K.L.N. College of Engineering

(An Autonomous Institution Affiliated to Anna University, Chennai)

by National Assessment and Accreditation Council (NAAC)

Pottapalayam – 630612.(11 km From Madurai City) TamilNadu, India.

Department of Mechanical Engineering

Accredited by NBA, New Delhi

Approved Research Center by Anna University, Chennai

Approved Nodal Center for e – YANTRA Lab

Regulations – 2020

Odd Semester

20ME3L1
Strength of Materials Laboratory

Laboratory Manual

Lab In charge

Dr. P. Sabarinath , Associate Professor / Mech.

Prepared by

Dr. P. Sabarinath, Associate Prof. / Mech.

Approved by

Dr. P. Udhayakumar
HOD / Mech. Engg.

DEPARTMENT OF MECHANICAL ENGINEERING

VISION

To become a Centre of excellence for Education and Research in Mechanical Engineering.

MISSION

- **Attaining academic excellence through effective teaching learning process and state of the art infrastructure.**
- **Providing research culture through academic and applied research.**
- **Inculcating social consciousness and ethical values through co-curricular and extra-curricular activities.**

PROGRAM EDUCATIONAL OBJECTIVES (PEOs)

PEO I	**Graduates will have successful career in Mechanical Engineering and service industries.**
PEO II	**Graduates will contribute towards technological development through academic research and industrial practices.**
PEO III	**Graduates will practice their profession with good communication, leadership, ethics and social responsibility.**
PEO IV	**Graduates will adapt to evolving technologies through lifelong learning.**

PROGRAM SPECIFIC OUTCOMES (PSOs)

PSO1	**Derive technical knowledge and skills in the design, develop, analyze and manufacture of mechanical systems with sustainable energy, by the use of modern tools and techniques and applying research based knowledge.**
PSO 2	**Acquire technical competency to face continuous technological changes in the field of mechanical engineering and provide creative, innovative and sustainable solutions to complex engineering problems.**
PSO 3	**Attain academic and professional skills for successful career and to serve the society needs in local and global environment.**

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General Instructions for Laboratory Classes

- Students must attend the lab classes with **ID cards**
- Enter Lab with **CLOSED FOOTWEAR**
- Boys should **"TUCK IN"** the shirts
- Students should wear **uniform only**
- **LONG HAIR** should be protected
- Any other machines/ equipments **should not be operated** other than the prescribed one for that day.
- POWER SUPPLY to your test table should be obtained only through the **LAB TECHNICIAN**
- Do not **LEAN** and do not be **CLOSE** to the machine components.
- **TOOLS, APPARATUS & GUAGE** Sets are to be returned before leaving the Lab.
- **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.

20ME3L1	STENGTH OF MATERIALS LABORATORY	L	T	P	C
		0	0	3	1.5

OBJECTIVES:

- **To understand the fundamental modes of loading of the structures**
- **To measure loads, displacements and strains.**
- **To obtain the strength of the material and stiffness properties of structural elements**
- **To study the mechanical properties of materials when subjected to different types of loading.**
- **To understand the hardening and tempering process**

PREREQUISITE: NIL

LIST OF EXPERIMENTS

1. Tensile test
2. Double shear test
3. Torsion test
4. Impact test
5. Strain Measurement using Single and Tri axial strain gauges.
6. Hardness test - Brinell Hardness Number
7. Hardness test - Rockwell Hardness Number
8. Deflection test on beams
9. Compression test on helical springs
10. Effect of hardening- Improvement in hardness and impact resistance of steels.
11. Tempering- Improvement Mechanical properties Comparison
    (i) Unhardened specimen and
    (ii) Quenched Specimen

TOTAL: 45 PERIODS

OUTCOMES:

AT THE END OF THE COURSE, LEARNERS WILL BE ABLE TO:

- Explain the concept of determining stresses and strains from the member forces.
- Apply the basic concepts and effects of axial loads, shear, and torsion on structural components.
- Determine the young's modulus of beams by means of deflection of beam experiments.
- Calculate the hardness of different materials by means of Brinell and Rockwell hardness experiments.
- Calculate the modulus of rigidity and stiffness of spring by means of open coil and closed coil experiments.
- Calculate the hardness and Physical insight into the behavior materials by means of hardening and tempering experiments.

LIST OF EQUIPMENT FOR A BATCH OF 30 STUDENTS

S.No.	Name of The Equipment	Quantity
1	Universal Tensile Testing machine with double shear attachment	1
2	Torsion Testing Machine	1
3	Impact Testing Machine	1
4	Brinell Hardness Testing Machine	1
5	Rockwell Hardness Testing Machine	1
6	Spring Testing Machine for tensile and compressive loads	1
7	Muffle Furnace	1
8	Rosette strain gauge	1
9	Metallurgical Microscope	1
10	Disc Polishing Machine	1

K.L.N. College of Engineering

Department of Mechanical Engineering

Strength of Materials and Fluid Mechanics and Machinery Laboratory

Semester: IV **Subject Code:** 20ME3L1

List of Experiments

Strength of Materials Laboratory

1. Study of Material Properties
2. Tension Test on Mild Steel Rod on Universal Testing Machine.
3. Torsion Test on Mild Steel Rod.
4. Compression Test on Helical Spring on Tension Testing Machine.
5. Deflection Test on Beam Wood Testing Machine.
6. Hardness Test on Metals Brinell Hardness Testing Machine.
7. Rockwell Hardness & Impact Test - Charpy Type
8. Double Shear Test on Mild Steel Rod and Aluminium Rods on Universal Testing Machine.
9. Tension Test on Helical Spring on Tension Testing Machine.
10. Strain Measurement using Rosette Strain gauge
11. Effect of Hardening – Improvement in hardness and impact resistance of steels.
12. Tempering – Improvement Mechanical properties Comparison.
    (i). Unhardened Specimen
    (ii). Quenched Specimen and
    (iii). Quenched and Tempered Specimen
13. Microscopic Examination of
    (i). Hardened samples and
    (ii). Hardened and Tempered samples.

INDEX

Name : ……………………………………… Batch ………………………….………….

Roll No.:…………………… Year ……………..Section……………………………….....

CONTENTS

S. No.	*Date of Experiment*	*Name of the Experiments*	*Marks Awarded*	*Signature of the Staff*
1.				
2.				
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Ex No : **Date :**

Introduction

Classification of Materials:

The engineering material may be classified as follows:

1. Metals:

(e.g Iron, Aluminium, Copper, Zinc, Lead etc.)

2. Non-Metals:

(Leather, Rubber, Asbestos, Plastics, Carbon, Sulphur, Phosphorus, Timber, Concrete etc.) Metals are further subdivided as:

(i) Ferrous Metals:

(e.g. Cast iron, Wrought iron and Steel) and alloys (e.g. Silicon steel, High speed steel, Spring steel etc.)

(ii) Non-Ferrous Metals:

(Copper, Aluminium, Zinc, Lead etc.) and alloys (Brass, Bronze, Duralumin etc.)

The iron group, which includes all irons and steels, are called ferrous metals whilst other are specified as non-ferrous.

Non-Metals:

The commonly adopted non-metallic materials are leather, rubber, asbestos and plastics. Leather is used for belt drives and as packing or as washers. It is very flexible and will stand considerable wear under suitable conditions. The modulus of elasticity varies according to load. Rubber is used as a packing, belt drive and as an electric insulator. It has a high bulk modulus and must have lateral freedom if used as a packing ring.

Asbestos is used for lagging round steam pipes and steam boilers automobile types etc. Plastic are divided roughly into two classes, called thermoplastic and thermosetting plastics. Materials in the former group become soft and pliable when heated to moderate temperatures and then hardened when cooled. They will soften every time when heat is applied and reworked as often as desired. Thermosetting plastics soften the first time they are heated hardened when cooled and cannot be softened by reheating. Plastics can be moulded, cast, folded into sheets and extruded.

Mechanical Properties of Metals

Strength:

The strength of a material is its ability to sustain failure under the action of applied load. Depending on the type of loading, the strengths are termed as tensile strength, compressive strength, shear strength, flexural strength of a material. The strength may be expressed as

1. Elastic strength
2. Ultimate strength
3. Breaking strength

Elastic Strength:

Elastic strength is determined from the highest stress at which the behaviour of materials remains elastic. It is generally measured by the stress at the end of proportionality limit.

Ultimate Strength

Ultimate strength is the maximum stress sustained by the material before fracture.

Breaking Strength

Breaking strength is the highest stress attained by the material just at the time of breaking.

Stiffness:

The ability of material to resist elastic deformation is called stiffness. It depends on the shape of the structural or machine member. For identical geometries of components, their stiffness is proportional to the elastic modulus of materials.

Elasticity and Plasticity:

Behaviour of a material, by virtue of which the strains (deformations) disappear on removal of load, is known as elasticity. Ability of a material to undergo permanent deformation before rupture is called plasticity. Elasticity is characterized by elastic action, and plasticity by yielding, strain hardening and neck formation.

Resilience, Proof Resilience and Toughness:

Resilience or strain energy is the capacity of a material to absorb energy within elastic limit.

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

Toughness is the strain energy absorbing capacity of material in both elastic and plastic deformation upto fracture.

Ductility and Brittleness:

A material is said to be ductile if it elongates considerably under tension in plastic range. Total elongation is the sum of elastic and plastic elongations. Property of material that enables it to be elongated is known as ductility. Ductility is associated with tensile loading.

A brittle material fractures under tension with negligible plastic elongation. Thus brittleness is the property that restricts elongation generally beyond the elastic limit.

Malleability:

A material that can be pressed into the form of a sheet under compressive load is said to be malleable. Thus malleability is the property that enables a material to be converted into flat sheet. Silver is most malleable metal followed by gold.

Testing of Materials:

Purpose:

Materials are tested for one or more of the following purposes:

1. To assess numerically the fundamental mechanical properties of ductility, malleability, toughness etc.
2. To check chemical composition.
3. To determine suitability of a material for a particular application.
4. To determine data i.e., force deformation (or stress) values to draw up sets of specifications upon which the engineer can base his design.
5. To determine the surface or surface defects in raw materials or processed parts.

Classification of test:

Test on materials may be classified as

1. Non-destructive tests.
2. Destructive tests.

In Non-destructive testing a component does not break and even after being tested, so it can be used for the purpose for which it was made.

Example: Radiography, ultrasonic inspection etc.

In destructive testing the component or specimen either breaks or remains no longer useful for further use.

Example: Tensile test, impact test, torsion test etc.

Non-Destructive Test:

Non-destructive tests may be defined as those which in a specific context would not damage the material being examined to an extent such that it is rendered useless for future for which it was originally meant.

Although non-destructive tests do not provide direct measurement of mechanical properties, yet they are extremely useful in revealing defects in components that could impart their performance when put in service. These test make components more reliable, safe and economical.

The various methods used for non-destructive testing are as follows:

1. X- ray radiography
2. Gama radiography
3. Magnetic particle inspection
4. Ultrasonic testing
5. Electrical methods
6. Damping test.

Destructive Tests (Mechanical Tests):

The component or specimen, after being destructively tested, either breaks or remains no longer useful for further use. Examples of destructive or mechanical test are tensile test, impact test, torsion test, bend test, fatigue test etc.

Importance of Mechanical Tests:

Structures, machines and products of various kinds are usually subjected to load and deformation. Therefore, the properties of material under the action of load and deformation so produced under various environments become an important engineering consideration. The microscopic properties of materials under applied forces or loads are broadly classed as 'mechanical properties'. They area measure of the strength and lasting characteristic of material in service and are of great importance particular to the design engineer.

Unfortunately these properties cannot be desired from the structural or bonding considerations along since most of them are structure-sensitive, are much more affected by crystal imperfection and other factors such as composition, grain size, heat treatment etc. Therefore, mechanical properties do not depend on them in all situations. A great number of mechanical properties are, therefore, best evaluated by mechanical testing of the materials like metals and alloys.

The following important mechanical tests give valuable information about metals and alloys as given below:

S. No.	Name of Test	Information supplied about
1.	Tensile Test	Tensile strength, yield point, elastic limit, young's modulus, ductility, toughness etc.
2.	Impact Test	Toughness of a material under shock loading conditions
3.	Hardness Test	Wear resistance, indentation resistance, scratch resistance or cutting ability of a material.
4.	Fatigue Test	Behaviour of a material under repeatedly applied stress and its endurance limit.
5.	Creep Test	Behaviour of a material under a steady load over a long period of time and creep limit of a material.

Viva Questions:

1. Explain Mechanical properties

a. Ductility d. Hardness g. Fatigue

b. Brittleness e. Strength h. Creep

c. Malleability f. Toughness

Tension Test on Mild Steel Rod

Introduction:

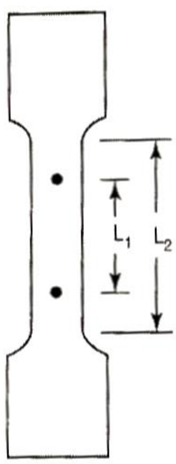
Stress Strain Relation:

The stress strain relation of any material is obtained by conducting tension test in the laboratories on standard specimen. Different materials behave differently and their behaviour in tension and in compression differ slightly.

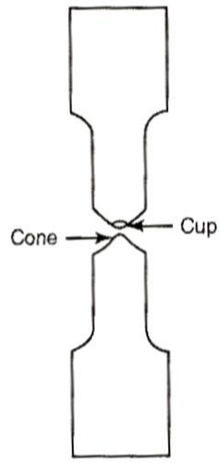
Behaviour in Tension:

Mild Steel:

The Fig. Shows typical tensile test specimen of mild steel. Its ends are gripped into universal testing machine. Extensometer is fitted to test specimen, which measure extension over the length L_1. The length over which extension is measured is called gauge length. The load is applied gradually and at regular interval of loads extension is measured. After certain load, extension increases at faster rate and the capacity of extensometer to measure extension comes to an end and, hence, it is removed before this stage is reached and extension is measured from scale on the universal testing machine. Load is increased gradually till the specimen breaks.

