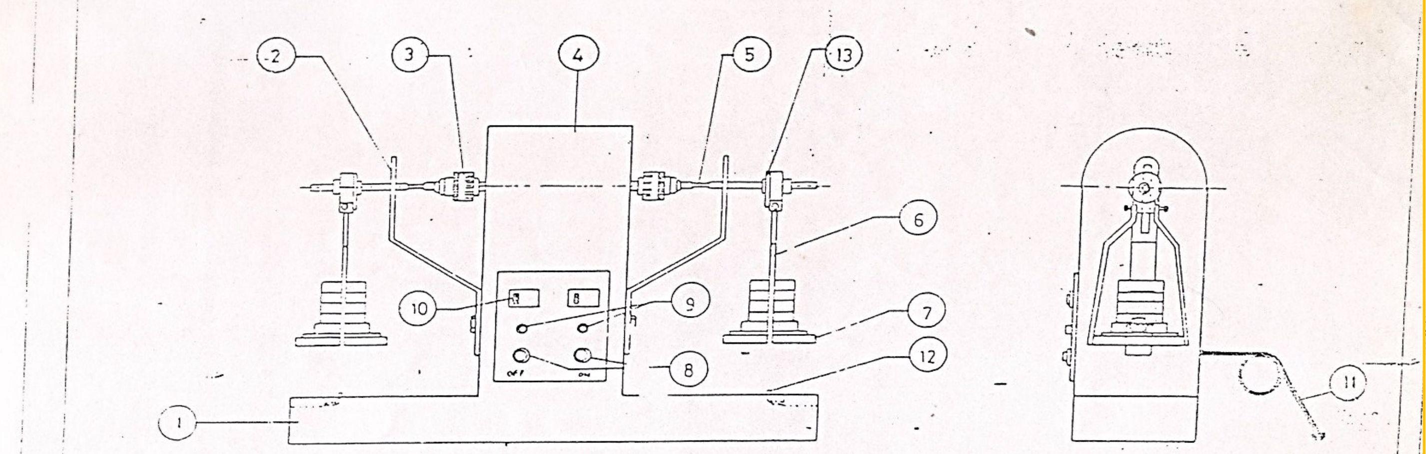
$$\tau_s = \left(\frac{2Tmax}{\pi r^3}\right)$$

Thus, to determine the modulus of rigidity, TV's curve is obtained on a torsion testing machine. Thus, by knowing the parallel length of the test piece and its radius, the modulus of rigidity can be determined. The modulus of rupture can be calculated by maximum torque from t-curve. By knowing the maximum torque form TV curve, the ends of specimen flattened to avoid the slipping during twisting may be made according to the machine used.

EQUIPMENT:

1) Torsion testing machine,
2) Test pieces,
3) Micrometre,

4) Foot rule,
5) Slide wrench.



FATIGUE TESTING MACHINE

S.NO.	DESCRIPTION	S.NO.	DESCRIPTION	S.NO.	DESCRIPTION
1	BASE	6	WEIGHT HANGER	11	MAINS LEAD
2	SUPPORT FOR SAMPLE	7	BALANCE	12	STOP COUNTER
3	CHECKS	8	ON – OFF-SWITCH	13	GRIPPERS
4	BODY	9	INDICATORS		
5	SAMPLE FOR TESTING	10	COUNTERS		

PROCEDURE: -

1) Measure the diameter of the test piece at four different places along its parallel length, at angles to each other.
2) Measure the parallel length of the test piece.
3) Insert the test piece in the grip of the machine.

4) Select a suitable scale on the machine and adjust the initial torque and angle of twist reading to new position.
5) Apply the torque initial by hand up to 10° angle of twist. The angle of twist and torque may be noted at an internal of 1° from 10° to 20°, the reading and may be noted at 2° interval. After this the machine may be operated electrically and the reading may be noted at an interval of 5° to 10° which even is convenient.
6) Continue noting the readings until the specimen breaks.
7) Initially a line may be marked parallel to the length of test piece to see the helix formation.

OBSERVATION: -

Material of test =

Least count of micrometre =

Parallel length of test piece =

Average dia. Of different places =

Sr. No.	Torque	Angle of twist	Torque (N/m	Angle of twist

Maximum torque =…………………………………

RESULT: -

Dia. Of test pieces =………… m

Torque of limit of proportionality =………… N/m

Shear strength at limit of proportionality =………… N/m^2

Maximum torque =………… N/m

Modulus of rupture =………… N/m^2

Modulus of rigidity =………… N/m^2

Total angle of twist to fracture =………… $^{\circ}$

PRECAUTIONS: -

1) Test piece dia. Should be measured accurately.
2) The rate of angle of twist should be kept the test piece so avoid any accident.
3) The guard should be closed around the test piece to avoid any accident.
4) The test piece should be free from tool marks.

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2. ASTM E143-20. Standard Test Method for Shear Modulus at Room Temperature. ASTM International.

3. IS 1717: 2012. Metallic Materials - Wire - Simple Torsion Test. Bureau of Indian Standards, New Delhi.
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	Sant Longowal Institute of Engineering & Technology Longowal-148106 (Govt of India)	**LAB MANUAL** Strength of Materials Lab
	Practical Experiment Instruction sheet **Experiment No.04(a)**	Subject Code: PCME-525 Class: DEGREE Programme

AIM: - TO PERFORM BRINELL HARDNESS TEST.

OBJECTIVE: -

a) Study and working of Brinell Hardness Testing machine
b) To determine the hardness of the given specimens with a Brinell hardness testing machine.

APPARATUS: -

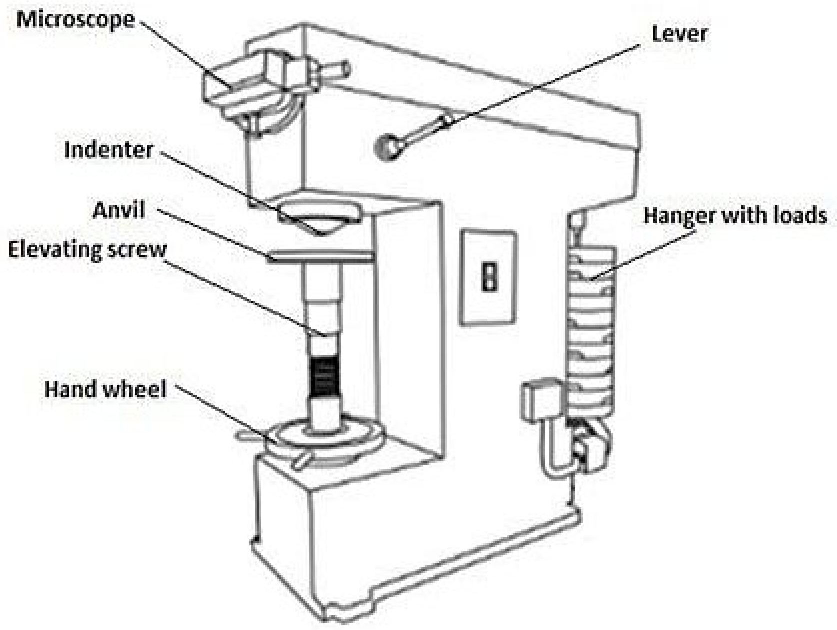
Brinell hardness testing machine, given specimen and a low power microscope.