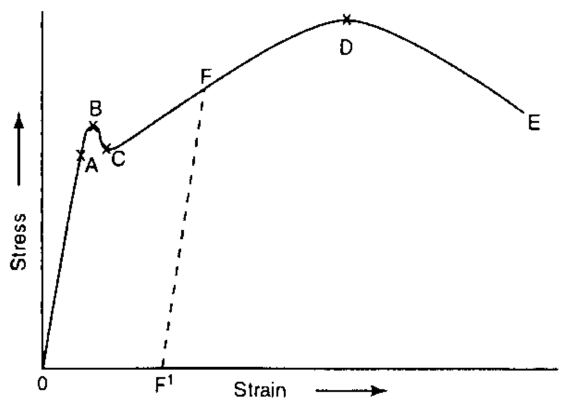


Tension Test



Tension Test Specimen After Breaking

Load divided by original cross sectional area is called as nominal stress or simply as stress. Strain is obtained by dividing extensometer readings by gauge length of extensometer (L_1) and by dividing scale readings by grip to grip length of the specimen (L_2). The Fig. shows Stress Vs Strain diagram for the typical mild steel specimen. The following sailent points are observed on stress strain curve.



a. **Limit of Proportionality (A):** It is the limiting value of the stress up to which stress is proportional to strain.

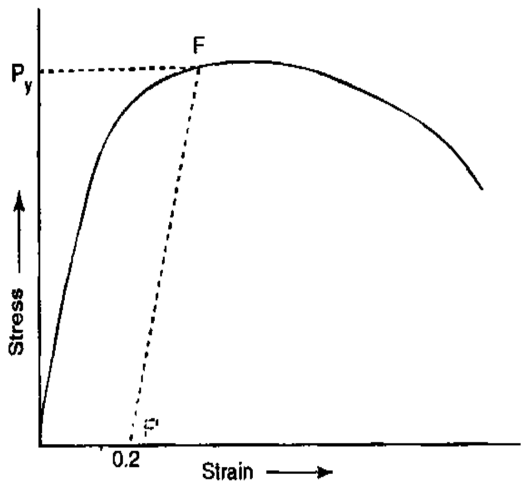
b. ***Elastic Limit:*** This is the limiting value of stress up to which if the material is stressed and then released (Unloaded) strain disappears completely and the original length is regained. This point is slightly beyond the limit of proportionality.

c. **Upper Yield Point (B):** This is the stress at which , the load starts reducing and the extension increases. This phenomenon is called yielding of material. At this stage strain is about 0.125 per cent and stress is about 250 N/mm^2.

d. **Lower Yield Point (C):** At this stage the stress remains same but strain increases for some time.

e. **Ultimate Stress (D):** This is the maximum stress the material can resist. This stress is about 370 – 400 N/mm^2. At this stage cross sectional area at a particular section starts reducing very fast. This is called neck formation. After this stage load resisted and hence the hence the stress developed starts reducing.

f. **Breaking Point (E):** The stress at which finally the specimen fails is called breaking point. At this state strain is 20 to 25 per cent.

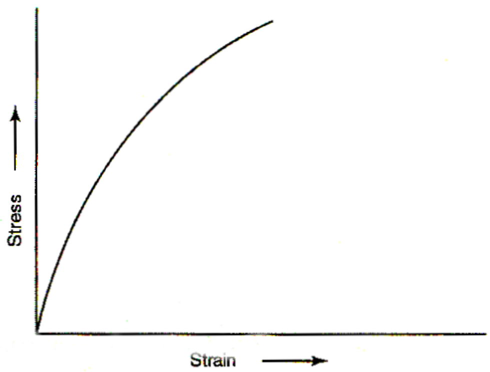


Stress – Strain Relation in Aluminium and High Strength Steel.

If unloading is made within elastic limit the original length is regained i.e. the stress strain curve follows down the loading curve. If unloading is made after loading the specimen beyond elastic limit, it follows a straight line parallel to the original straight portion as shown by line FF. Thus if it is loaded beyond elastic limit and then unloaded a permanent strain (OF) is left in the specimen. This is called permanent set.

Stress – Strain Relation in Aluminium and High Strength Steel:

In these elastic materials there is no clear-cut yield point. The necking takes place at ultimate stress and eventually the breaking point is lower than the ultimate point. The typical



stress strain diagram. The stress p at which if unloading is made there will be 0.2 per cent permanent set is known as 0.2 per cent proof stress and this point is treated as yield point for all practical purposes.

Stress – Strain Relation in Brittle Material:

The Fig. Shows typical stress – strain relation in a brittle material like cast iron. In these materials, there is no appreciable change in rate of strain. There is no yield point and no necking takes place. Ultimate point and breaking point are one and the same. The strain at failure is very small.

Behaviour of Materials Under Compression:

As there is chance of buckling (laterally bending) of long specimen, for compression tests short specimen are used. Hence, this test involves measurement of smaller changes in length. It results into lesser accuracy. However precise measurements have shown the following results.

a. In case of ductile materials stress strain curve follows exactly same path as in tensile test up to and even slightly beyond yield point. For larger values the curves diverge. There will not be necking in case of compression tests.
b. For most brittle materials ultimate compressive stress in compression is much larger than in tension. It is because of flows and cracks present in brittle materials, which weaken the material in tension but will not affect the strength in compression.

This test is mainly used to determine strength, ductility, toughness, resilience and other mechanical properties.

Ex No : ***Date :***

Tension Test on Mild Steel Rod

Aim:

1. To find the Young's Modulus of the specimen.
2. To find the Yield stress, Ultimate stress and Breaking stress.
3. To determine Percentage elongation and Percentage reduction in area of the specimen.
4. To plot the stress-strain diagram.

Specification of the Machine:

Name : Universal Testing Machine.

Capacity : 100 Tonnes

Apparatus Required:

1. Extensometer 2. Vernier Caliper, 3. Scale

Formula:

1. Yield stress = Yield Load / Original cross-section area.
2. Ultimate stress = Ultimate Load / Original cross-section area.
3. Breaking stress = Breaking Load / Original cross-section area.
4. % Elongation = Increase in length / Original Length × 100
5. % Reduction in area = $(\pi / 4) (D^2 - d^2)) / (\pi D^2) / 4$
6. Stress = Load / Area.
7. Strain = Change in length / Original length
8. Young's Modulus (E) = Stress / Strain

Theory:

A tension test is the most applied test of all the mechanical tests. In this test the ends of the specimen are fixed into the grips, of the universal testing machine and an extensometer is fixed at a particular 'gauge length'. When the machine is started it begins to apply a gradually increasing load upon the specimen. At regular intervals the load and elongation of the specimen are recorded. When the applied load is small enough, the deformation is entirely elastic. As the rate of loading increase and crosses a certain limit known as 'Elastic limit' the material experiences a permanent deformation. When a stress-strain curve is drawn as shown in the figure, the initial part of the curve represents the elastic nature. Hook's law states that, within the elastic limit, the stress is directly proportional to the strain. The initial straight line in the curve represents this. Beyond the elastic limit the specimen undergoes plastic

Observation:

Diameter of specimen at top :

Middle :

Bottom :

Average diameter of specimen :

Length of the specimen :

Extensometer gauge length :

Least count of extensometer :

Tabulation:

S.No.	Load		Extensometer Reading (mm)		Extension in (mm)	Stress in (N/mm^2)	Strain in $\times 10^{-4}$	Young's Modulus in $\times 10^5$ (N/mm^2)
	KN	N	Left	Right				
1.								
2.								
3.								
4.								
5.								
6.								
7.								
8.								
9.								
10.								

Yield point load :

Ultimate load :

Breaking load :

Diameter at neck :

Final length of rod :

Where,

D = Original diameter of the rod

d = Neck diameter of the rod

deformation. In mild steel the onset of plastic deformation is denoted by sudden drop in the load, indicating both upper and lower yield point. As the load increases, it passes through a maximum value and then begins to decrease. This gives the ultimate load. Further loading will eventually cause reduction in cross-section area or neck formation and then the specimen breaks into two pieces, which gives the breaking load. Tension test is conducted at room temperature.

Graph:

1. Load Vs Elongation

S. No.	Load KN	Elongation mm
1.		
2.		
3.		
4.		
5.		
6.		
7.		
8.		
9.		
10.		

2. Stress Vs Strain

S. No.	Stress N/mm2	Strain × 10–5
1.		
2.		
3.		
4.		
5.		
6.		
7.		
8.		
9.		
10.		

Model Calculations:

1. Yield stress = Yield Load / Original cross-section area.

2. Ultimate stress = Ultimate Load / Original cross-section area.

3. Breaking stress = Breaking Load / Original cross-section area.

4. % Elongation = Increase in length / Original Length $\times 100$

5. % Reduction in area = $(\pi / 4)\ (D^2 - d^2)) / (\pi D^2\ ) / 4$

6. Stress = Load / Area.

7. Strain = Change in length / Original length

8. Young's Modulus (E) = Stress / Strain

Procedure:

1. Measure the diameter of the specimen at top, middle and bottom and determine the average diameter.
2. Leaving a clear space of 70mm at either ends, measure the length of the specimen and mark.
3. Assume 500KN as the average ultimate tensile stress of steel, and calculate the maximum load the specimen will take. Choose a range at a higher order accommodate the calculated load.
4. Switch on the machine. Fix the specimen between the jaws and set the pointer at zero.
5. Fix the extensometer at the middle of the rod.
6. Start the machine and apply the load gradually.
7. Record the load and extensometer readings at regular intervals and at the elastic limit remove the extensometer.
8. Obtain the yield point load when the pointer drops back, or stands still for a few seconds.
9. Increase the rate of loading and record the ultimate load.
10. Record the breaking load, observed at the time of hearing the breaking sound.
11. Remove the specimen and measure the 'neck' diameter and total elongation.
12. Plot a graph connecting stress and strain.

Graph:

1. Load Vs Elongation
2. Stress Vs Strain

Inference:

Student can obtain knowledge practically about Young's Modulus of a material.

Application:

This knowledge can be used while designing element for particular purpose.

Result:

1. Yield stress :
2. Ultimate stress :
3. Breaking stress :
4. Percentage Elongation :
5. Percentage Reduction in area :
6. Young's Modulus (E) :

Viva Questions:

1. Which steel have you tested?
2. What general information are obtained from tensile test regarding the properties of a material?
3. Which stress have you calculated, nominal stress or true stress?
4. What kind of fracture has occurred in the tensile specimen and why?
5. Which is the most ductile metal?

Observation:

Test - I

Test specimen :

Diameter of the specimen :

Length of the specimen :

Cross-section area :

Ultimate shear load :

Test - II

Test specimen :

Diameter of the specimen :

Length of the specimen :

Cross-section area :

Ultimate shear load :

Model Calculations:

1. Cross-section are =

2. Ultimate shear strength =

Model Calculations:

1. Ultimate shear strength = Ultimate load / (2 × Cross-section area)

Ex No : ***Date :***

Double Shear Test

Aim:

To find the shear strength of the given material.

Specification of the machine:

Name : Universal Testing Machine

Capacity : 100 Tonnes.

Apparatus required:

1. Vernier caliper 2. Scale

Formula:

Ultimate shear strength = Ultimate load / (2 × Cross-section area)

Theory:

A force which is parallel to the lateral dimension and perpendicular to the longitudinal axis of the rod is called shear force. Failure caused by this force is called shear failure. There are two types of shear namely double shear and twisting shear.

In double shear, the force is perpendicular to the longitudinal axis. In twisting shear, the force is parallel to the circumferential surface of the rod.

In the double shear attachment, there are two strips with a gap between them like a rectangular channel in the bottom die. A bottom die is inserted inside the gap of the bottom die. A hole is present in common to the top and bottom die, in which a shearing ring is inserted. This attachment is connected with the platens of the Universal testing machine. The specimen is inserted in the shearing ring. The moving plate of the UTM is activated. The material shears of at the two sides of the top die.

Procedure:

1. The top die is placed in the gap in the bottom die.
2. The specimen is inserted through the shearing rings which are coaxial.
3. Switch on the machine and the specimen is loaded.
4. The load is indicated in the dial and the at the time of failure, the black indicator returns back and the red indicator gives the ultimate load.

Inference:

Student can obtain knowledge of shear strength of a material. He can compare young's modulus and shear strength of a material.

Application:

This knowledge can be used while designing element.

Result:

1. The shear strength of the given M.S rod :
2. Aluminium rod :

Viva Questions:

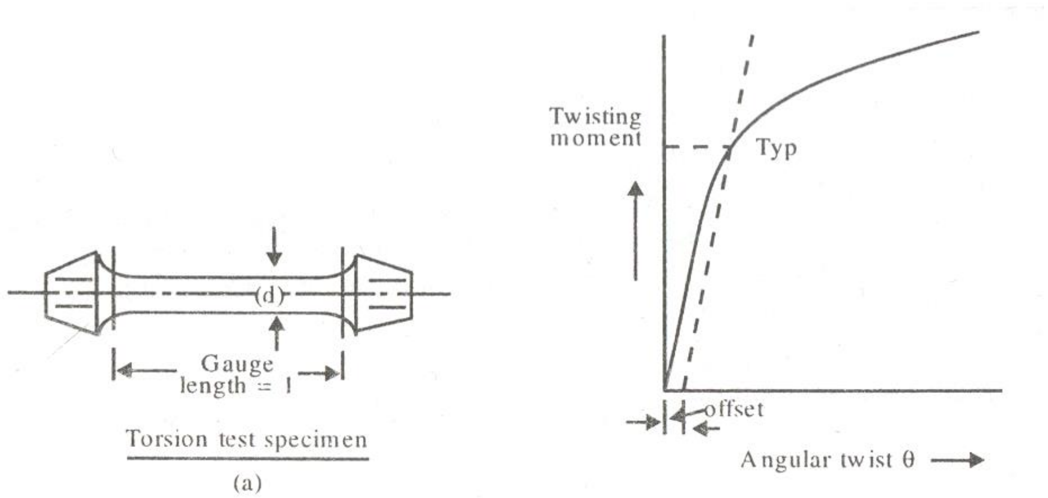
1. What is double shear?
2. What is find in shear test?
3. What is the unit of shear strength?

Torsion Test

Introduction:

Behaviour of Materials Under Torsion:

Torsion tests are performed on materials to determine properties such as Modulus of rigidity, yield strength and modulus of rupture. Parts such as shafts, axles and drills are subjected to torsional loading in service and torsion test is performed on such full sized members otherwise a test specimen is made on which the test is performed. The specimen generally has circular cross section and in the elastic range, shear stress varies linearly from



zero at the center to the maximum at the surface. In the case of thin walled tube, shear stress in nearly uniform over the cross section of the specimen and it is preferable to use thin walled tube specimens for the determination of yield strength and modulus of rupture.

The torsion test specimen is gripped in the chucks of a torsion testing machine. Twisting moment is gradually applied on the twisting head gripping one end of the specimen and torque T is measured on the weighing head connected to the other end of the specimen. Angular twist θ is measured with the help of a troptometer near one end of the test section with respect to the test section of the specimen at the other end. A torque Vs θ (angular twist) diagram usually obtained for a ductile material.

The elastic properties in torsion may be obtained by using the torque at the proportional limit or the torque at some offset angle of twist, generally 0.04 radian / meter of gauge length, and calculating the shear stress at the twisting moment T_{yp}, using the torsion formula where T_{yp} is the torque at the yield point.

Because of stress gradient across the radius of the solid shaft, the surface fibres are restrained from yielding by the lesser stressed inner fibres. There fore, the first onset of yielding is not readily apparent. The use of a thin-walled tubular specimen minimizes this effect because the shear stress is nearly uniform in the section of tube. However, an ultimate tensional shear strength or modulus of rupture is frequently determined by using T_{max} in the torsion formula.

Modulus of rigidity, $G = Tl / J\theta$

Where

θ = Angular twist within elastic limit corresponding to torque T.

Polar moment of inertia $J = \pi d^4 / 32$

Modulus of rupture, $\tau_r = T_{max} / J \times d / 2$

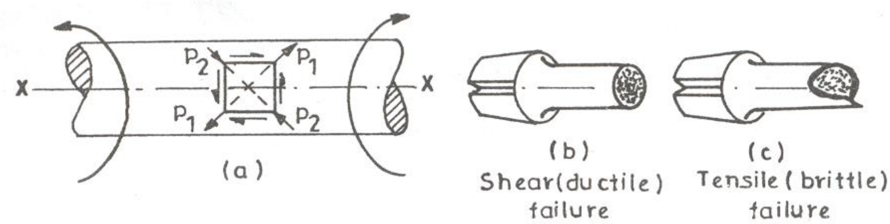
Where

d = diameter of solid circular section

l = Gauge length of the specimen

Torsion Failure:

The state of stress at a point on the surface of the circular specimen tested under torsion. The maximum shear stress occurs on two mutually perpendicular planes, parallel and perpendicular to the longitudinal axis XX of the specimen. The principal stresses p_1 and p_2



make an angle of 45° with the longitudinal axis and are equal in magnitude to the shear stresses, p_1 is a tensile stress and p_2 is an equal compressive stress.

Torsion failures are different from tensile failures. Ductile materials fail in tension after considerable elongation and reduction in area, and showing cup and cone type fracture while in torsion a ductile material fails by shear along one of the planes of maximum shear stress. Generally the plane of fracture is normal to the longitudinal. A brittle material fails in torsion along a plane perpendicular to the direction of the maximum tensile stress. This plane bisects the angle between the two planes of maximum shear stress and makes an angle of 45° with the longitudinal axis, resulting in a helical fracture.

Ex No : ***Date :***

Torsion Test on Mild Steel

Aim:

To conduct torsion test on mild steel specimen to find out modulus of rigidity.

Apparatus Required:

1. Torsion testing machine.
2. Standard specimen of mild steel.
3. Steel rule
4. Verniercaliper.

Formula Used:

Where

D = Diameter J = Polar M.I.

J = $\pi d^4 / 32$

1. Modulus of Rigidity (C) = $Tl / J\theta$

2. Stress at limit of Proportionality (f_s) = $T \times R / J$

Theory:

A torsion test is quite instrumental in determining the value of modulus or rigidity (ratio of shear stress to shear strain) of a metallic specimen. The value of modulus of rigidity can be found out through observations made during the experiment by using the torsion equation.

$$\frac{T}{J} = \frac{C\theta}{I} = \frac{f_s}{R}$$

Where,

T	=	torque applied.	I	=	length of the specimen.
J	=	polar moment of inertia.	f_s	=	shear stress.
C	=	modulus of rigidity.	R	=	radius of rod.
θ	=	angle of twist (radians).			

Observations:

1. Gauge length :
2. Dia of rod Top :

   Middle :

   Bottom :

Tabulation:

S.No.	Dial Readings (Kgf cm)	Angle of twist (θ) (in degrees)		Torque (T) (N mm)	Modulus of Rigidity (C) (N/mm^2)	Shear stress (f_s) (N/mm^2)
		Degree	radians			
1.						
2.						
3.						
4.						
5.						
6.						

Model Calculations:

Where

D = Diameter *J = Polar M.I.*

$$J = \frac{\pi d^4}{32}$$

1. Modulus of Rigidity (C) = $Tl / J\theta$

2. Stress at limit of Proportionality (f_s) = $T \times R / J$

Procedure:

1. Select the driving dogs to suit the size of the specimen and clamp it in the machine by adjusting the length of the specimen by means of a sliding spindle.
2. Measure the diameter at about three places and take the average a value.
3. Choose the appropriate range by capacity.
4. Fix the specimen between the center.
5. Set the initial torque to zero and note the dial reading.
6. Load the machine in suitable increments, observing and recording strain readings.
7. Record the ultimate torque.
8. Plot the graph angle of twist (θ) Vs Torque T (N)

Graph:

Angle of Twist Vs Torque

Inference:

Student can differentiate Modulus of Elasticity and modulus rigidity

Application:

This knowledge used during designing of elements.

Result:

1. Shear stress (f_s) =
2. Modulus of Rigidity =

Viva Questions:

1. What is torsional bending?
2. What is axial load?

Impact Test

Introduction:

Impact test measures the strength of a material under dynamic loading. In impact test, the material is subjected to sudden (impact) load. For this, a hammer is made to swing from a fixed height and strike the standard impact specimen.

Impact test determines the behaviour of materials in different conditions, namely.

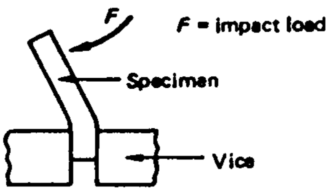
1. Deformation at a relatively low temperature.
2. A high strain rate, and
3. A triaxial stress state (which may be introduced by the presence of a notch).

Impact strength of a material is defined as the capability of the material to absorb energy without failure under impact loading.

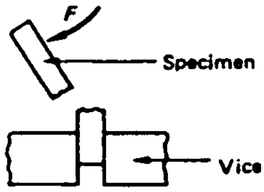
Toughness:

It is the total energy absorbed by a material before fracturing. A tough material is resistant to crack propagation.

Toughness is a combination of strength and ductility. The material which is tough must have the ability to resist permanent deformation and also deform before braking. A material that only deforms excessively is not strong, similarly a material that breaks suddenly without yielding has poor ductility i.e., Brittle. Hence both strength (i.e., the yield strength should be high) and ductility (ability to undergo plastic deformation) must be more.

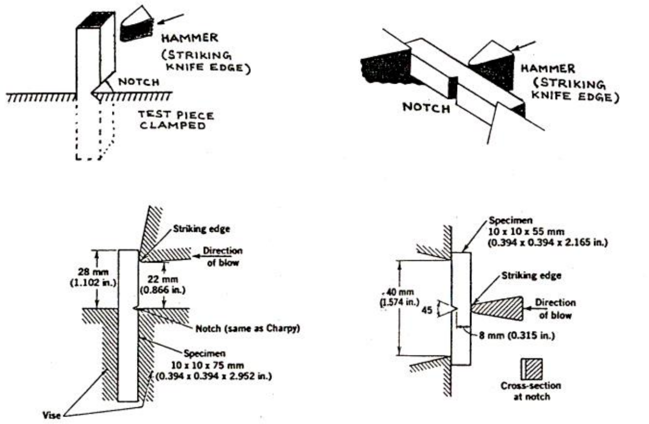


Tough: Bends when hit



Brittle: Breaks (shatters) when hit

To measure the impact energy (also termed notch toughness) there are two standardized test.



1. Charpy impact test 2. Izod impact test

In both the cases, the standard specimen is in the form of a notched beam. In charpy test the specimen is placed as simply supported beam while in Izod test as cantilever beam.

Standard size of these specimen are shown in related figures. The specimens have standard V – shaped notch of 45°. Notches of U – shape and keyhole – shape are also common. The notch is located on the tension side of the specimen during impact loading. Depth of the notch is generally taken as t/5 to t/3 where t is the thickness of the specimen.

Purpose of keeping a notch on the tension side is double fold. First purpose is that the stress raises to a peak value at the base of the notch due to elastic stress concentration. Second is that the yield stress is raised due to elastic and plastic actions. The two effects combine together and break the specimen due to brittle fracture more readily in presence of a sharp notch than in an unnotched specimen. The nature of a ductile material to behave as brittle material in the presence of a notch is called notch sensitivity.

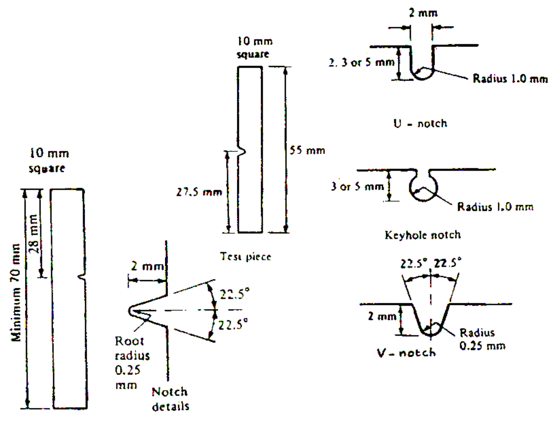


Fig. Standard Izod test piece for a metal

Fig. Standard charpy test piece for a metal

S. No.	Consideration	Charpy test	Izod test
1.	Placement of specimen	Easier on machine as specimen is centrally located	Needs adjustment in location of specimen
2.	Temperature suitability	Better for low temperature tests	Suitable for room and high temperature tests
3.	Type of beam	Simply supported	Cantilever
4.	Strike of hammer	On the opposite side of the notch	On the same side of the notch
5.	Length of the specimen	Smaller	Longer
6.	Cross-section of the specimen	Equal	Equal
7.	Falling height of the hammer	From topmost height	From certain predetermined height
8.	Angle of strike α	α > 90°, normally 160°	α ≤ 90°, normally 90°

The ideal impact test would be one in which all the energy of a blow is transmitted to the test specimen.

Energy possessed by the pendulum is used to rupture the specimen and the pendulum rises on the other side of the machine to a height lower than its initial height on the opposite side of the impact testing machine.

This energy in Joules is the notch toughness or impact strength. Impact strength of material is governed by many factors such as temperature, heat strength chemical composition and grain size.

Effect of Variables:

Impact test results are affected by the following factors.

(i) Velocity:

This is the velocity of the striking hammer. The velocity of 3 to 5 m/sec does not affect the test results. Above some critical velocity the impact resistance decreases. Hence the velocities are kept below the critical velocity.

(ii) Specimen:

Decrease in either width or thickens affects the energy absorbed by a specimen. This is due to the decrease in the volume of the specimen.

(iii). Notch Effect:

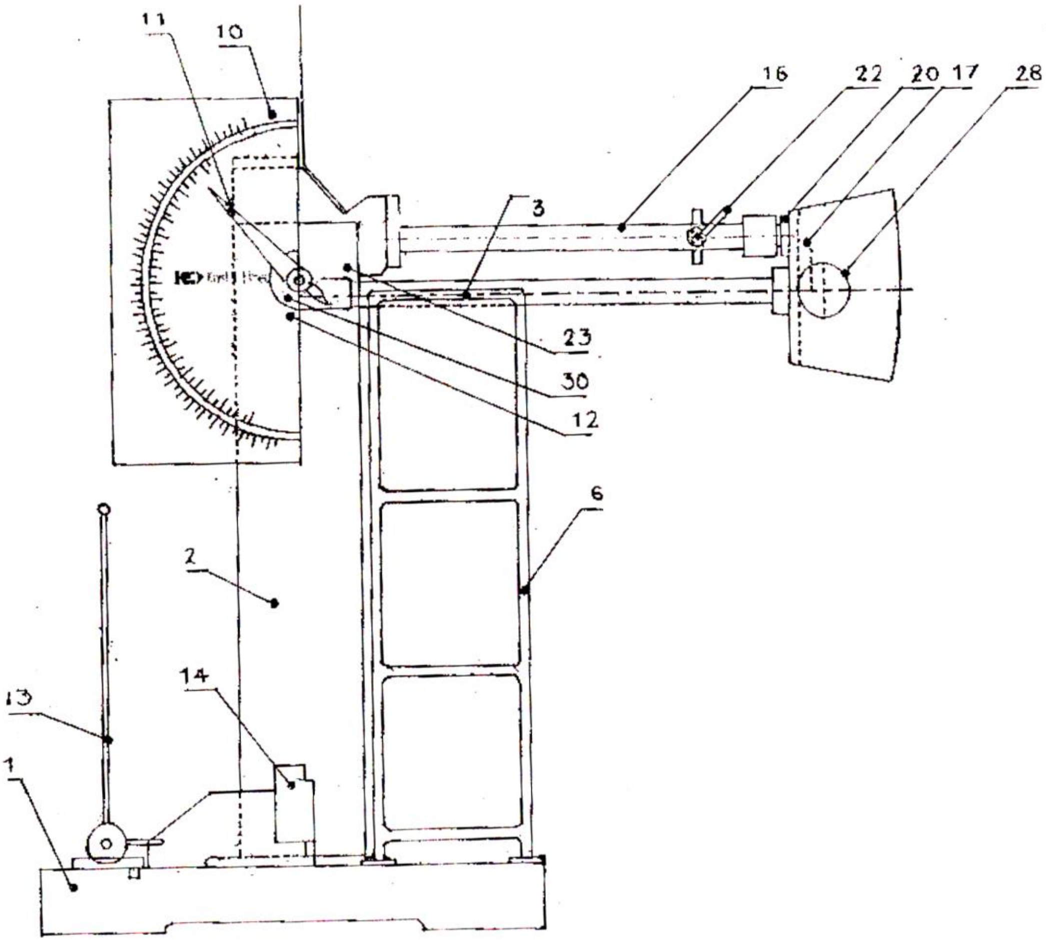
As the sharpness of V – notch increases, the energy of rupture decreases, this is due to the increase in the stress concentration caused due to the sharpness of the V – notch. A notch of less than 60° does not affect the results.

(iv). Ductile to brittle transition temperature:

Under certain situation a ductile material fails in the brittle manner in the service and such a failure causes lower absorptions of energy. One of the factors that contribute to the brittle type of fracture is low temperature. The temperature at which a ductile material fails in the brittle manner is called ductile – brittle transition temperature.