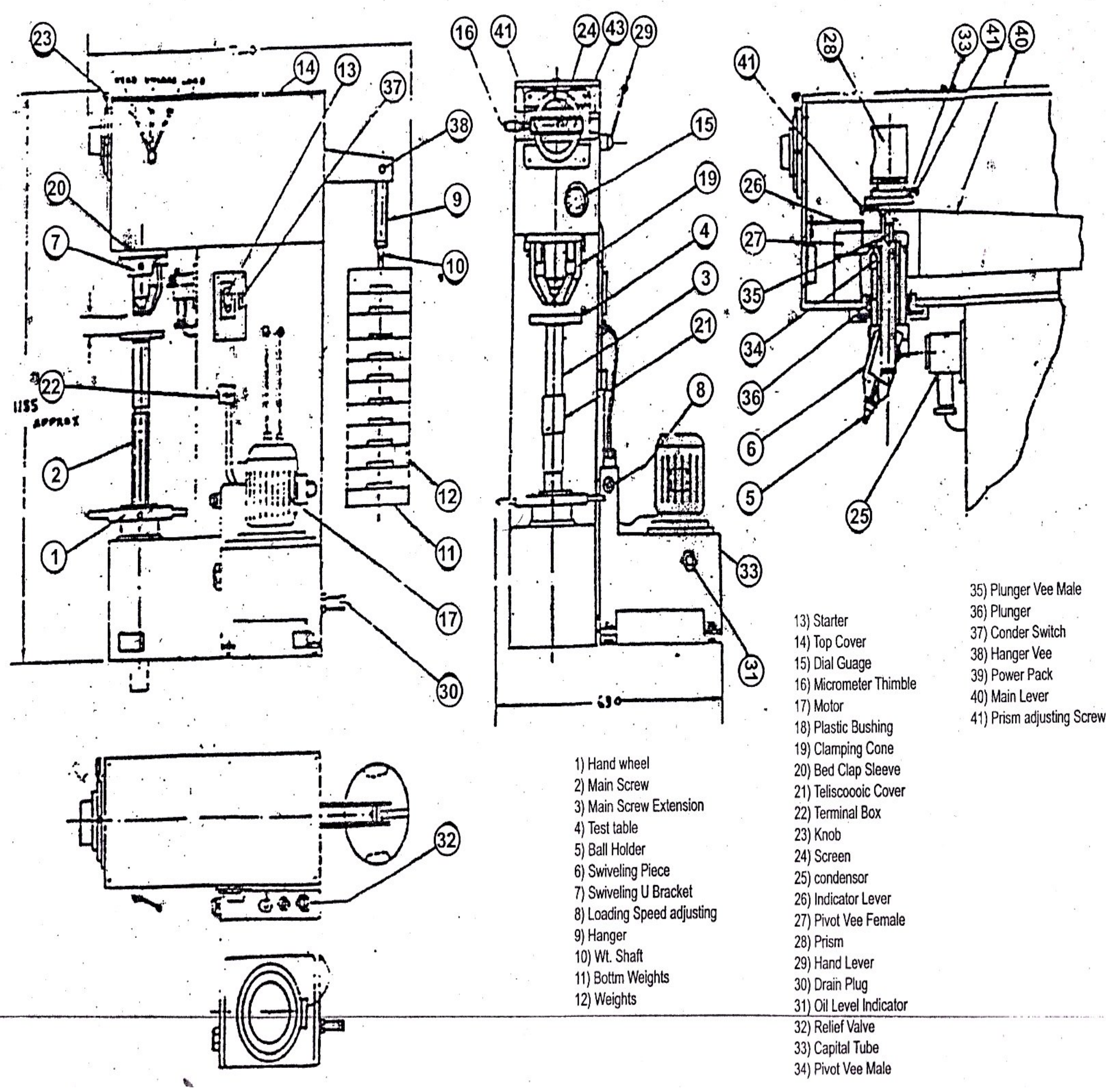
INTRODUCTION: -

In general, hardness may be understood as the property, which provides resistance to permanent plastic deformation. Hardness for engineering purposes is defined as resistance to indentation or scratching. Various parts of machine and structure such as gears, axels and rails are subjected to service requirements where high resistance to indentation or abrasion is required.

THEORY: -

The standard Brinell hardness test is applicable to materials with a hardness up to approximately 450 HBS when using a hardened steel ball, and up to approximately 650 HBW when using a tungsten carbide ball. The test consists of pressing a hardened steel ball into a test specimen. In the standard Brinell hardness test, a ball of 10 mm diameter is used as the indenter. A load of 3000 kgf is used for hard metals, 1500 kgf for metals of intermediate hardness, and 500 kgf (or as low as 100 kgf) for soft metals. The full load is applied for a period of 15 seconds, or 30 seconds for softer metals. After this period, the load is removed and the diameter of the indentation is measured with a microscope to an accuracy of 0.01 mm. The BHN is then determined either from a standard table or from the following formula.





$$\textbf{BHN} = \frac{Load\ on\ Ball}{Indented\ Area} = \frac{2P}{\pi D\left(D-\sqrt{D^2-d^2}\right)}$$

P= load applied in Kg.

D= Dia. Of steel ball in mm

D= Dia. Of indentation in mm

DESCRIPTION OF MACHINE: -

The machine consists of a hand-operated vertical hydraulic press, designed to force the ball indenter into the test specimen. The equipment is designed in such a way that it facilitates slow and progressive loading at right angles to the test surface. A gauge is provided to display the load at any instant. Downward movement of the anvil can be done by releasing the hydraulic pressure through a valve.

PROCEDURE: -

1) Clean the surface of specimen and table of the machine.
2) Press a 10 mm dia. hardened steel ball into the surface of the specimen by gradually applied load.
3) Provide the above load for a standard time. Usually 30 sec. for softer metals and 15 sec. for hard metals.
4) Release the load and remove specimen from the machine.
5) Measure the dia. In mm two directions normal to each other with the help of microscope and determine BHN.

OBSERVATION:

1) Test load (P) =______________________Kg.
2) Dia. Of the ball (D) =______________________mm.

Table, for measurement of dia. Indentation and BHN

S.NO.	MATERIAL	d1(mm)	d2(mm)	d(mm)	BHN
1)					
2)					
3)					
4)					
5)					

1. PRECAUTIONS:
2. Ensure that the specimen is free from dirt and scale before testing.
3. Select an appropriate load based on the material being tested.
4. Do not conduct the test on defective or unsuitable specimens.

- For Brinell Hardness Number (BHN) measurements:
- The standard Brinell hardness test (HB) is limited to approximately 500 HB when using a hardened steel ball.
- As the tested material becomes harder, the indenter may deform, leading to inaccurate readings.

5. Using a tungsten carbide ball instead of a hardened steel ball can extend the upper hardness limit to approximately 650 HB.
6. Apply the load gradually to avoid sudden stress variations.

- Take hardness readings at appropriate distances:
- Maintain a minimum spacing of at least 4d between consecutive readings.

7. Keep a minimum distance of 2.5d from the edge of the specimen, where d is the indentation diameter.
8. Perform the test at room temperature (~20°C).

- Ensure that the top and bottom surfaces of the specimen are parallel.
- The ratio of indentation diameter (d) to ball diameter (D) should be between 0.3 and 0.5, and must not exceed 0.6.
- Adjust the applied load accordingly to maintain this ratio

REFERENCES:

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3. ISO 6506-1:2014. Metallic Materials - Brinell Hardness Test - Part 1: Test Method. International Organization for Standardization.
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AIM: - TO PERFORM ROCKWELL HARDNESS TEST.

OBJECTIVE: -

A) Study and working of Rockwell hardness testing machine.
B) To determine the hardness of given specimens with a Rockwell hardness testing machine.

APPARATUS: -

Rockwell hardness testing machine, diamond cone penetrator, steel ball penetrator and given specimen

INTRODUCTION: -

In this method, hardness is measured on an arbitrary scale on which hardness no is inversely proportional to depth of indentation surface area is taken into account.

THEORY: -

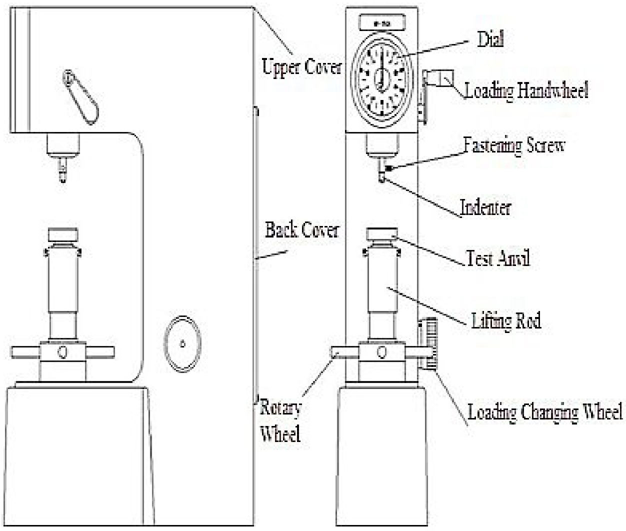
Rockwell hardness test uses a direct reading instrument based on differential depth measurement. The test is performed by slowly raising the specimen against the indenter until a fixed minor load has been applied. This is indicated on the dial gauge. Then major load is applied through a loader lever system. After the dial pointer comes to rest the major load is removed and with minor load still acting, the Rockwell hardness number is read on the dial gauge. Since order of number is reversed on dial gauge, a shallow impression on a soft material will result in a low number.