In many operations, as well as during the service life of components, materials are subjected to impact (or *dynamics)* loading, as in high – speed metal working operations such as drop forging. Impact tests are particularly useful in determining the ductile to brittle transition temperature of materials. Materials that have impact resistance are generally those that have high strength and high ductile, hence high toughness. Sensitivity to surface defects *(Notch Sensitivity)* is important as it lowers impact toughness. Materials which show identical properties when tested in tension, however they show different properties when tested under an impact load. Impact tests are used to determine the ability of the materials to withstand impact or shock or suddenly applied load while in service. Impact test also helps to determine the tendency of certain ductile materials to behave in a brittle manner while in service.

Impact Test (Izod)



List of Parts

1. Base with specimen support fitted	14. Specimen Support
2. Column	16. Latching tube for Izod test
3. Pendulum Pipe	17. Striker for Izod test
6. Guard	20. Latch for Izod test
11. Reading Pointer	22. Lever to release the Pendulum
12. Pointer Carrier	23. Bearing Housing
13. Brake for Pendulum	30. Pendulum Shaft.

Ex No : ***Date :***

Impact Test (Izod)

Aim:

To determine the Impact toughness of the given specimen by Izod impact test.

Specification of the machine:

Name	:	Impact testing machine
Capacity	:	168 Joules.
Least count	:	2 Joules.

Apparatus Required:

1. Vernier caliper 2. Scale

Formula:

Impact Strength = Energy absorbed / Area of cross- section

Theory:

A simple tensile test does not reveal the brittle nature of the metals. The tensile test data alone is not perfectly reliable for a material, because a material may be capable of carrying heavy loads when it is gradually applied and the same material may fail when subjected to a less but sudden load. Hence it is necessary to test the material under shock or sudden load. A heavy load applied suddenly at a very small period of time is impact.

A swinging hammer is made to strike the specimen held firmly in the specimen holder. The pendulum weight is lifted and clamped to a particular height and when it is released it carries an energy of 168 Joules. When it strikes the specimen some energy is absorbed by the material specimen. This energy absorbed gives a count of the toughness strength. Toughness is the property of the material by which it is capable of withstanding heavy shock. Brittle fracture tendency in the material develops due to i) The triaxial state of stress at the notch. ii) Low temperature and iii) Rapid rate of loading.

The test specimen shall be 75 mm long and of square section with 10 mm sides. At a distance of 28 mm from one end a notch shall be carefully prepared for a depth of 2mm, at an angle of 45°.

Observation:

Size of the specimen : $75 \times 10 \times 10$ mm

Position of 'V' notch : 28 mm from one end of the specimen

S. No.	***Specimen***	***Behaviour of specimen***	***Energy absorbed by bearing friction (J)***	***Energy absorbed by the specimen (J)***	***Residual energy in the pendulum (J)***	***Impact strength (J/m^2)***
1.						
2.						
3.						
4.						

Model Calculations:

1. Area of cross- section = $10 \times 8 = 80$ mm

2. Impact Strength = Energy absorbed / Area of cross- section

Procedure:

1. Raise the hammer and lock it.
2. Set the pointer to the maximum energy of the dial.
3. Release the trigger and allow the pendulum to swing, which in turn actuates the pointer in the dial.
4. Record the energy absorbed by friction in bearing, as shown by the pointer in the dial.
5. Raise the pendulum hammer and lock it in position.
6. Place the specimen in the support and clamp it as cantilever, keeping the 45° V – notch horizontally in the direction of the striking edge of the hammer.
7. Set the pointer to read the maximum energy marked in the dial.
8. Release the pendulum to strike the specimen.
9. Record the energy absorbed by the specimen and the Residual energy in the pendulum.

Inference:

Student can understand the difference between shear strength and Impact strength

Application:

This knowledge can be utilized while designing.

Result:

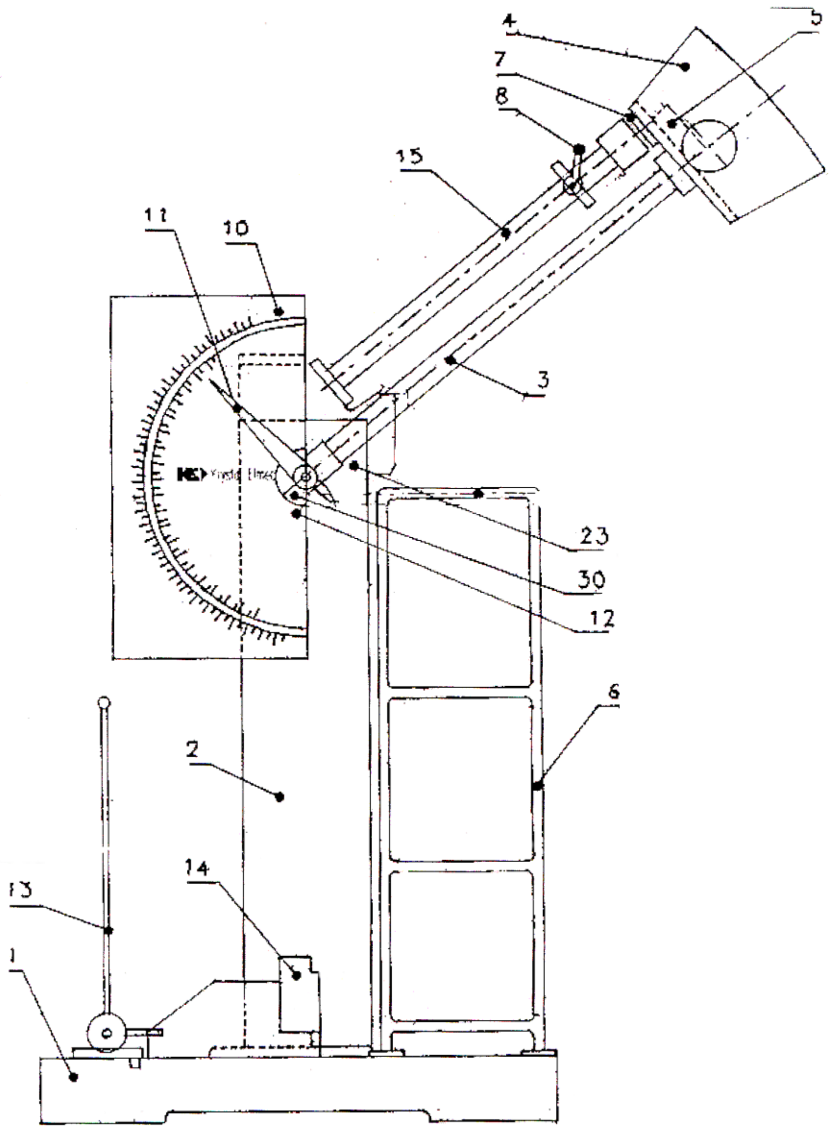
The impact strength of the given specimen:

Viva Questions:

Impact test - Izod and charpy test

1. What is resilience? How is it different from proof resilience and toughness?
2. What is the necessity of making a notch in impact test specimen ?

Impact Test (Charpy)



List of Parts

1. Base with specimen support fitted	11. Reading Pointer
2. Column	12. Pointer carrier
3. Pendulum Pipe	13. Brake for Pendulum
4. Pendulum Hammer	14. Specimen Support
5. Striker for Charpy Test	15. Latching tube for Charpy Test
6. Guard	23. Bearing Housing
7. Latch for Charpy Test	30. Pendulum Shaft
8. Lever to release the Pendulum	

Ex No : ***Date :***

Impact Test (Charpy)

Aim:

To determine the Impact toughness of the given specimen by Charpy impact test.

Specification of the Machine:

Name	:	Impact testing machine
Capacity	:	300 Joules.
Least count	:	2 Joules.

Apparatus Required:

1. Vernier caliper 2. Scale

Formula:

Impact Strength = Energy absorbed / Area of cross- section

Theory:

A simple tensile test does not reveal the brittle nature of the metals. The tensile test data alone is not perfectly reliable for a material, because a material may be capable of carrying heavy loads when it is gradually applied and the same material may fail when subjected to a less but sudden load. Hence it is necessary to test the material under shock or sudden load. A heavy load applied suddenly at a very small period of time is impact.

A swinging hammer is made to strike the specimen held firmly in the specimen holder. The pendulum weight is lifted and clamped to a particular height and when it is released it carries an energy of 300 Joules. When it strikes the specimen some energy is absorbed by the material specimen. This energy absorbed gives a count of the toughness strength. Toughness is the property of the material by which it is capable of withstanding heavy shock. Brittle fracture tendency in the material develops due to i) The triaxial state of stress at the notch. ii) Low temperature and iii) Rapid rate of loading.

The test specimen shall be 75 mm long and of square section with 10 mm sides. At a distance of 28 mm from one end a notch shall be carefully prepared for a depth of 2mm, at V – type.

Observation:

Size of the specimen : 75 × 10 × 10 mm

Position of 'V' notch : 28 mm from one end of the specimen

S. No.	*Specimen*	*Behavior of specimen*	*Energy absorbed by bearing friction (J)*	*Energy absorbed by the specimen (J)*	*Residual energy in the pendulum (J)*	*Impact strength (J/m^2)*
1.						
2.						
3.						
4.						

Model Calculations:

1. Area of cross- section = $10 \times 8 = 80\ mm^2$

2. Impact Strength =

Procedure:

1. Raise the hammer and lock it.
2. Set the pointer to the maximum energy of the dial.
3. Release the trigger and allow the pendulum to swing, which in turn actuates the pointer in the dial.
4. Record the energy absorbed by friction in bearing, as shown by the pointer in the dial.
5. Raise the pendulum hammer and lock it in position.
6. Place the specimen in the support and clamp it as cantilever, keeping the V – notch horizontally in the direction of the striking edge of the hammer.
7. Set the pointer to read the maximum energy marked in the dial.
8. Release the pendulum to strike the specimen.
9. Record the energy absorbed by the specimen and the Residual energy in the pendulum.

Inference:

Student can understand the difference between shear strength and Impact strength

Application:

This knowledge can be utilized while designing.

Result:

The impact strength of the given specimen =

Viva Questions:

Impact test - Izod and charpy test

1. What is the necessity of making a notch in impact test specimen ?
2. If the sharpness of V-notch is more in one specimen than the other, what will be its effect on the test result?
3. What is difference between Izod and Charphy test?

Ex No : ***Date :***

Hardness

Introduction:

Hardness is defined as the ability of a material to resist surface abrasion. The various hardness tests depend upon.

1. Nature of scratch
2. Nature of indentation
3. Nature of rebound

Moh's test:

The relative hardness of minerals is assessed by using Moh's Scale. This is the oldest method used by the mineralogists. This consists of a list of materials arranged in order that any mineral in the list will scratch any one below it. Thus diamond, the hardest known material, is on the top of the list with a hardness index of 10 whilst talc is at the bottom of the list with a hardness index of 1.

Mineral	*Hardness index*
Diamond	10
Corundum	9
Topaz	8
Quartz	7
Feldspar	6

Mineral	*Hardness index*
Apatite	5
Fluorite	4
Calcite	3
Gypsum	2
Talc	1

The surface hardness of any substance can be related to Moh's scale by determining which of these standard substances will just scratch it.

Rebound hardness:

Hardness measurements are sometimes made by dropping a hard object on the surface and observing the height of its rebound. Usually a diamond point is used to strike the surface. As it falls its potential energy is converted into the kinetic energy. A part of this kinetic energy is stored in the form of recoverable elastic strain energy in the surface and a part is dissipated in producing plastic deformation. The amount of strain energy stored depends upon the yield point, stiffness and damping capacity of the material. All the elastic strain energy is not recovered in the form of rebound of indentor due to the internal friction of the metal. So the rebound hardness measures a combination of hardness, stiffness and damping capacity of the material.

In the shore stereoscope test, a pointed hammer is allowed to fall from a height of 25.4 cm, within a glass tube, which has graduated scale inscribed on it. The standard hammer is approximately 6.35 mm diameter, 1.9 cm long and 2.4 gm weight with a diamond-striking tip of radius 0.25 mm. The scale is graduated in 140 divisions. A rebound of 100 is approximately equivalent to the hardness of martens tic high carbon steel.

Nature of Indentation:

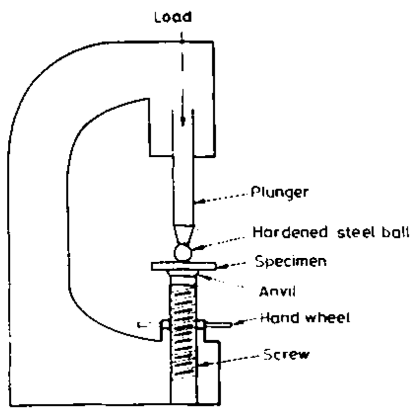
But for most of the engineering practice the hardness test depends upon the Nature of indentation.

Indentation hardness measures the resistance against indentation. Indentation hardness number is dependent on the nature of indenter. The shape of indenters may be a spherical ball, a cone or a pyramid.

Requirement of indenter:

1. Indenter should be relatively harder than that of the material being under test.
2. Indenter is mostly made up of hardened steel, sintered tungsten carbide or diamond.

Requirement of the specimen being tested:

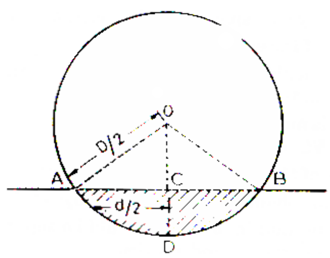


1. Indentation should not be near the edge of the specimen.
2. Two-indentation impression should be separated by thrice the diameter of previous indentation.
3. Thickness of the specimen should be >10½ times that of impression.
4. Indentation should be perpendicular to the specimen.

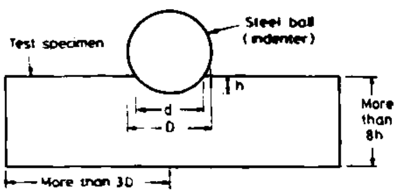
Various hardness test methods are:

1. Brinell's hardness test 2. Rockwell's hardness test

3. Vicker's hardness test 4. Knoop's hardness test



Brinell's hardness test:



This test was devised by a Swede, Dr. Johann Brinell is 1900. In this test a hardened steel ball is forced into the surface of the test specimen using an appropriate specified load. Normally load is applied for 30 sec for soft materials and 15 sec for hard material. The diameter of the indentation is measured and the Brinell's Hardness Number (BHN) is derived from.

BHN = Load (P) / Surface area of indentation

Where

$$BHN = P / (\pi D/2)\left(D - \sqrt{D^2 - d^2}\right)$$

D = diameter of steel ball

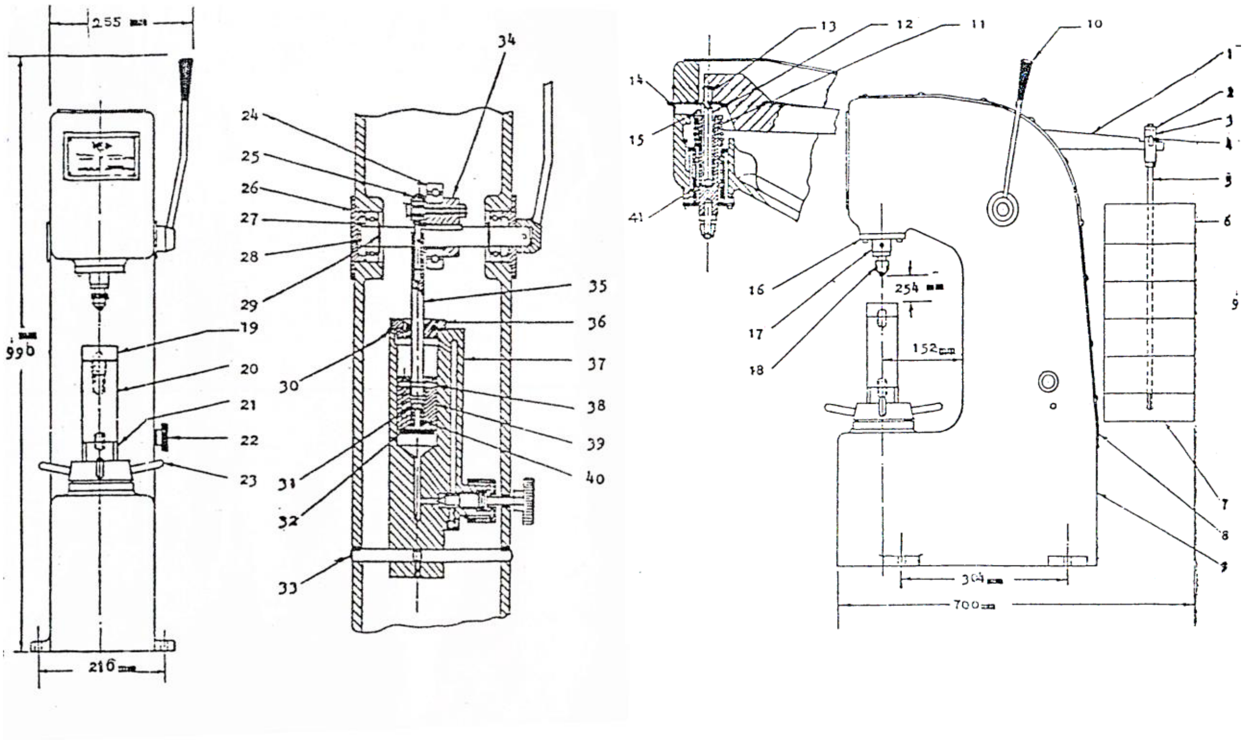
d = diameter of indentation or impression

This gives the unit kgf / mm^2 but hardness values are always quoted as hardness number.

In Brinell's hardness test the important points are:

1. Brinell's hardness test gives the hardness of material in terms of BHN, which is proportional to tensile strengths.
2. The hardened steel ball indenter is used to test the specimen.
3. Width of the test specimen should not be less than 8 times the depth of the indentation / impression.
4. Indentation mark on the test specimen should not be less than 3 times the diameter of indenter.
5. The diameter of indentation d = 0.3 D to 0.6 D.
6. Brinell's hardness test is not correct for BHN more than 500.
7. Brinell hardness test is best for measuring hardness of grey iron and hard iron carbide.

Brinell Hardness Test



List of Parts

1. Main lever	2. Hanger	3. Hanger Vee (Female)
4. Hanger Vee (Male)	5.Weight Hanger	6. Weight
7. Bottom Weight	8. Cover	9. Frame
10. Operating lever	11. Spindle Spring	12. Spindle Shaft
13. Main Knife Edge	14. Pivot Vee	15. Pivot Vee
16. Spindle Bushing	17. Spindle	18. Ball Holder
19. Flat Anvil	20. Adaptor	21. Elevating Screw
22. Metering Valve	23. Hand Wheel	24. Bearing No.6215
25. Rod End	26. Cam Shaft Cover	27. Bearing No.6205
28. Cam Shaft	29. Circlip	30. Washer
31. Valve Disc Screw	32. Valve Disc	33. Trunion
34. Case	35. Connecting Rod	36. Cylinder Cover
37. Cylinder	38. Dowel Pin	39. Piston
40. Valve Spring	41. Ball Cage	

Ex No : ***Date :***

Brinell Hardness Test

Aim:

To find the Brinell Hardness Number for the given specimen.

Name of the machine:

Brinell Hardness Testing Machine

Apparatus required:

1. Brinell micrometer, 2. 10 mm diameter ball indenter.

Formula used:

$$\text{Brinell Hardness Number (BHN)} = P / (\pi D/2)\left(D - \sqrt{D^2 - d^2}\right)$$

When,

P – Load.

D – Diameter of the steel ball indenter.

d – Diameter of the indentation.

Reference Table:

S. No.	***Material***	***Value of*** $P \times D^2$	***Load Select*** $P \times D \times D$
1.	Hard materials like steel	30	
2.	Bross	10	
3.	Copper, Aluminium	5	

Theory:

Hardness is the property of a material by which it offers a great resistance to scratch, wear, abrasion or indentation. If the hardness of a material is more, the resistance to indentation is more. Therefore depth of penetration is inversely proportional to the hardness of the material.

The indenter is first placed upon the surface and the specific load is applied gradually. When the load is removed an indentation is left upon the surface.

The diameter of the indentation is measured by a low power microscope. Using the diameter of indentation and the diameter of indenter, the area of indentation can be calculated. The ratio of the load to the area of the indented surface is defined as the Brinell Hardness Number (BHN)

Tabulation:

S.No.	Material	Load applied (Kgf)	Indenter used	Diameter of Indentation				Brinell Hardness Number
				d_1	d_2	d_3	Avg.	
1.								
2.								
3.								
4.								
5.								
6.								

Model calculations:

1. **Brinell Hardness Number (BHN)** = $P / (\pi D/2)\left(D - \sqrt{D^2 - d^2}\right)$

25. TABLE FOR BRINELL HARDNESS NUMBER

HB (kg/mm²) BRINELL D - 5 mm

d (mm)	P (kg.) 750	P (kg.) 250	d (mm)	P (kg) 750	P (kg) 250	d (mm)	P (kg.) 750	P (kg.) 250	d (mm)	P (kg.) 750	P (kg.) 250
1.26	592	197	1.71	317	106	2.16	195	64.9	2.61	130	43.3
1.27	582	194	1.72	313	104	2.17	193	64.2	2.62	129	42.9
1.28	573	191	1.73	309	103	2.18	191	63.6	2.63	128	42.6
1.29	564	188	1.74	306	102	2.19	189	63.0	2.64	127	42.2
1.30	555	185	1.75	302	101	2.20	187	62.4	2.65	126	41.9
1.31	547	182	1.76	298	99.5	2.21	185	61.8	2.66	125	41.5
1.32	538	179	1.77	295	98.3	2.22	184	61.2	2.67	124	41.2
1.33	530	177	1.78	292	97.2	2.23	182	60.6	2.68	123	40.9
1.34	522	174	1.79	288	96.1	2.24	180	60.1	2.69	122	40.5
1.35	514	171	1.80	285	95.0	2.25	179	59.5	2.70	121	40.2
1.36	507	169	1.81	282	93.9	2.26	177	59.0	2.71	120	39.9
1.37	499	166	1.82	278	92.8	2.27	175	58.4	2.72	119	39.6
1.38	492	164	1.83	275	91.7	2.28	174	57.9	2.73	118	39.2
1.39	485	162	1.84	272	90.7	2.29	172	57.3	2.74	117	38.9
1.40	477	159	1.85	269	89.7	2.30	170	56.8	2.75	116	38.6
1.41	471	157	1.86	266	88.7	2.31	169	56.3	2.76	115	38.3
1.42	464	155	1.87	263	87.7	2.32	167	55.8	2.77	114	38.0
1.43	457	152	1.88	260	86.6	2.33	166	55.2	2.78	113	37.7
1.44	451	150	1.89	257	85.8	2.34	164	54.8	2.79	112	37.4
1.45	444	148	1.90	255	84.9	2.35	163	54.3	2.80	111	37.1
1.46	438	146	1.91	252	84.0	2.36	161	53.8	2.81	110	36.8
1.47	432	144	1.92	249	83.0	2.37	160	53.3	2.82	110	36.5
1.48	426	142	1.93	246	82.1	2.38	158	52.8	2.83	109	36.3
1.49	420	140	1.94	244	81.3	2.39	157	52.3	2.84	108	36.0
1.50	415	138	1.95	241	80.4	2.40	156	51.9	2.85	107	35.7
1.51	409	136	1.96	239	79.6	2.41	154	51.4	2.86	106	35.4
1.52	404	135	1.97	236	78.7	2.42	153	51.0	2.87	105	35.1
1.53	398	133	1.98	234	77.9	2.43	152	50.5	2.88	105	34.9
1.54	393	131	1.99	231	77.1	2.44	150	50.1	2.89	104	34.6
1.55	388	129	2.00	229	76.3	2.45	149	49.6	2.90	103	34.3
1.56	383	128	2.01	226	75.5	2.46	148	49.2	2.91	102	34.1
1.57	378	126	2.02	224	74.7	2.47	146	48.8	2.92	101	33.8
1.58	373	124	2.03	222	73.9	2.48	145	48.4	2.93	101	33.6
1.59	368	123	2.04	219	73.2	2.49	144	47.9	2.94	99.9	33.3
1.60	363	121	2.05	217	72.4	2.50	143	47.5	2.95	99.2	33.1
1.61	359	120	2.06	215	71.7	2.51	141	47.1	2.96	98.4	32.8
1.62	354	118	2.07	213	71.0	2.52	140	46.7	2.97	97.7	32.6
1.63	350	117	2.08	211	70.2	2.53	139	46.3	2.98	96.9	32.3
1.64	345	115	2.09	209	69.5	2.54	138	45.9	2.99	96.2	32.1
1.65	341	114	2.10	207	68.8	2.55	137	45.5	3.00	95.5	31.8
1.66	337	112	2.11	204	68.2	2.56	135	45.1			
1.67	333	111	2.12	202	67.5	2.57	134	44.8			
1.68	329	110	2.13	200	66.8	2.58	133	44.4			
1.69	325	108	2.14	198	66.2	2.59	132	44.0			
1.70	321	107	2.15	197	65.5	2.60	131	43.7			

HB (kg/mm²)			BRINELL						D-10 mm
d	P (kg)				d	P (kg)			
(mm)	3000	1000	500	250	(mm)	3000	1000	500	250
2.50	601	200	100	50.1					
2.51	597	199	99.4	49.7	2.96	426	142	71.0	35.5
2.52	592	197	98.6	49.3	2.97	423	141	70.5	35.3
2.53	587	196	97.8	48.9	2.98	420	140	70.1	35.0
2.54	582	194	97.1	48.6	2.99	417	139	69.6	34.8
2.55	578	193	96.3	48.1	3.00	415	138	69.1	34.6
2.56	573	191	95.5	47.8	3.01	412	137	68.6	34.3
2.57	569	190	94.8	47.4	3.02	409	136	68.2	34.1
2.58	564	188	94.0	47.0	3.03	406	135	67.7	33.9
2.59	560	187	93.3	46.6	3.04	404	135	67.3	33.6
2.60	555	185	92.6	46.3	3.05	401	134	66.8	33.4
2.61	551	184	91.8	45.9	3.06	398	133	66.4	33.2
2.62	547	182	91.1	45.6	3.07	395	132	65.9	33.0
2.63	543	181	90.4	45.2	3.08	393	131	65.5	32.7
2.64	538	179	89.7	44.9	3.09	390	130	65.0	32.5
2.65	534	178	89.0	44.5	3.10	388	129	64.6	32.3
2.66	530	177	88.4	44.2	3.11	385	128	64.2	32.1
2.67	526	175	87.7	43.8	3.12	383	128	63.8	31.9
2.68	522	174	87.0	43 5	3.13	380	127	63.3	31.7
2.69	518	173	86.4	43.2	3.14	378	126	62.9	31.5
2.70	514	171	85.7	42.9	3.15	375	125	62.5	31.3
2.71	510	170	85.1	42.5	3.16	373	124	62.1	31.1
2.72	507	169	84.4	42.2	3.17	370	123	61.7	30.9
2.73	503	168	83.8	41.9	3.18	368	123	61.3	30.7
2.74	499	166	83.2	41.6	3.19	366	122	60.9	30.5
2.75	495	165	82.6	41.3	3.20	363	121	60.5	30.3
2.76	492	164	81.9	41.0	3.21	361	120	60.1	30.1
2.77	488	163	81.3	40.7	3.22	359	120	59.8	29.9
2.78	485	162	80 8	40.4	3.23	356	119	59.4	29.7
2.79	481	160	80.2	40.1	3.24	354	118	59.0	29.5
2.80	477	159	79.6	39.8	3 25	352	117	58.6	29.3
2.81	474	158	79.0	39.5	3.26	350	117	58.3	29.1
2.82	471	157	78.4	39.2	3.27	347	116	57 9	29.0
2.83	467	156	77.9	38.9	3.28	345	115	57.5	28 8
2.84	464	155	77.3	38.7	3.29	343	114	57.2	28.6
2.85	461	154	76.8	38.4	3.30	341	114	56.8	28.4
2.86	457	152	76.2	38.1	3.31	339	113	56.5	28.2
2.87	454	151	75.7	37.8	3.32	337	112	56.1	28.1
2.88	451	150	75.1	37.6	3.33	335	112	55.8	27.9
2.89	448	149	74.6	37.3	3.34	333	111	55.4	27.7
2.90	444	148	74.1	37.0	3.35	331	110	55.1	27.5
2.91	441	147	73.6	36.8	3.36	329	110	54.8	27.4
2.92	438	146	73.0	36.5	3.37	326	109	54.4	27.2
2.93	435	145	72.5	36.3	3 38	325	108	54.1	27.0
2 94	432	144	72.0	36.0	3 39	323	108	53.8	26.9
2.95	429	143	71.5	35.8	3.40	321	107	53.4	26.7