There are two Rockwell machines, the standard tester for relatively thick section, and superficial tester for thin section. The minor load is 10 kg. on a normal tester and 3 kg on superficial test. There are two standard forms of indenters there are: -

a) Ball indenter- hardened steel ball 1/16-inch (1.58 mm) dia. For red scale
b) Cone indenter: diamond cone of 120° angle terminating in a spherical tip of 0.2 mm radius, used on the black (C) scale.

DESCRIPTION OF MACHINE: -

In the Rockwell hardness testing machine, there are two scales on the dial. 'B' marked in red scale and 'C' is black. Zero of 'C' scale is opposite to number 30 on 'B' scale. So that there is difference of thirty hardness numbers between the two scales at any point.



PROCEDURE: -

1) Check the accuracy of machine with the help of given specimen.
2) Keep the lever '9' at position 'A'
3) Place the cleaned and polished specimen on the anvil /table of machine.
4) Turn the hand wheel to raise the specimen, to make contact with indenter and continue turning until long hand of dial has made three complete turns which brings the small hand at red spot (at '3') and big hand at 0.
5) Turn the lever '9' from the position 'A' to 'B' so that load will act.
6) When the big pointer of the dial reaches a steady position, take back the lever '9' to 'A' position slowly. Sudden release of lever may show erratic reading.
7) Read off the reading; use the black scale for the cone penetrator and the red scale for the ball penetrator.
8) Turn back the hand wheel and remove the job.

OBSERVATION: -

For measurement of Rockwell hardness number.

S.NO.	MATERIAL	PENETRATE USED	MINOR LOAD + MAJOR LOAD	ROCKWELL HARDNESS NO.
1)				
2)				

PRECAUTIONS:

1. Ensure that the specimen is free from dirt, scale, and oil before testing.
2. Mark new indentations away from previous penetration marks to avoid inaccurate readings.
3. The thickness of the specimen should be at least 10 times the depth of the indentation to ensure reliable results.
4. Frequently check the performance of the machine using standard specimens to maintain accuracy.
5. Standardize the speed of load application by adjusting the dashpot of the machine to maintain a loading period of 4 to 5 seconds.
6. Ensure that the machine table remains stationary during the test.
7. For curved plates, the concave side should preferably face the indenter for accurate indentation.
8. Check the condition and shape of the indenter before performing the test to avoid measurement errors.
9. Take readings immediately after removing the additional load to ensure precision.

VIVA QUESTIONS :

1. What is the Rockwell hardness test?
2. What is the principle of the Rockwell hardness test?
3. What are the different Rockwell hardness scales, and how are they determined?
4. What types of indenters are used in the Rockwell hardness test?
5. What is the difference between the minor and major loads in the Rockwell test?
6. How is Rockwell hardness measured, and how is the reading obtained?
7. Why is the Rockwell hardness number scale reversed?
8. What materials are typically tested using the Rockwell hardness test?
9. What is the difference between the Rockwell and Brinell hardness tests?
10. Why is a minor load applied before the major load in the Rockwell test?

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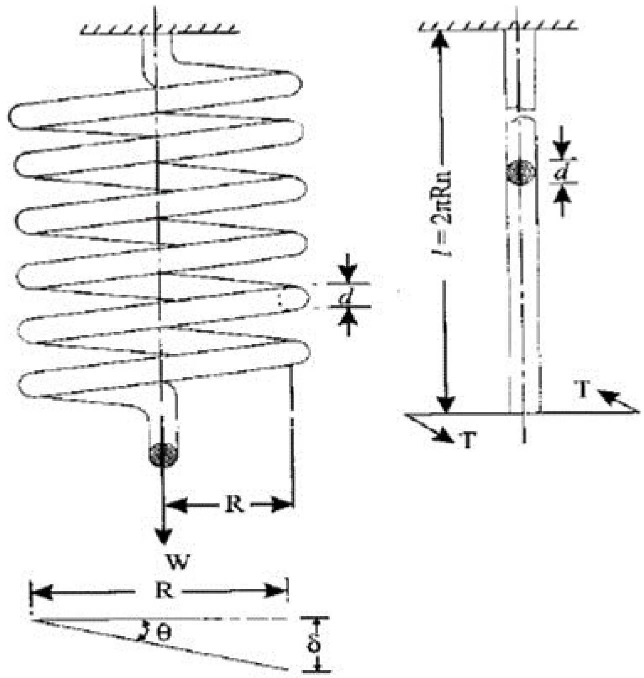
AIM: TO DETERMINE THE STIFFNESS OF THE SPRING AND MODULUS OF RIGIDITY OF THE SPRING

APPARATUS:

i) Spring testing machine.
ii) A spring iii) Vernier caliper,
iii) Scale.
iv) Micrometer.

DIAGRAM:



Close-coiled helical spring.

THEORY:

Springs are elastic member which distort under load and regain their original shape when load is removed. They are used in railway carriages, motor cars, scooters, motorcycles, rickshaws, Governors etc. According to their uses the springs perform the following Functions:

1) To absorb shock or impact loading as in carriage springs.
2) To store energy as in clock springs.
3) To apply forces to and to control motions as in brakes and clutches.
4) To measure forces as in spring balances.
5) To change the vibration characteristics of a member as in flexible mounting of motors.

The spring is usually made of either high carbon steel (0.7 to 1.0%) or medium carbon alloy steels. Phosphor bronze, brass, 18/8 stainless steel and Monel and other metal alloys are used for Corrosion resistance spring. Several types of spring are available for different application. Springs may classify as helical springs, leaf springs and flat spring depending upon their shape. They are fabricated of high shear strength materials such as high carbon alloy steels spring form elements of not only mechanical system but also structural system. In several cases it is essential to idealize Complex structural systems by suitable spring.

PROCEDURE:

1) Measure the diameter of the wire of the spring by using the micrometer.
2) Measure the diameter of spring coils by using the vernier caliper
3) Count the number of turns.
4) Insert the spring in the spring testing machine and load the spring by a suitable weight and note the corresponding axial deflection in tension or compression.
5) Increase the load and take the corresponding axial deflection readings.
6) Plot a curve between load and deflection. The shape of the curve gives the stiffness of the Spring.

OBSERVATION

Least count of micrometer = ...mm

Diameter of the spring wire, d =......... mm (Mean of three readings) Least count of vernier caliper = ...mm

Diameter of the spring coil, D= ....mm (Mean of three readings) Mean coil diameter, Dm = D – d =......... mm

Number of turns, n =.........

TABLE:

S.No	Load W (in N)	Deflection (δ) mm	Stiffness $K = \frac{W}{\delta}$	Modulus of Rigidity(C)$\frac{N}{mm^2}$

Mean k = ...

$$Modulus\ of\ rigidity\ C = \frac{8WD^3n}{\delta D^4{}_m}$$

$$Spring\ Index = \frac{D_m}{D}$$

PRECAUTIONS:

1) The dimension of spring was measured accurately.
2) Deflection obtained in spring was measured accurately

ADVANTAGES:

1. To apply forces and to control motions as in brakes and clutches.
2. To store energy as in clock springs.
3. This test is conducted to find the material properties of the spring like modulus of rigidity. This can be obtained by observing the values of deflections of the spring with the application of Different amounts of the load applied along the axis of the spring. The observed Values of deflections are compared with the theoretical value for the deflection of the spring under the load and shear modulus is to be obtained.
4. To reduce the effect of shock or impact loading as in carriage springs

RESULT:

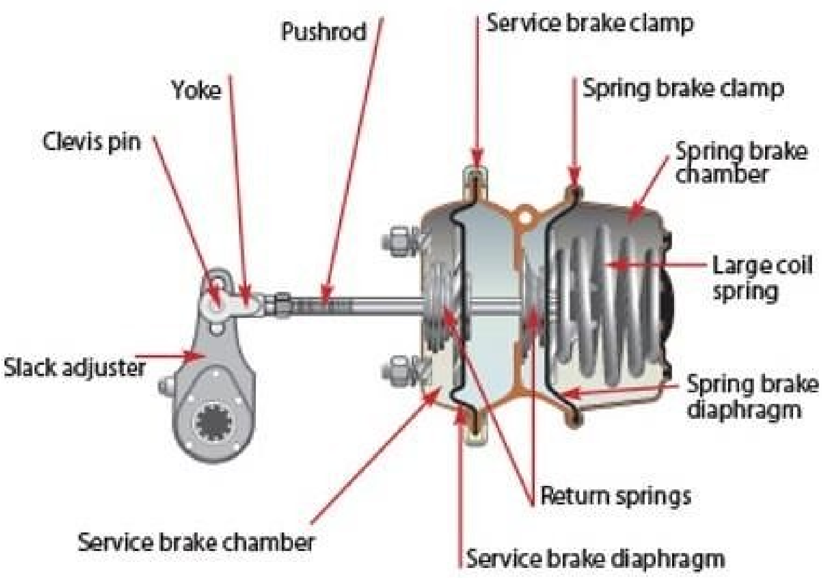
The value of spring constant k of closely coiled helical spring is found to be_______N/ mm