HB (kg/mm²) BRINELL D–10 mm

d (mm)	P (kg) 3000	1000	500	250	d (mm)	P (kg) 3000	1000	500	250
3.41	319	106	53.1	26.6	3.86	246	82.1	41.1	20.5
3.42	317	106	52.8	26.4	3.87	245	81.7	40.9	20.4
3.43	315	105	52.5	26.2	3.88	244	81.3	40.6	20.3
3.44	313	104	52.2	26.1	3.89	242	80.8	40.4	20.2
3.45	311	104	51.8	25.9	3.90	241	80.4	40.2	20.1
3.46	309	103	51.5	25.8	3.91	240	80 0	40.0	20.0
3.47	307	102	51.2	25.6	3.92	239	79.6	39.8	19.9
3.48	306	102	50.9	25.5	3.93	237	79.1	39.6	19.8
3.49	304	101	50.6	25.3	3.94	236	78.7	39.4	19.7
3.50	302	101	50.3	25.2	3.95	235	78.3	39.1	19.6
3.51	300	100	50.0	25.0	3.96	234	77.9	38.9	19.5
3.52	298	99.5	49.7	24.9	3.97	232	77.5	38.7	19.4
3.53	297	98.9	49.4	24.7	3.98	231	77.1	38.5	19.3
3.54	295	98.3	49.2	24.6	3.99	230	76.7	38.3	19.2
3.55	293	97.7	48.9	24.4	4.00	229	76.3	38.1	19.1
3.56	292	97.2	48.6	24.3	4.01	228	75.9	37.9	19.0
3.57	290	96.6	48 3	24.2	4.02	226	75.5	37.7	18.9
3.58	288	96.1	48.0	24.0	4.03	225	75.1	37.5	18.8
3.59	286	95.5	47.7	23.9	4.04	224	74.7	37.3	18.7
3.60	285	95.0	47.5	23.7	4.05	223	74.3	37.1	18.6
3.61	283	94.4	47.2	23.6	4.06	222	73 9	37.0	18.5
3.62	282	93.9	46.9	23.5	4.07	221	73.5	36.8	18.4
3.63	280	93.3	46.7	23.3	4 08	219	73.2	36.6	18.3
3.64	278	92.8	46.4	23.2	4.09	218	72.8	36.4	18.2
3.65	277	92.3	46.1	23.1	4.10	217	72.4	36.2	18.1
3.66	275	91.7	45.9	22.9	4.11	216	72.0	36.0	18.0
3.67	274	91.2	45.6	22.8	4.12	215	71.7	35.8	17.9
3.68	272	90.7	45.4	22.7	4.13	214	71.3	35.7	17.8
3.69	271	90.2	45.1	22.6	4.14	213	71.0	35.5	17.7
3.70	269	89.7	44.9	22.4	4.15	212	70.6	35.3	17.6
3.71	268	89.2	44.6	22.3	4.16	211	70.2	35.1	17.6
3.72	266	88.7	44.4	22.2	4.17	210	69.9	34.9	17.5
3.73	265	88.2	44.1	22.1	4.18	209	69 5	34.8	17.4
3.74	263	87.7	43.9	21.9	4.19	208	69.2	34.6	17.3
3.75	262	87.2	43.6	21.8	4.20	207	68.8	34.4	17.2
3.76	260	86.8	43.4	21.7	4.21	205	68.5	34.2	17.1
3.77	259	86.3	43.4	21.6	4.22	204	68.2	34.1	17.0
3.78	257	85.8	42.9	21.5	4.23	203	67.8	33.9	17.0
3.79	256	85.3	42.7	21.3	4.24	202	67.5	33.7	16.9
3.80	255	84.9	42.4	21.2	4 25	201	67.1	33.6	16.8
3.81	253	84.4	42.2	21.1	4.26	200	66.8	33.4	16.7
3.82	252	84.0	42.0	21.0	4.27	199	66.5	33.2	16.6
3.83	250	83 5	41.7	20.9	4.28	198	66.2	33.1	16.5
3.84	249	83.0	41.5	20.8	4.29	198	65 8	32.9	16.5
3.85	248	82.6	41.3	20.6	4.30	197	65.5	32 8	16.4

HB (kg/mm²) BRINELL D-10 mm

d (mm)	P (kg) 3000	1000	500	250
4.31	196	65.2	32.6	16.3
4.32	195	64.9	32.4	16.2
4.33	194	64.6	32.3	16.1
4.34	193	64.2	32.1	16.1
4.35	192	63.9	32.0	16.0
4.36	191	63.6	31.8	15.9
4.37	190	63.3	31.7	15.8
4.38	189	63.0	31.5	15.8
4.39	188	62.7	31.4	15.7
4.40	187	62.4	31.2	15.6
4.41	186	62.1	31.1	15.6
4.42	185	61.8	30.9	15.5
4.43	185	61.5	30.8	15.4
4.44	184	61.2	30.6	15.3
4.45	183	60.9	30.5	15.2
4.46	182	60.6	30.3	15.2
4.47	181	60.4	30.2	15.1
4.48	180	60.1	30.0	15.0
4.49	179	59.8	29.9	14.9
4.50	179	59.5	29.8	14.9
4.51	178	59.2	29.6	14.8
4.52	177	59.0	29.5	14.7
4.53	176	58.7	29.3	14.7
4.54	175	58.4	29.2	14.6
4.55	174	58.1	29.1	14.5
4.56	174	57.9	28.9	14.5
4.57	173	57.6	28.8	14.4
4.58	172	57.3	28.7	14.3
4.59	171	57.1	28.5	14.3
4.60	170	56.8	28.4	14.2
4.61	170	56.5	28.3	14.1
4.62	169	56.3	28.1	14.1
4.63	168	56.0	28.0	14.0
4.64	167	55.8	27.9	13.9
4.65	167	55.5	27.8	13.9
4.66	166	55.2	27.6	13.8
4.67	165	55.0	27.5	13.8
4.68	164	54.8	27.4	13.7
4.69	164	54.5	27.3	13.6
4.70	163	54.3	27.1	13.6
4.71	162	54.0	27.0	13.5
4.72	161	53.8	26.9	13.4
4.73	161	53.5	26.8	13.4
4.74	160	53.3	26.6	13.3
4.75	159	53.0	26.5	13.3
4.76	158	52.8	26.4	13.2
4.77	158	52.6	26.3	13.1
4.78	157	52.3	26.2	13.1
4.79	156	52.1	26.1	13.0
4.80	156	51.9	25.9	13.0
4.81	155	51.6	25.8	12.9
4.82	154	51.4	25.7	12.9
4.83	154	51.2	25.6	12.8
4.84	153	51.0	25.5	12.7
4.85	152	50.7	25.4	12.7
4.86	152	50.5	25.3	12.6
4.87	151	50.3	25.1	12.6
4.88	150	50.1	25.0	12.5
4.89	150	49.8	24.9	12.5
4.90	149	49.6	24.8	12.4
4.91	148	49.4	24.7	12.4
4.92	148	49.2	24.6	12.3
4.93	147	49.0	24.5	12.2
4.94	146	48.8	24.4	12.2
4.95	146	48.6	24.3	12.1
4.96	145	48.4	24.2	12.1
4.97	144	48.1	24.1	12.0
4.98	144	47.9	24.0	12.0
4.99	143	47.7	23.9	11.9
5.00	143	47.5	23.8	11.9
5.01	142	47.3	23.7	11.8
5.02	141	47.1	23.6	11.8
5.03	141	46.9	23.5	11.7
5.04	140	46.7	23.4	11.7
5.05	140	46.5	23.3	11.6
5.06	139	46.3	23.2	11.6
5.07	138	46.1	23.1	11.5
5.08	138	45.9	23.0	11.5
5.09	137	45.7	22.9	11.4
5.10	137	45.5	22.8	11.4
5.11	136	45.3	22.7	11.3
5.12	135	45.1	22.6	11.3
5.13	135	45.0	22.5	11.2
5.14	134	44.8	22.4	11.2
5.15	134	44.6	22.3	11.1
5.16	133	44.4	22.2	11.1
5.17	133	44.2	22.1	11.1
5.18	132	44.0	22.0	11.0
5.19	132	43.8	21.9	11.0
5.20	131	43.7	21.8	10.9

HB (kg/mm²)			BRINELL						D–10 mm
d	P (kg)				d	P (kg)			
(mm)	3000	1000	500	250	(mm)	3000	1000	500	250
5.21	130	43.5	21.7	10.9	5.66	108	36.3	18.1	9.1
5.22	130	43.3	21.6	10.8	5.67	108	36.1	18.1	9.0
5.23	129	43.1	21.6	10.8	5.68	108	36.0	18.0	9.0
5.24	129	42.9	21.5	10.7	5.69	107	35.8	17.9	9.0
5.25	128	42.8	21.4	10.7	5.70	107	35.7	17.8	8.9
5.26	128	42.6	21.3	10.6	5.71	107	35.6	17.8	8.9
5.27	127	42.4	21.2	10.6	5.72	106	35.4	17.7	8.9
5.28	127	42.2	21.1	10.6	5.73	106	35.3	17.6	8.8
5.29	126	42.1	21.0	10.5	5.74	105	35.1	17.6	8.8
5.30	126	41.9	20.9	10.5	5.75	105	35.0	17.5	8.8
5.31	125	41.7	20.9	10.4	5.76	105	34.9	17.4	8.7
5.32	125	41.5	20.8	10.4	5.77	104	34.7	17.4	8.7
5.33	124	41.4	20.7	10.3	5.78	104	34.6	17.3	8.7
5.34	124	41.2	20.6	10.3	5.79	103	34.5	17.2	8.6
5.35	123	41.0	20.5	10.3	5.80	103	34.3	17.2	8.6
5.36	123	40.9	20.4	10.2	5.81	103	34.2	17.1	8.6
5.37	122	40.7	20.3	10.2	5.82	102	34.1	17.0	8.5
5.38	122	40.5	20.3	10.1	5.83	102	33.9	17.0	8.5
5.39	121	40.4	20.2	10.1	5.84	101	33.8	16.9	8.5
5.40	121	40.2	20.1	10.1	5.85	101	33.7	16.8	8.4
5.41	120	40.0	20.0	10.0	5.86	101	33.6	16.8	8.4
5.42	120	39.9	19.9	10.0	5.87	100	33.4	16.7	8.4
5.43	119	39.7	19.9	9.9	5.88	99.9	33.3	16.7	8.3
5.44	119	39.6	19.8	9.9	5.89	99.5	33.2	16.6	8.3
5.45	118	39.4	19.7	9.9	5.90	99.2	33.1	16.5	8.3
5.46	118	39.2	19.6	9.8	5.91	98.8	32.9	16.5	8.2
5.47	117	39.1	19.5	9.8	5.92	98.4	32.8	16.4	8.2
5.48	117	38.9	19.5	9.7	5.93	98.0	32.7	16.3	8.2
5.49	116	38.8	19.4	9.7	5.94	97.7	32.6	16.3	8.1
5.50	116	38.6	19.3	9.7	5.95	97.3	32.4	16.2	8.1
5.51	115	38.5	19.2	9.6	5.96	96.9	32.3	16.2	8.1
5.52	115	38.3	19.2	9.6	5.97	96.6	32.2	16.1	8.0
5.53	114	38.2	19.1	9.5	5.98	96.2	32.1	16.0	8.0
5.54	114	38.0	19.0	9.5	5.99	95.9	32.0	16.0	8.0
5.55	114	37.9	18.9	9.5					
5.56	113	37.7	18.9	9.4					
5.57	113	37.6	18.8	9.4					
5.58	112	37.4	18.7	9.4					
5.59	112	37.3	18.6	9.3					
5.60	111	37.1	18.6	9.3					
5.61	111	37.0	18.5	9.2					
5.62	110	36.8	18.4	9.2					
5.63	110	36.7	18.3	9.2					
5.64	110	36.5	18.3	9.1					
5.65	109	36.4	18.2	9.1					

Procedure:

1. Polish the specimen with 0 – 0 emery paper.
2. Place the specimen on the anvil of the machine.
3. Select the load depending on the specimen material and the diameter of ball indenter.
4. Insert the ball indenter into the holder.
5. Rotate the work table and raise it till the specimen is brought in contact with the indenter.
6. Apply the proper load for a particular time (6 – 8 sec.).
7. Release the load and remove the specimen.
8. Measure the diameter of the impression in two perpendicular directions D_1 and D_2 by micrometer.
9. Repeat the same procedure to obtain three more readings for each specimen.
10. Tabulate the observations.

Inference:

Student can obtain knowledge about hardness. Different types of Hardness Numbers can be learnt.

Application:

This knowledge can be used during Heat – Treatment.

Result:

The hardness of the given specimen is BHN =

Viva Questions:

1. What is the limitation of Brinell hardness test and why ?
2. What is the unit of B.H.N?
3. Which ball size is recommended for Brinell test?

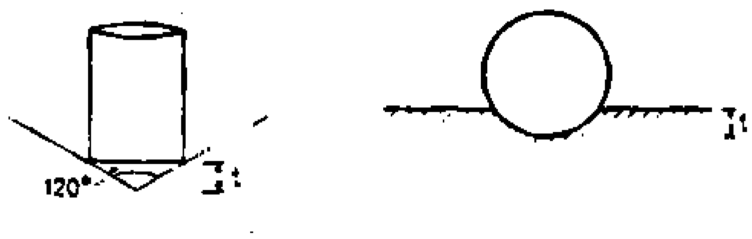
Ex No : *Date :*

Rockwell's Hardness Test

Introduction:

This test is faster and simpler than Brinell's hardness test, because in this test the loads are smaller and therefore the resulting indentation on the test specimen is smaller and shallower. In this test there is no need to measure the diameter of indentation because the Rockwell machine gives direct reading on the dial.

This test employs a variety of indenters and loads. Indenters include hard steel ball of diameter 1/16, 1/8 , ¼ and ½ inch and a 120° conical diamond point. The figures shows the two types of indenters.

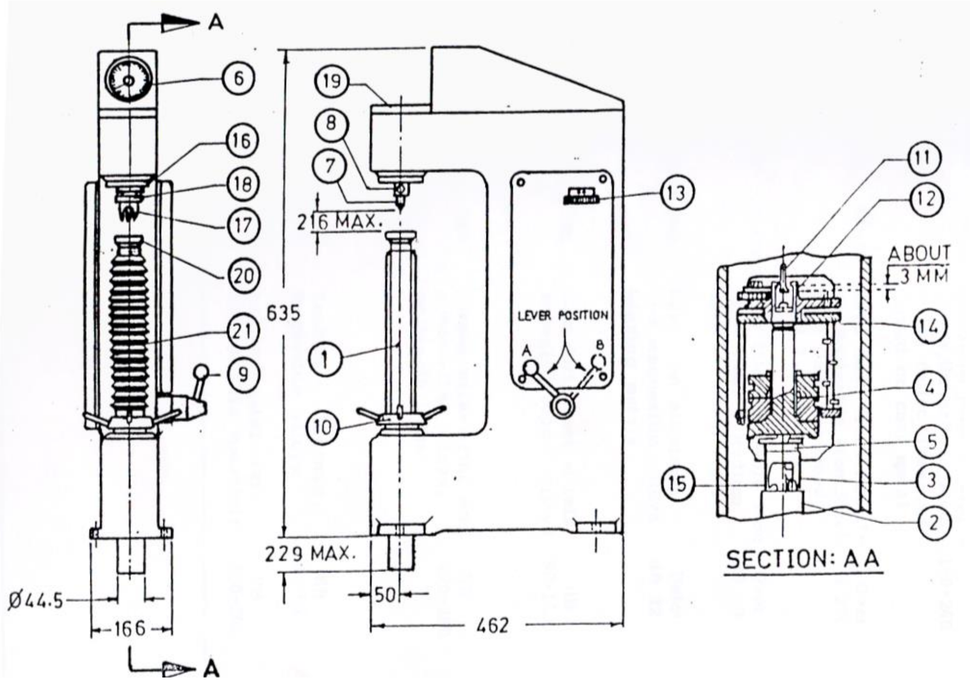


(a) Diamond cone indenter (b) Hard steel ball indenter
Type of indenter (t = depth of indentation (mm)).

ASTM specifies 13 scales for testing of wide range of materials ranging from very soft to very had material. These scales are specified as : A,B,C,D,E,F,G etc. Out of these scales, B – scale and C – scale are commonly used.

Rockwell hardness test is suitable to measure the hardness of the material beyond the range of BHN. Rockwell's hardness method may be used to determine hardness of blades, piston, wires etc.,

Rockwell Hardness Test



List of Parts

1. Main Screw	2. Dash pot	3. Plunger
4. Loads	5. Valve Screw	6. Dial Gauge
7. Indenter Penetrator	8. Diamond Holder	9. Lever
10. Hand Wheel	11. Load Hanger	12. Weight Shaft Clip
13. Load Selector Disc	14. Washers	15. Dash Pot Oil Fill Hole
16. Diamond Holder	17. Clamping Cone	18. Clamping Check Nut
19. Top Plate	20. Test Table (Anvil)	21. Rubber Bellow

Tabulation:

S.No.	***Material***	***Load applied (Kgf)***	***Indenter used***	***Dial Gauge Reading (1)***	***Dial Gauge Reading (2)***	***Dial Gauge Reading (3)***	***Avg.***	***HRB***
1.								
2.								
3.								
4.								
5.								
6.								

Ex No : ***Date :***

Rockwell Hardness Test

Aim:

To determine Rockwell hardness number for the given specimen.

Name of the machine:

Rockwell Hardness Testing Machine.

Apparatus required:

1. 1/16 " Ball Indenter, 2. Diamond Indenter.

Theory:

Hardness is the property of a material by which it offers a great resistance to scratch, wear, abrasion or indentation.

If the hardness of a material is more, the resistance to indentation is more. Therefore depth of penetration is inversely proportional to the hardness of the material.

Rockwell hardness test gives a direct reading. A small pointer indicates the application of the minor load of 10 Kgf. The anvil with the specimen placed on it is lifted upwards and as the indenter touches the specimen the small pointer comes to the red dot. The main pointer is set to zero. Then the load is applied and the hardness is found.

The common indenter used in Rockwell Hardness test are 1/16" hardened steel ball and 120° conical shaped diamonds with a 0.2mm diameter spherical indenting tip. When the former indenter is used, the major load is maintained at 100 Kgf and the hardness values are read in the 'B' scale. When the diamond cone indenter is used, the major load is maintained at 150 Kgf and the hardness values are read in the 'C' scale.

Procedure:

1. Polish the specimen with emery sheet, and place it on the anvil of the machine.
2. Depending on the specimen material, select the indenter and the corresponding load.
3. Insert the indentor into the holder.
4. Raise the anvil until the specimen touches the indenter and apply the minor load.
5. The major load to be applied is 100Kgf for HRB tests and 150Kgf for HRC tests.
6. The time of application of the load is as follows:
7. HRC test 5 to 6 seconds after application of the minor load.
8. HRB test 6 to 8 seconds after application of the minor load.
9. The hardness number is read from the B scale and C scale, after releasing the load.
10. Repeat the procedure to obtain 3 readings for a specimen.

Inference:

Student can obtain knowledge about hardness. Different types of Hardness Numbers can be learnt.

Application:

This knowledge can be used during Heat – Treatment.

Result:

The hardness of the given specimen is = HRB.

Viva Questions:

1. Can we predict the tensile strength of a material if its hardness in known ?
2. Which is the hardest material? and why ?

Observation:

Length of the specimen :

Cross-section dimensions :

Breadth (b) :

Depth (d) :

Least count of Deflect meter :

1.

Tabulation:

S.No.	Deflection	Load (Kgf)	Load N	Young's Modulus (N/mm^2)	Max. Bending stress (N/mm^2)
1.					
2.					
3.					
4.					
5.					
6.					

S.No.	Load	Deflection		Average
		Load	Unload	
1.				
2.				
3.				
4.				
5.				
6.				

Ex No : ***Date :***

Bending and Deflection Test on Wood

Aim:

To determine the Young's modulus by performing Bending and Deflection test.

To find the bending stresses developed.

To plot the graph between load and deflection and find the value of Young's modulus from the graph.

Specifications of Machine:

Name	:	Wood Testing Machine
Range	:	0 – 50 KN.

Apparatus Required:

1. Bending apparatus with simple supports.
2. Deflect meter.
3. Scale
4. Vernier caliper.

Formula:

1. Young's modulus (E) = $WL^3 / 48\, \delta\, I$
2. I – Moment of inertia = $bd^3 / 12$
3. Maximum bending stress (σ_{max}) = $(WL / 4I) \times (d / 2)$

Where,

I	–	Moment of inertia in mm^4.	W	–	load in N.
d	–	depth of the beam in mm.	L	–	length in mm.
b	–	breadth of beam in mm.	δ	–	deflection in mm.

Theory:

When a beam is loaded, it is bent and subjected to bending moments. Bending stresses are induced in the cross-section and varies along the depth of the beam. Bending stresses are maximum at the external fibers of the cross-section. The bending equation establishes a relation between the Radius of curvature to which the beam bends, the bending moment, the bending stresses and its cross-section dimensions.

Bending equation = $$\frac{M}{I} = \frac{\sigma}{y} = \frac{E}{R}$$

Where,

M	–	moment or resistance.
I	–	moment of inertia of the section about the Neutral axis (NA).
E	–	Young's modulus of elasticity.
R	–	Radius of curvature of NA.
σ	–	Bending stress.

Calculation:

1. ***I – Moment of inertia*** = $bd^3 / 12$

2. ***Young's modulus (E)*** = $WL^3 / 48\,\delta I$

3. ***Maximum bending stress (σ_{max})*** = $(WL / 4I) \times (d / 2)$

As a result of the bending moment or couple, the length of the beam will take up a curved shape, which may be treated as a part of the arc of a circle. At the outer radii the material will be in tension and at the inner radii in compression and at some radius there will be no stress. This layer of the material is the Neutral Axis (NA).

Procedure:

1. Measure the length and cross-section dimensions of the specimen.
2. Keep the ends of the specimen resting over the simple supports.
3. Fix the deflectometer under the specimen at mid span.
4. Bring the loading unit in contact with the specimen vertically at mid span.
5. Set the load dial and deflectometer dial to zero, by zero adjustment initially.
6. Apply the load gradually and record the deflectometer readings at regular intervals.
7. After that, start unloading gradually and record the deflectometer readings at the specified intervals.
8. Plot the graph between load and deflection.

Inference:

Student can understand the knowledge bending stress of wood

Application:

This knowledge can be utlised during designing.

Result:

1. Young's modulus of wood =
2. Maximum Bending stress at load =
3. From graph, Young's modulus of wood =

Viva Questions:

1. What is mean by deflection?
2. Types of beam?
3. Explain the each type of beam?

Test on Spring

Introduction:

Spring are subjected to many engineering applications such as automobiles and railway buffers in order to cushion, absorb or control energy due to shock and vibrations. The energy may be restored slowly or rapidly depending upon a particular application. They are used as vibration dampers in machines which are acted upon by vibrating loads. Springs are also used to measure force in the form of a spring balance, gauges or engine indicators. Another important application of these springs is to control motion by maintaining contact between two elements such as cam and its follower or by restoring a machine part to its normal position when the disturbing force is removed such as in a governor and valve or by producing the necessary pressure in a friction device such as brake or clutch. Spring can also store energy as in clock works or starters. Springs can suffer a sizeable change in form without being distorted permanently.

Classification of springs:

Spring can be classified according to shape as follows:

1. Coiled helical spring
2. Spiral spring
3. Leaf spring or carriage spring or plate spring
4. Flat tapered or dish shaped disks.

A coiled helical spring is defined as one, which is, wound form a length of a wire into a helix or spiral shape. Coiled springs may further be classified as

***1. Helical conical springs* –** When the axis of the wire is in the form of a helix wound a round a right circular cone.

***2. Helical cylindrical spring* -** When the axis of the wire has the form of a helix described on a right circular cylinder. Coiled helical spring are also classified as.

***3. Close coiled Helical Springs* –** When the coils of the spring are quite close such that each coil lies approximately in plane perpendicular to the axis of the spring. Here the angle of helix is less than 8 to 10°

4. Open Coiled Helical Spring – When the coils of the spring are not close to each other. Here the angle of helix is greater than 8 to 10° Coiled helical springs are used to take up forces which tend to shorten, lengthen or twist them. These springs are subjected to either axial loads or torsion loads, the corresponding main stresses produced being torsion and bending respectively. Helical springs are generally made of round wire.

The stress induced by the load in spiral, leaf and disk springs is bending.

Ex No : ***Date :***

Test on Spring (Open Coil)

Aim:

a. To determine the modulus of Rigidity of the given specimen.

b. To find the shear stress, strain energy and stiffness of the given specimen.

Specifications of Machine:

Name : Spring Testing Machine

Capacity : 1000 Kg.

Apparatus Required:

1. Vernier caliper. 2. Scale.

Formula Used:

1. Pitch = Free length of the spring / No. of turns
2. tan θ = Pitch / π Dm
3. Mean radius (R) = External diameter + Internal diameter / 4
4. Rigidity modulus (G) = $\dfrac{1}{\dfrac{(\delta d^4)}{64WR^3 n\cos\theta} - \dfrac{2\tan^2\theta}{E}}$
5. Stiffness (K) = W / δ
6. Shear stress = (16WR) / π d^3
7. Strain Energy = 1 / 2 W δ

Where,

θ – helix angle; d – diameter of the wire

Dm – mean diameter of the coil; G – modulus of rigidity

W – load applied; R – mean radius of the coil

E – Young's modulus = 2 x 10^5 N/mm^2.

Theory:

A coil in a open coil helical spring is inclined at considerable angle with the plane normal to the axis. These springs are often loaded under axial compression. The effect of open-ness of the coil is that any section of the wire of the spring is subjected to torque T and bending moment M, which are given by

T = WR cos θ

M = WR sin θ

Observation:

External diameter of the spring :

Internal diameter of the spring :

Thickness of the spring wire (d) :

Number of turns in the coil (n) :

Tabulation:

S.No.	***Deflection***	***Load (Kgf)***	***Load N***	***Shear Stress (N/mm^2)***	***Rigidity Modulus (G) (N/mm^2)***	***Strain Energy (N mm)***	***Stiffness (k) (N/mm)***
1.							
2.							
3.							
4.							
5.							
6.							

S.No.	**Load**	**Deflection**		**Average**
		Load	**Unload**	
1.				
2.				
3.				
4.				
5.				
6.				

Model Calculations:

1. Pitch = Free length of the spring / No. of turns

2. Mean radius (R) = External diameter + Internal diameter / 4

3. tan θ ***= Pitch /*** π ***Dm***

4. Rigidity modulus (G) =

$$\frac{1}{\frac{(\delta d^4)}{64WR^3 n\cos\theta} - \frac{2\tan^2\theta}{E}}$$

5. Stiffness (K) = W / δ

6. Shear stress $= (16WR) / \pi d^3$

7. Strain energy $= 1 / 2 W \delta$

Procedure:

1. Measure the outer and inner diameter of the coil of the spring.
2. Measure the thickness of the spring wire (d).
3. Count the number of turns in the coil.
4. Fix the specimen in the spring testing machine. Apply an axial compressive load and read the deflection.
5. Record the load and the deflection at regular intervals.
6. Plot the graph between load and deflection.

Inference:

Student can understand spring is a Energy-storage device.

Application:

Student can design simple springs for a particular purpose.

Result:

1. Modulus of rigidity (G) =
2. Spring Constant (k) =
3. Strain energy at a load of =
4. Shear stress at a load of =

Viva Questions:

1. Types of spring?
2. Define stiffness?
3. Define shear modulus?

Ex No : ***Date :***

Test on Spring (Closed Coil)

Aim:

To determine the modulus of rigidity and Young's of the specimen material.

To find the stiffness, shear stress and strain energy.

Specifications of the Machine:

Name	:	Spring Testing Machine
Capacity	:	1000 Kg

Apparatus Required:

1. Vernier Caliper. 2. Scale.

Formula:

1. Stiffness = W / δ
2. Mean radius (R) = External diameter + Internal diameter / 4
3. Shear stress = $16\ WR / \pi\ d^3$
4. Strain energy = $1 / 2\ W\ \delta$
5. Rigidity modulus (G) = $64\ W\ R^3\ n / \delta\ d^4$
6. Young's modulus (E) = $2G\ (1 + 1/m)$

Where

W	–	Load applied	G	–	Modulus of Rigidity
R	–	Mean radius of coil	1/m	–	Poisson's ratio.
n	–	No. of turns of coil	E	–	Young's modulus
d	–	Diameter of the wire			

Theory:

Energy can be stored in a spring. In closed coil helical spring, the coils arc close to each other such that each turn is practically at right angles to the axis of the spring and the helix angle is less than 30°. Stiffness of the spring is defined as the force per unit deflection and Resilience is the energy stored in the spring. A close coiled helical spring is used under axial pull. It is subjected to a torsional shear stress and also a direct shear stress. The stiffness of and also a direct shear stress. The stiffness of the spring is otherwise known as spring constant (K).