VIVA QUESTIONS:

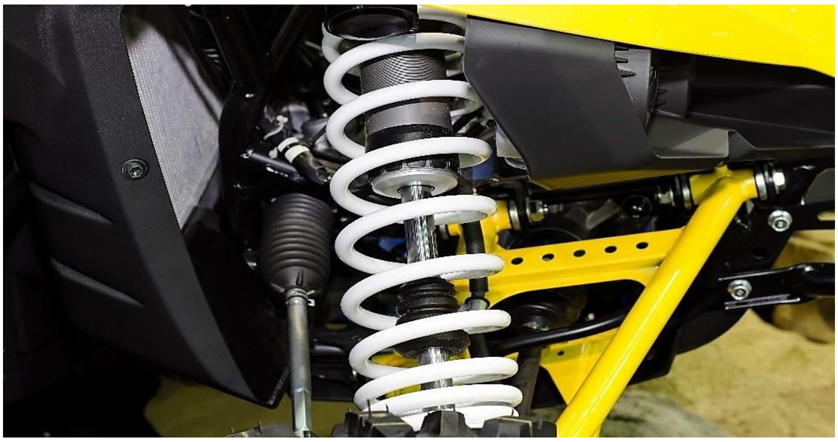
1. What is meant by stiffness?
2. Define deflection.
3. What are the different types of springs?
4. Define a helical spring.
5. What is the strain energy stored in a spring?
6. What is the difference between open-coil and closed-coil helical springs?
7. Explain the significance of the spring constant (stiffness) in spring design.
8. What is the difference between compression and tension springs?
9. What is the formula for the deflection of a helical spring?
10. How does the number of coils in a spring affect its stiffness and deflection?

APPLICATIONS:

1. To apply forces and controlling motion, as in brakes and clutches.



2. Used in suspension system



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	Sant Longowal Institute of Engineering & Technology Longowal-148106 (Govt of India)	**LAB MANUAL**
		Strength of Materials Lab
	Practical Experiment Instruction sheet	Subject Code: PCME-525
	Experiment No.06	Class: DEGREE Programme

AIM: TO STUDY THE BEHAVIOUR OF THE GIVEN MATERIAL UNDER COMPRESSIVE LOAD AND TO DETERMINE THE FOLLOWING:

- Modulus of elasticity
- Maximum Compressive strength or ultimate stress
- Percentage Decrease in length
- Percentage Increase in area

APPARATUS:

Universal Testing Machine, Dial gauge, Vernier caliper and scale.

MATERIAL: Wood/Cast Iron

THEORY:

Ductile materials attain a Bulge or a Barrel shape after reaching the maximum compression load. No fracture takes place and there is change in cross-section and compression value remains the same on reaching the maximum load as shown in the fig.1. For brittle Materials, there will be no change in the cross-sections or height of the specimen due to the compression load. On reaching the maximum compression load, the specimen suddenly fractures as shown in the Fig2.

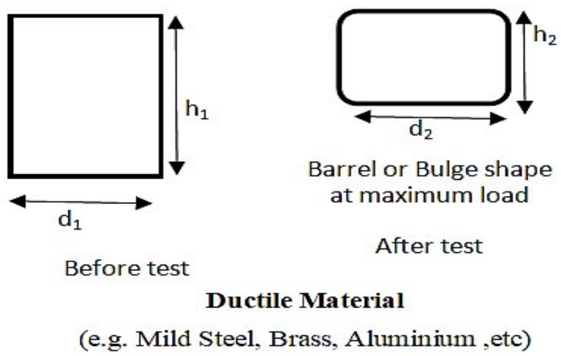


Fig.1

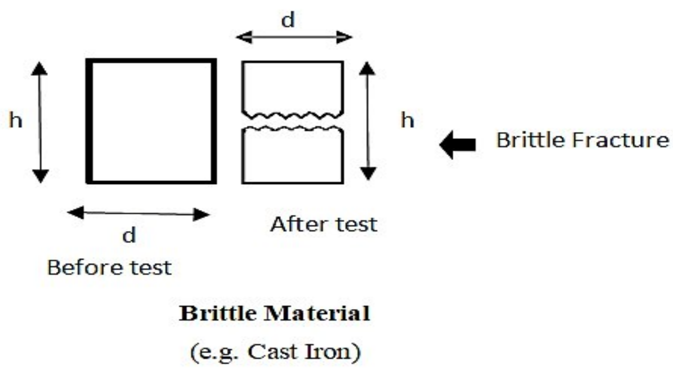
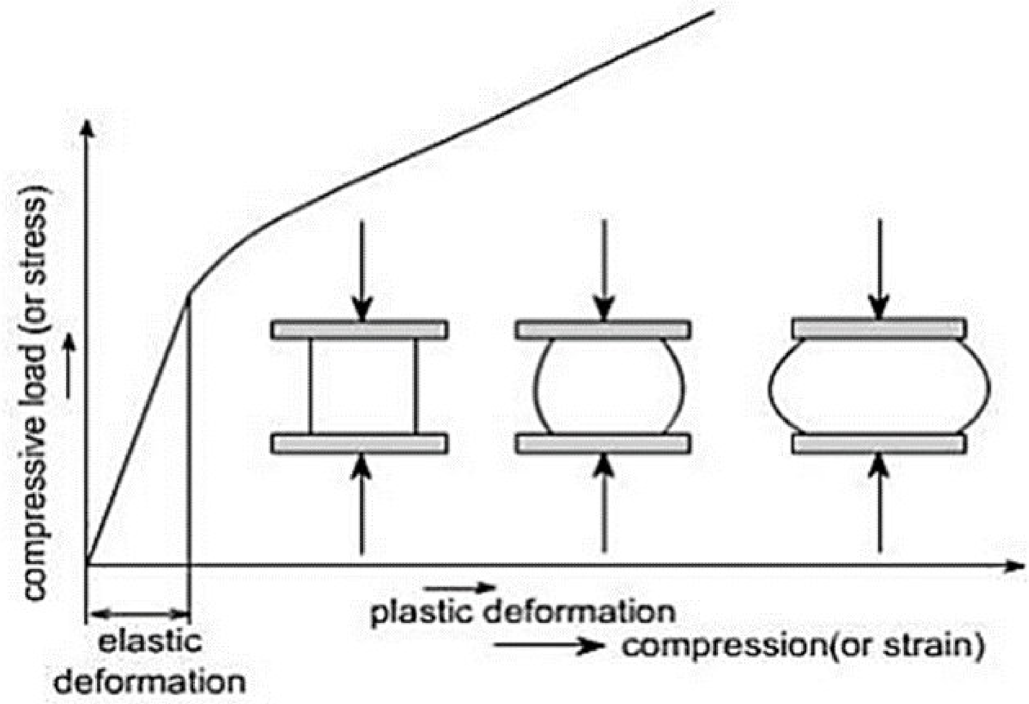


Fig.2

The compression test is just opposite to tension test, regarding direction. However, there are certain practical difficulties which may induce error in this test. They are Difficulty in applying truly axial load. There is always a tendency of the specimen to bend in addition to Contraction. To avoid these errors, usually the specimen for this test shall be short in length (not more than 2 time the diameter) In a compression test, stress – strain curve is drawn up to the elastic limit of proportionality. Metals have approximately the same modulus of elasticity as in tension test. The curve, for ductile materials, continues almost without limit as there is no fracture of the material due to its ductility and cross-sectional area increases continuously with increase in load. The specimen will shorten and bulge out. Compression test is mainly used for testing brittle materials such as cast iron, concrete etc. Brittle materials commonly fail along a diagonal plane due to shearing.

Procedure:



1. The original dimensions of the specimen like original dia., gauge length etc.
2. The specimen is mounted on the Universal Testing machine between the fixed and movable jaws.
3. The load range in the machine is adjusted to its maximum capacity (300 kN)
4. The dial gauge is mounted on the machine at the appropriate positions and adjusted to zero.
5. The machine is switched on and the compressive load is applied gradually.
6. For every 10 kN of load, the readings of dial gauge is noted and tabulated.
7. Remove the dial gauge at slightly below the expected load at yield point.
8. Record the load at yield point, at the yield point the pointer on load scale will remain stationary for small interval of time and blue needle will come back by 1 or 2 divisions that point is lower yield point.
9. The specimen is loaded continuously up to the ultimate load (red needle will stops) which is to be noted.
10. The specimen is removed, and final dimensions are measured.

TABULAR COLUMN:

S.No	Load (P) in N	Area (A) mm^2	Stress ($\frac{P}{A}$)	E = $\frac{stress}{strain}$
1.				
2.				
3.				
4.				
5.				

CALCULATIONS:

- Stress = $\sigma = \frac{Load}{Area} = \frac{P}{A}$…………………..$N/mm^2$
- Strain = $\epsilon = \frac{change\ in\ length}{original\ length} =$ …………..
- Young's modulus= E = $\frac{stress}{strain}$…………N/mm^2
- % Decrease in Length = $\frac{l_i - l_f}{l_i} \times 100$=………..%
- % Increase in area = $\frac{A_f - A_i}{A_i} \times 100$=……….%
- Ultimate Compressive strength = $\sigma = \frac{ultimate\ Load}{initial\ area} =$ ……………N/mm^2

RESULTS:

1. Modulus of elasticity = E =……………N/mm²
2. Maximum Compressive strength or ultimate stress = σ_{uc} =……………N/mm^2
3. Percentage Decrease in length =………..%
4. Percentage Increase in area =………………. %

VIVA QUESTIONS :

1. What is compressive strength?
2. How is a compressive test performed?
3. What is the difference between compressive strength and tensile strength?
4. What types of materials exhibit high compressive strength?
5. What is the stress-strain curve for a material under compression?
6. What are the factors affecting compressive strength?
7. Why do brittle materials have higher compressive strength than tensile strength?
8. What is the role of modulus of elasticity in compression testing?
9. What is the difference between elastic and plastic deformation in compression?
10. What is buckling, and how does it affect materials under compression?
11. What is Poisson's ratio, and how does it relate to compression?
12. Why is the shape of the specimen important in a compressive test?
13. What are the different types of failures observed in compression tests?
14. How does the length-to-diameter ratio of a specimen affect compression testing?
15. What is the significance of the end conditions of a specimen in compression testing?

REFERENCES:

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AIM: - TO PERFORM THE CHARPY IMPACT TEST ON THE GIVEN TEST SPECIMEN.

EQUIPMENT: -

1) Charpy impact testing machine.
2) Test specimens.

DESCRIPTION:

Several engineering materials have to withstand impact or suddenly applied load while in use impact strength, in general are less as compared to the strength achieved by the slowly applied load. An impact test signifies toughness of material that is ability of material to observe energy during plastic deformation.

To determine the notched-beam impact strength, three types of notches are used: V-notch, U-notch, and Key-hole notch. These notches are shown in the figure. The test piece should be machined all over and shall be 55 mm long and of square cross-section with 10 mm sides. The notch is made at the centre of the test specimen. The plane of symmetry of the notch should be perpendicular to the longitudinal axis of the test piece. The distance of the plane of symmetry of the notch from the end of the test piece shall be 27.5 ± 0.42 mm and the angle between the plane of symmetry of the notch and the longitudinal axis of the test piece shall be $90 \pm 2^{\circ}$.

The notch should be prepared carefully by any machining method like milling or shaping, but no grooves should be visible to the naked eye. The test piece should lie squarely against the supports, with the plane of symmetry of the notch within 0.5 mm of the plane midway between them as shown. It should be struck by the hammer in the plane of symmetry of the notch on the side opposite to the notch. The speed of striking should be 5 m/s. The centre of percussion should be at the point of impact of the hammer. The accuracy of the graduation on the scale should be ± 0.5 % of the maximum capacity of the machine. In our case, the maximum capacity of the machine is approximately 30 kgf·m (300 J).

PROCEDURE: -

1) Lift the hammer to an appropriate knife-edge position and note the energy stored in the hammer. For the standard Charpy test, it should be approximately 30 kgf·m (300 J).
2) Locate the test piece on the machine support as showed.
3) Release the hammer. The hammer will break the specimen and shoot up to the other side of the machine.
4) Note the residual energy indicated on the scale by hammer.
5) The impact strength of the test piece is the difference of the initial energy stored in the hammer and the residual energy.
6) Calculate the impact strength, given by the ratio of energy absorbed to the cross-sectional area at the notch.

OBSERVATIONS: -

Material of the test piece =

Type of the notch =

Dimensions of the test piece =

Room temperature =

Velocity of striking =

Test No.	Initial energy (Joules)	Residual energy (Joules)	Energy absorbed (Joules)
1)			
2)			

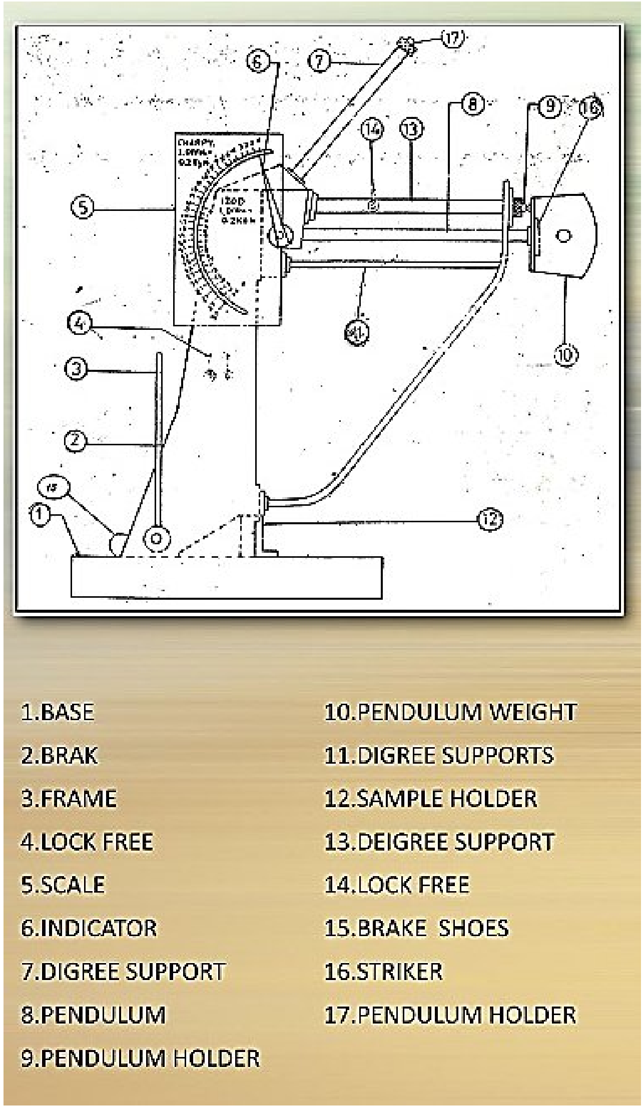
Mean value of impact strength= _______Joules.

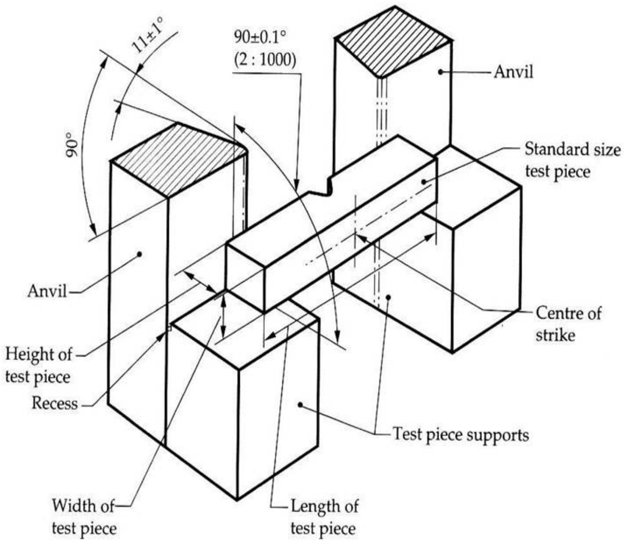
PRECAUTIONS:

3) Ensure that the notch is properly machined to the required dimensions and shape.
4) Place the test specimen correctly on the supports to ensure accurate impact results.
5) Lubricate the machine bearings and moving parts to minimize friction and ensure smooth operation.
6) Account for frictional energy loss in the bearings and resistance to the hammer to obtain precise test results.

VIVA QUESTIONS ON CHARPY IMPACT TEST:

1) What is the Charpy Impact Test, and why is it performed?
2) What is the principle behind the Charpy Impact Test?
3) What is the difference between the Charpy and Izod Impact Tests?
4) How is the Charpy test specimen prepared?
5) What are the standard dimensions of a Charpy test specimen?
6) Why is a notch provided in the Charpy Impact Test specimen?
7) What are the different types of notches used in the Charpy test?
8) How is the Charpy Impact Test performed step by step?
9) How is the energy absorbed by the specimen measured in the Charpy test?
10) What materials are typically tested using the Charpy Impact Test?
11) What is ductile-to-brittle transition temperature (DBTT), and why is it important?
12) How does temperature affect the Charpy impact test results?
13) What type of fracture occurs in brittle and ductile materials during the Charpy test?
14) How does strain rate influence the impact energy of materials?
15) What is the significance of the impact velocity of the pendulum in the Charpy test?
16) What is the role of the anvil in the Charpy Impact Test?
17) What are the safety precautions to be taken while performing the Charpy Impact Test?
18) How can Charpy test results be used in material selection for engineering applications?
19) What are the limitations of the Charpy Impact Test?
20) Why is the pendulum released from a fixed height in the Charpy test?





SOURCE OF ERRORS: -

1) Velocity of striking.
2) Friction in bearing.
3) Air resistance to hammer.
4) Temperature changes during test.
5) Errors in machining of notch.
6) Variations in material compositions.

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AIM: TO PERFORM THE IZOD IMPACT TEST ON THE GIVEN TEST SPECIMEN.

EQUIPMENT

1) Izod impact testing machine.
2) Test specimen.
3) Other instructions are same as in Charpy impact testing.

DESCRIPTION: Two types of test pieces are used for this test as given below:

1) Square cross section.
2) Round cross section.

The specimen may have a single notch, two notches, or three notches. The square test pieces are shown in the figure. In each case the plane of symmetry of the notch is kept perpendicular to the longitudinal axis of the test pieces. The surface of the specimen should be smooth and free from grooves running parallel to the plane of symmetry of the notch. The centre of percussion shall be at the point of impact of the hammer. The accuracy of the graduation of the scale of the machine shall be 1.37 N·m. The angle between the plane of symmetry of the notch and the axis of the test piece should be 90 ±2°. The testing machine should have the following specifications:

Angle between top face of grips and face holding the specimen = 90°

Angle of tip of hammer= 75°

Angle between normal to the specimen and undesired face of hammer at striking point = 10°

Speed of hammer at impact = 3 to 4 m/s

Striking energy = 162.4 ± 3.33 Nm

The longitudinal axis of the test piece shall lie on the place of swing of the centre of the gravity of the hammer. The notch shall be positioned so that its plane of symmetry coincides with the top face of the grip. The notch shall be at right angle to the plane of swing of the centre of the gravity of the hammer.

During testing of the two and three notch test pieces the materials remaining for testing after each test shall be examined to ensure that the correct length of test piece.

PROCEDURE: -

1) Lift the hammer to an appropriate knife-edge position and note the energy stored in the hammer. For the standard Izod test, it should be approximately 17 kgf·m (168 J).
2) Locate the test piece on the machine support as showed.
3) Release the hammer. The hammer will break the specimen and shoot up to the other side of the machine.
4) Note the residual energy indicated on the scale by hammer.
5) The impact strength of the test piece is the difference of the initial energy stored in the hammer and the residual energy.
6) Calculate the impact strength, given by the ratio of energy absorbed to the cross-sectional area at the notch.

OBSERVATIONS: -

Material of the test piece =

Type of the notch =

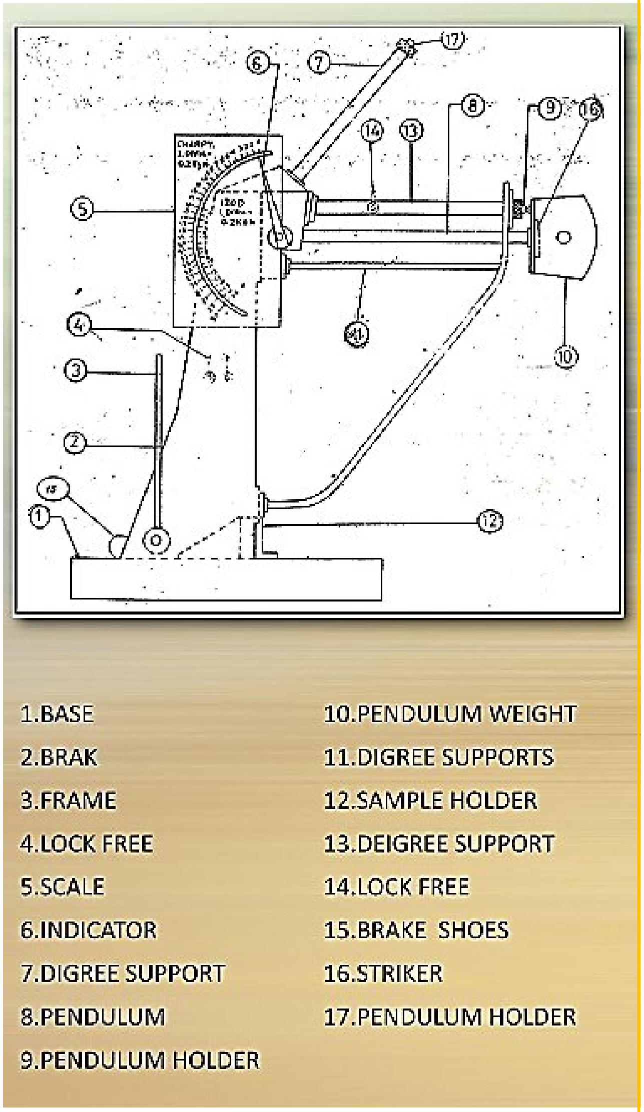
Dimensions of the test piece =

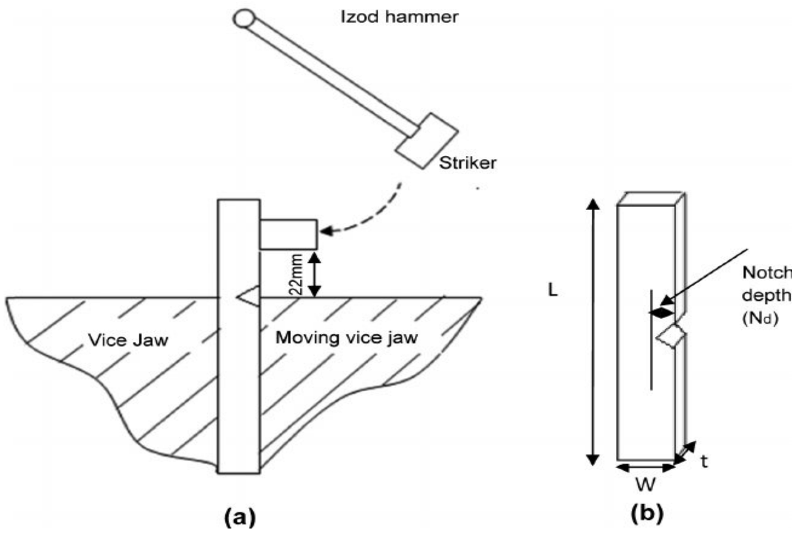
Room temperature =

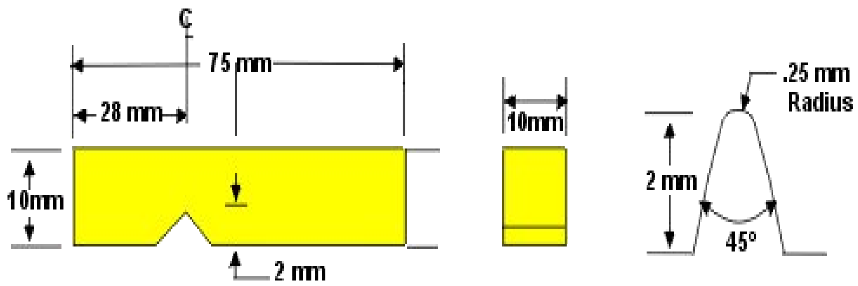
Velocity of striking =

Test No.	Initial energy (Joules)	Residual energy (Joules)	Energy absorbed (Joules)
1)			
2)			

Mean value of impact strength= _______Joules.







PRECAUTIONS: -

1) The notch should be properly machined.
2) The test specimen should be correctly placed on the supports.
3) Machine bearing and moving parts should be lubricated.
4) Frictional energy loss in bearing and resistance to hammer should accounted for.

SOURCE OF ERRORS: -

1) Velocity of striking.
2) Friction in bearing.
3) Air resistance to hammer.
4) Temperature changes during test.

5) Errors in machining of notch.
6) Variations in material compositions.

VIVA QUESTIONS ON IZOD IMPACT TEST:

1) What is the Izod Impact Test, and why is it performed?
2) What is the principle behind the Izod Impact Test?
3) How does the Izod test differ from the Charpy Impact Test?
4) What are the standard dimensions of an Izod test specimen?
5) What is the standard notch used in the Izod test specimen?
6) Why is the specimen notched in the Izod test?
7) What materials are commonly tested using the Izod Impact Test?
8) How is the specimen positioned in the Izod Impact Test?
9) How is the energy absorbed by the specimen measured in the Izod test?
10) What type of fractures are observed in brittle and ductile materials during the Izod test?
11) What is ductile-to-brittle transition temperature (DBTT), and how is it related to impact testing?
12) How does the angle of the pendulum affect the impact energy?
13) Why is temperature an important factor in impact testing?
14) What is the significance of impact strength in material selection?
15) What are the limitations of the Izod Impact Test?
16) What safety precautions should be taken while performing the Izod test?
17) How does strain rate influence impact strength?
18) What is the difference between absorbed energy and impact resistance?
19) What role does the support fixture play in the Izod Impact Test?
20) How can impact test results be used in real-world applications?

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	Sant Longowal Institute of Engineering & Technology Longowal-148106 (Govt of India)	**LAB MANUAL**
		Strength of Materials Lab
	Practical Experiment Instruction sheet	Subject Code: PCME-525
	Experiment No.08	Class: DEGREE Programme

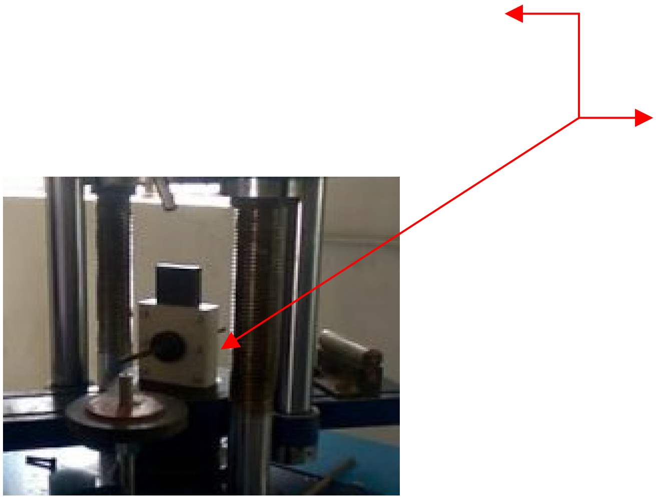
AIM: -STUDY OF DIRECT SHEAR TEST OF MILD STEEL ON UNIVERSAL TESTING MACHINE.

APPARATUS: - Universal testing machine, Shear test attachment, Specimens.

THEORY:

A type of force which causes or tends to cause two contiguous parts of the body to slide relative to each other in a direction parallel to their plane of contact is called the shear force. The stress required to produce fracture in the plane of cross-section, acted on by the shear force is called shear strength.

Place the shear test attachment on the lower table, this attachment consists of cutter. The specimen is inserted in shear test attachment & lift the lower table so that the zero is adjusted, then apply the load such that the specimen breaks in two or three pieces. If the specimen breaks in two pieces then it will be in single shear & if it breaks in three pieces then it will be in double shear.



PROCEDURE:

1. Insert the specimen in position and grip one end of the attachment in the upper portion and one end in the lower portion.
2. Switch on the main switch of universal testing machine.
3. Bring the drag indicator in contact with the main indicator.
4. Select the suitable range of loads and space the corresponding weight in the pendulum and balance it if necessary with the help of small balancing weights.
5. Operate (push) buttons for driving the motor to drive the pump.
6. Gradually move the head control level in left-hand direction till the specimen shears.
7. Note down the load at which the specimen shears.
8. Stop the machine and remove the specimen
9. Repeat the experiment with other specimens.

OBSERVATION:

1. Applied compressive force (F) = ---------kgf.
2. Diameter of specimen = ---------mm.
3. Cross sectional area of the pin (in single shear) = $\frac{\pi\times d^2}{4}$ mm^2
4. Cross sectional area of the pin (in double shear) = $\frac{2\times\pi\times d^2}{4}$ mm^2
5. Load taken by the specimen at the time of failure, W= …… (N)
6. Strength of the pin against shearing (τ) $=\frac{4\times W}{2\times\pi\times d^2}$

$$\text{Shear Strength of rod in single Shear} = \frac{\text{Load at failure in single shear}}{\text{cross sectional area in single shear}}$$

$$\text{Shear Strength of rod in double Shear} = \frac{\text{Load at failure in double shear}}{\text{cross sectional area in double shear}}$$

PRECAUTIONS:

1. The measuring range should not be changed at any stage during the test.
2. The inner diameter of the hole in the shear stress attachment should be slightly greater than the specimen.
3. Measure the diameter of the specimen accurately.
4. The method for determining the shear strength consists of subjecting a suitable Length of steel specimen in full cross-section to double shear, using a suitable test rig, in a testing m/c under a compressive load or tensile pull and recording the maximum load 'F' to fracture.

RESULT: The Shear strength of mild steel specimen is found

v) In single shear = …... N /mm^2
vi) In double shear = …... N /mm^2

VIVA QUESTIONS ON DIRECT SHEAR TEST OF MILD STEEL:

1) What is a direct shear test, and why is it performed on mild steel?
2) What is the shear strength of a material, and how is it calculated?
3) How does the Universal Testing Machine (UTM) apply shear force in the test?
4) What is the difference between single shear and double shear failure?
5) What are the factors that affect the shear strength of mild steel?
6) **REFERENCES:**

1. ASTM B565-04 (2014). Standard Test Method for Shear Testing of Aluminum and Aluminum-Alloy Rivets and Cold-Heading Wire and Rods. ASTM International.
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	Sant Longowal Institute of Engineering & Technology Longowal-148106 (Govt of India)	**LAB MANUAL** Strength of Materials Lab
	Practical Experiment Instruction sheet **Experiment No.09**	Subject Code: PCME-525 Class: DEGREE Programme

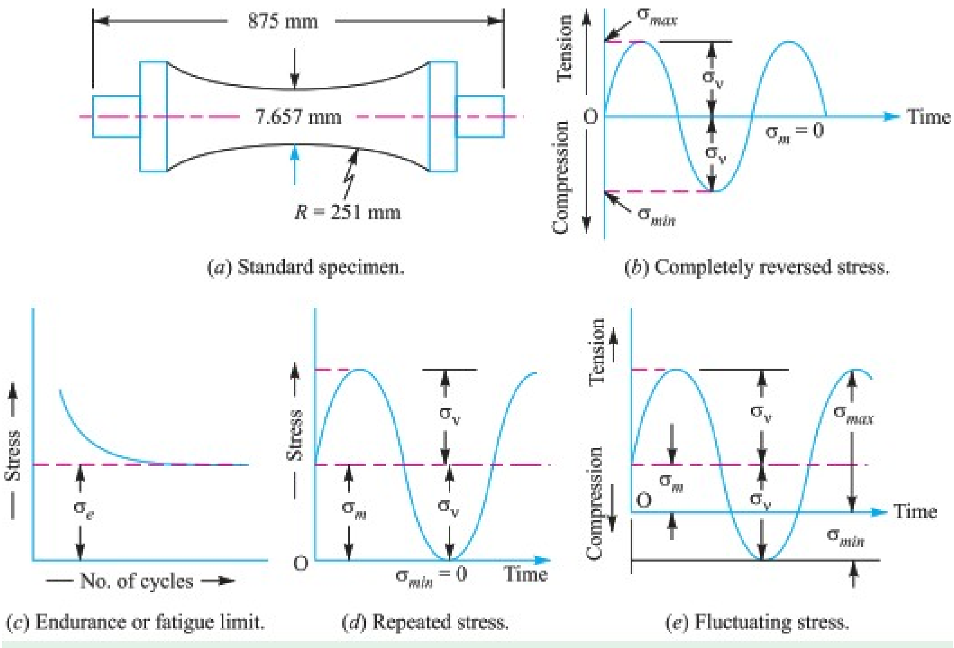
AIM: TO DETERMINE A MATERIAL'S FATIGUE BEHAVIOR BY USING FATIGUE TEST MACHINE.

APPARATUS: Motor drive, two main bearings, two load bearings

MATERIAL: Standard polished specimen

THEORY:

When a material is subjected to repeated stresses, it fails at stresses below the yield point stresses. Such type of failure of a material is known as fatigue. The failure is caused by means of a Progressive crack Formation which are usually fine and of microscopic size. The failure may occur even without any prior indication. The fatigue of material is affected by the size of the component, relative magnitude of static and fluctuating loads and the number of load reversals.



In order to study the effect of fatigue of a material, a rotating mirror beam method is used. In this method, a standard mirror polished specimen, as shown in Fig. 6.2 (a), is rotated in a fatigue testing machine while the specimen is loaded in bending. As the specimen rotates, the bending stress at the upper fibres varies from maximum compressive to maximum tensile while the bending stress at the lower fibres varies from maximum tensile to maximum compressive. In other words, the specimen is subjected to a completely reversed stress cycle. This is represented by a time-stress diagram as shown in Fig. 6.2 (b). A record is kept of the number of cycles required to produce failure at a given stress, and the results are plotted in stress-cycle curve as shown in Fig.6.2 (c). A little consideration will show that if the stress is kept below a certain value as shown by dotted line in Fig. 6.2 (c), the material will not fail whatever may be the number of cycles. This stress, as Represented by dotted line, is known as endurance or fatigue limit (σ_e). It is defined as the maximum value of the completely reversed bending stress which a polished standard specimen can withstand without failure for an infinite number of cycles (usually 10^6 to 10^7 cycles).

The stress verses time diagram for fluctuating stress having values σ_{min} & σ_{max} is shown in Fig. 6.2 (e). the variable stress, in general, may be considered as a combination of steady (or mean or average) stress and a completely reversed Stress component σ_v

The following relations are

derived from Fig. 6.2 (e):

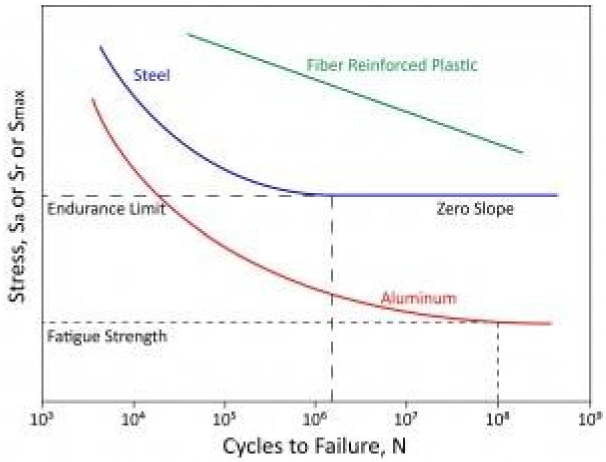
1. **Mean or average stress,**

$$\sigma_m = \frac{\sigma_{max} + \sigma_{min}}{2}$$

2. **Reversed stress component or alternating or variable stress,**

$$\sigma_v = \frac{\sigma_{max} - \sigma_{min}}{2}$$

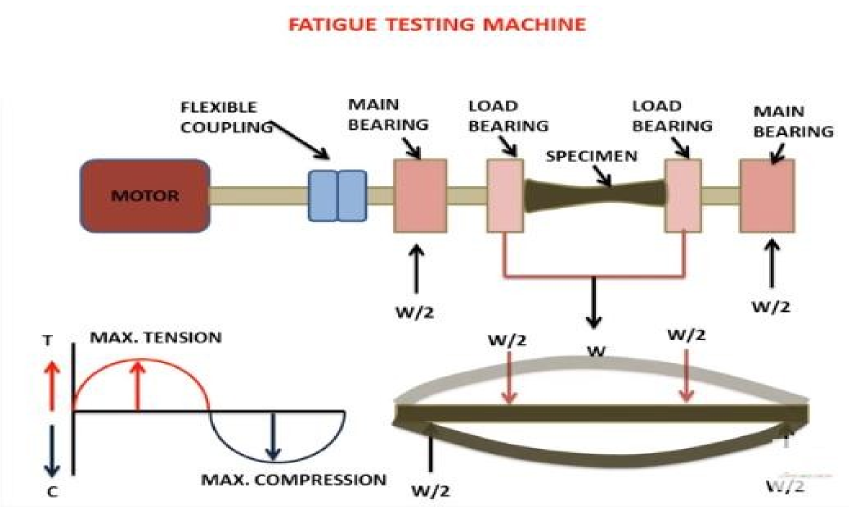
S-N Curve: An S-N curve, also known as a Wöhler curve, is a graph that shows a material's fatigue behavior and endurance limit if it is distinct. As the stress applied to the sample decreases, the number of cycles to failure will increase. The graph shows the stress amplitude (S), the difference between the maximum and minimum stress during a fatigue cycle divided by 2, and the number of cycles (N). A logarithmic scale is typically used for the number of cycles. Depending on the material the graph may approach a limit which is known as the Endurance Limit (SL).



Endurance Limit (SL): The endurance limit of a material is the maximum stress that can be applied to the material indefinitely without failure. Depending on the material, they may or may not show this behavior. Ferrous and titanium alloys typically have endurance limits along with polymers. Materials such as aluminum and copper do not and can fail at very low stresses. Cycling below the endurance limit can be Done indefinitely without failure.

Bending Moment: A bending moment is a force that causes a sample to bend. The bending moment is a function of the force applied, the distance from where the sample is supported to where the moment is acting, and the geometry of the sample.

DIAGRAM:



PROCEDURE:

1. Take the specimen in circular shape
2. Take the required dimensions of circular rod
3. A specimen is placed in the machine and a force is applied via a bending moment using weights hung off the sample
4. The force induces a surface stress that will be tensile on one side of the sample (generally the top) and compressive on the opposite side.
5. When the test is started, the sample will rotate at the desired rate and this rotation will cause the surfaces to interchange so that each surface experiences alternating tensile and compressive stresses
6. The sample is left in the machine until failure at which point ADMET's eP2 controller will display the number of cycles it looks for the sample to fail.
7. Finally take the readings.

PRECAUTIONS:

1. Specimen fix into the machine properly
2. Take the readings correctly.
3. Carefully applied loads.

RESULT:

VIVA QUESTIONS:

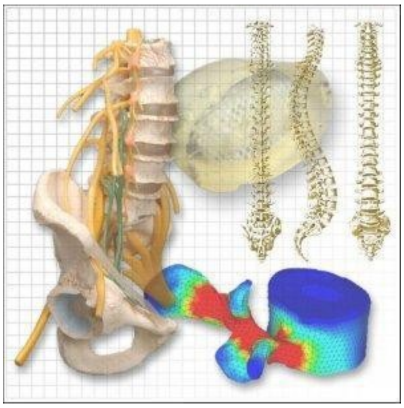
1) What is fatigue in materials?

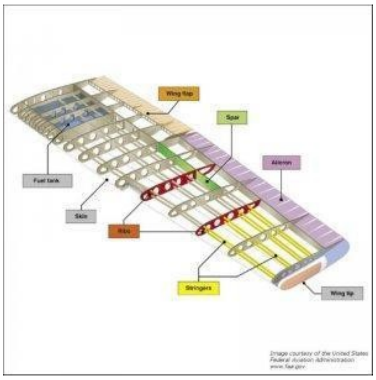
2) Define endurance strength.
3) What is the significance of the S-N curve in fatigue analysis?
4) What is bending stress?
5) What is cyclic stress
6) What are the different stages of fatigue failure?
7) How does temperature affect fatigue life?
8) What is the difference between low-cycle and high-cycle fatigue?
9) What factors influence the endurance limit of a material?
10) What are some real-world applications where fatigue failure is a major concern?

INDUSTRIAL APPLICATION:

1. Fatigue Testing Spine Implant

2. Aircraft Structural Testing | Equipment





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