Observation:

External diameter of the spring :

Internal diameter of the spring :

Thickness of the spring wire (d) :

Number of turns in the coil (n) :

Poisson's ratio (1/m) : 0.33

Tabulation:

S.No	Deflection	Load (Kgf)	Load N	Shear Stress (N/mm^2)	Rigidity Modulus (G) (N/mm^2)	Young's Modulus (N/mm^2)	Strain Energy (N mm)	Stiffness (k) (N/mm)
1.								
2.								
3.								
4.								
5.								
6.								

S.No.	Load	Deflection		Average
		Load	Unload	
1.				
2.				
3.				
4.				
5.				
6.				

Model Calculations:

1. Stiffness = W / δ

2. Mean radius (R) = *External diameter + Internal diameter / 4*

3. Shear stress = $16\ WR / \pi d^3$

4. Strain energy = $1 / 2 \, W \, \delta$

5. Rigidity modulus (G) = Rigidity modulus (G) = $64 \, W \, R^3 \, n / \delta d^4$

6. Young's modulus (E) = $2G \, (1 + 1/m)$

Procedure:

1. Measure the outer and inner diameter of the coil of the spring.
2. Measure the thickness of the spring wire (d).
3. Count the number of turns in the coil.
4. Fix the specimen in the spring testing machine. Apply the load, and read the deflection.
5. Record the load and deflection at regular intervals.
6. Plot the graph between load and deflection.

Inference:

Student can understand spring is a Energy-storage device.

Application:

Student can design simple springs for a particular purpose.

Result:

1. Modulus of rigidity (G) =
2. Spring Constant (k) =
3. Strain energy at a load of =
4. Shear stress at a load of =
5. Young's modulus (E) =

Viva Questions:

1. Difference between open coil and closed coil spring?
2. What is mean by strain energy?
3. Define shear stress?

Tabulation: 1

Readings with Digital Strain Indicator and Cantilever Beam

S. No.	Weight (in gms)	Readings with Quarter Bridge Connection (in Micro Strains)	Readings with Half Bridge Connection (in Micro Strains)	Readings with Full Bridge Connection (in Micro Strains)
1.				
2.				
3.				
4.				
5.				
6.				

Tabulation: 1

S. No.	Experiment	Theoretical
1.		
2.		
3.		
4.		
5.		
6.		

Ex .No : **Date :**

Strain Measurement Using Rosette Strain Gauge

Aim:

To measure the strain in the cantilever beam for various loads, using strain gauge.

Apparatus Required:

Strain Gauge, Cantilever beam, Set of hanger weights.

Formula:

Strain in a Cantilever Beam

1. Moment of Inertia

$I = bt^3 / 12 \ m^4$

where

w = width of the strip in meters.

t = thickness of the strip in meter

2. Bending Moment

$M = F \times L$ Nm.

where

F = force applied in Newton's

L = length of the strip from point of loading to the point of support.

3. Stress

$\sigma = M / I \times t / 2 \quad N / m^2$

4. Strain

$\varepsilon = \sigma / E$

$\varepsilon = (M / I \times t / 2) / E$

$$\varepsilon = \frac{6FL}{bt^2E}$$

where

E = young's modulus

= 200 GN / m^2 for steel

= 70 GN / m^2 for Aluminum

For the strip supplied (Aluminum)

L = 260 mm = 0.260 m

t = 6 mm = 0.006 m

w = 32 mm = 0.032 m

Calculation:

1. ***Moment of Inertia (I)*** = $bd^3/12$ m^4

2. ***Bending Moment (m)*** = $F \times L$ Nm.

3. ***Stress (σ)*** = $M/I \times t/2$ N/m^2

4. ***Strain (ε)*** = σ / E

$$\varepsilon = \frac{6FL}{bt^2E}$$

Procedure:

1. Plug the mains chord to 230 V, 50 Hz, supply.
2. Connect the strain gauges whose strain has to be measure to the "Input" terminals provided at the back panel. The connection should be made as per the strain gauge connection diagram enclosed.
3. Switch the instrument "On" using front panel toggle switch and allow the instrument to warm up approximately for 20 to 30 minutes.
4. Adjust the G.F. potentiometer to the required value (say 2.0).
5. Turn the "Select" Switch on the front panel to the "Zero" position.
6. Operate the "Coarse & Fine" potentiometer till the display reads zero.
7. Turn the "Gauge Resistance" switch to the proper position, i.e. if the strain gauges of 120 ohms resistance are used, the switch should be at 120 ohms, and for 350 ohms resistance, position it to 350 ohms. This is applicable only for half & quarter bridge configuration. For full bridge, it should be in the "F" position.
8. Turn the "Bridge Select" switch to the required position, i.e. if the full bridge is used the switch should be at the position "F", if half bridge is used, the switch position should be at "H" and if quarter bridge is used, the switch position should beat "Q".
9. Readjust the "Coarse & Fine" potentiometer to make the display to read zero.
10. Now turn the switch on the front panel to "Cal" position.

    Cal: Microstrain = Reg / KRc;

    Where

    Rg is the strain gauge resistance (120 oHms / 350 ohms)

    Rc is the calibration resistance (120 Kohms / 350 Kohms)

    K is the Gauge factor (2.0)
11. Turn the "Select" switch back to zero position. Now the instrument is ready for measurement.

Inference:

Student can understand the concept of bending in Beams.

Application:

Student can calculate theoretically Strain in the Beams & Compare with the Practical Results.

Result:

Strain at a load of ____________micro strains

Viva Questions:

1. Define strain?

2. Types of strain gauge ?

3. What is find in this experiment ?

Observation:

Material of specimen :

Size of the specimen :

Tabulation:

Table 1: Before Heat Treatment

S. No.	Name of Specimen	Hardness				Impact Strength		
		Load	Indentor	Scale	Rockwell Hardness Number	Energy absorbed	Cross Section Area	Impact Strength
1.								
2.								
3.								
4.								
5.								

Table 2: After Heat Treatment

S. No.	Name of Specimen	Hardness				Impact Strength		
		Load	Indentor	Scale	Rockwell Hardness Number	Energy absorbed	Cross Section Area	Impact Strength
1.								
2.								
3.								
4.								
5.								

Ex No : ***Date :***

Effect of Hardening – Improvement in Hardness & Impact Resistance

Aim:

To improve the hardness of the given specimen by heat treatment method and to determine the change in hardness and impact strength.

Apparatus Required:

Electric muffle furnace, Rockwell Hardness Testing Machine, Impact Testing Machine, Water, Tongs and Stop Watch.

Theory:

Hardening of steel is a process of heating the material of a temperature 30° C above the upper critical temperature line and cooling it drastically. At this high cooling rate, insufficient time is allowed for carbon to diffuse out of austenite structure, although same movement of iron atoms take place. The resultant structure is called martensite. It is super saturated solid solution of carbon trapped in a body – centered tetragonal structure. It is the martensite, which is responsible for the high hardness. Higher rate of cooling is obtained by quenching the hot material in water.

Procedure:

1. Find the initial hardness of the specimen.
2. Find the initial impact strength of the specimen.
3. Keep the specimen inside an electric muffle furnace and start heating.
4. When the furnace is at 950° C, slow down heating.
5. Maintain the specimen at this temperature for half an hour inside the furnace by suitably adjusting the power supply.
6. After the specified time, take out the specimen and quench it in large quantity of water.
7. Find the final hardness and impact strength of the specimen, after hardening.

Inference:

Student can understand the difference between shear strength and Impact strength

Application:

This knowledge can be utilized while designing.

Result:

1. Hardness of the specimen before heat treatment :
2. Hardness of the specimen after heat treatment :
3. Impact strength of the specimen before heat treatment :
4. Impact strength of the specimen after heat treatment :

Viva Questions:

1. Define hardness
2. Define impact resistance?
3. Explain heat treatment?
4. What do you learn from this experiment?

Observation:

Material :

Diameter of the Specimen :

Length of the Specimen :

Tabulation:

Table 1 : Unhardened Specimen

S. No.	***Name of the specimen***	***Load***	***Indentor***	***Scale***	***Rockwell Hardness Number***
1.					
2.					
3.					

Table 2 : Hardened and Quenched Specimen

S. No.	***Name of the specimen***	***Load***	***Indentor***	***Scale***	***Rockwell Hardness Number***
1.					
2.					
3.					

Table 3 : Tempered Specimen

S. No.	***Name of the specimen***	***Load***	***Indentor***	***Scale***	***Rockwell Hardness Number***
1.					
2.					
3.					

Ex No : ***Date :***

Tempering

Aim:

To study the hardness of the given specimen before and after tempering.

Apparatus Required:

1. Electric Muffle Furnace,
2. Rockwell Hardness Testing Machine,
3. Water,
4. Tongs and Stop Watch.

Theory:

After hardening process, the hardened steel is extremely brittle and highly stressed. The process of tempering which follows hardening consists of heating the steel to some temperature below the lower critical temperature. The purpose of tempering is to reduce the residual stress and to improve the ductility and toughness of the surface.

Procedure:

1. Find the hardness of the specimen before and after hardening.
2. Keep the specimen inside an electric muffle furnace and heat it to 550º C.
3. Maintain the specimen at this temperature for half an hour inside the furnace by suitably adjusting the power supply.
4. After the specified time, keep the specimen inside the furnace and slow down the heating.
5. Find the final hardness of the specimen, after the specimen is cooled.

Inference:

Student can obtain knowledge about hardness. Different types of Hardness Numbers can be learnt.

Application:

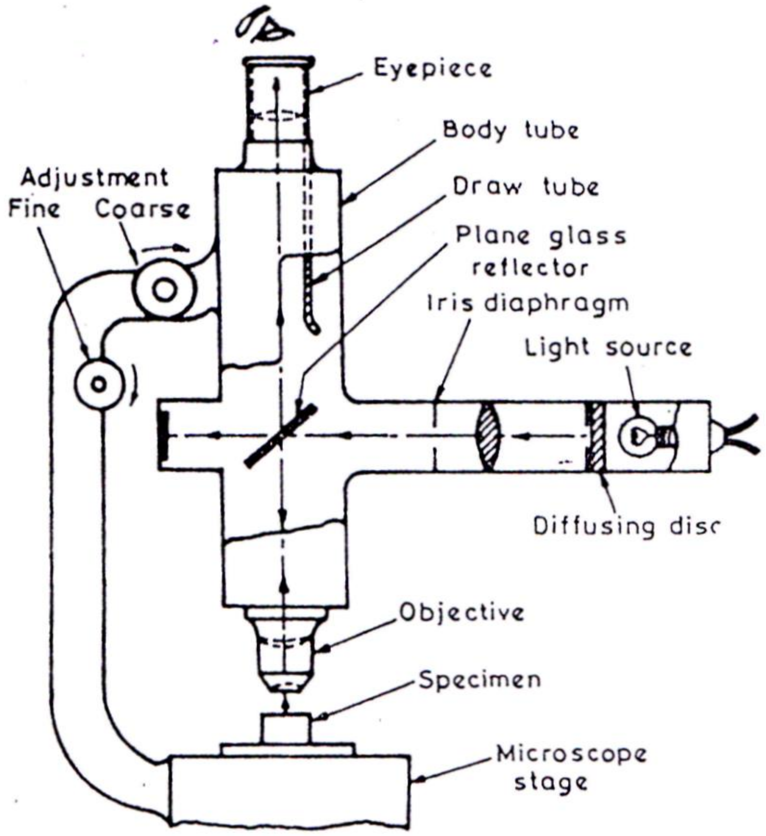
This knowledge can be used during Heat – Treatment.

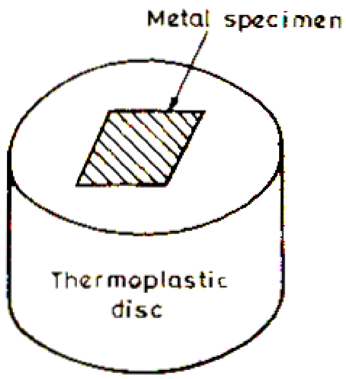
Result:

1. Hardness of the unhardened specimen :
2. Hardness of the hardened specimen :
3. Hardness of the tempered specimen :

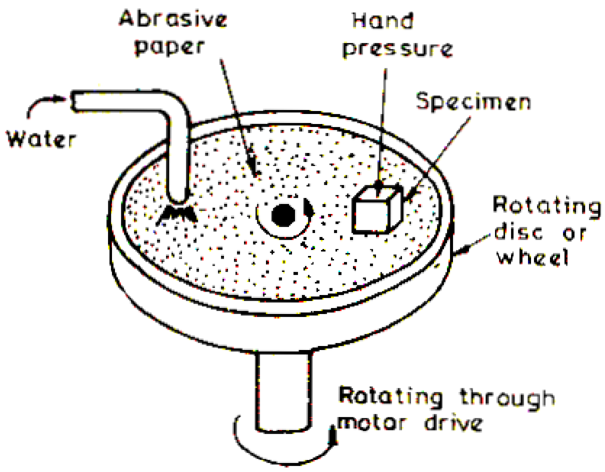
Viva Questions:

1. Define tempering?
2. What is the use of tepering?
3. Explain quencing?
4. Types of quencing?





(a)
Mounting the specimen.



(b)
Fine grinding.

Ex No : ***Date :***

Microscopic Examination of Hardened Specimen

Aim:

To study to microstructure of the hardened specimen using metallurgical microscope.

Apparatus Required:

Metallurgical microscope, emery paper No.1 1/0 , 2/0 , 3/0 and 4/0, polishing machine and alumina powder.

Specimen Preparation:

The ultimate objective of specimen preparation is to produce a flat, scratch free mirror like surface. The steps required to prepare a metallographic specimen are as follows:

1. Sampling 2. Rough Grinding 3. Mounting
4. Intermediate polishing 5. Fine polishing 6. Etching

1. Sampling:

If a failure is to be investigated, the sample should be chosen as close as possible to the are of failure and should be compared with one taken from the normal section.

If the material is soft, e.g. Non – ferrous metals, iron, heat treated steel, the section may be obtained by manual hacksawing. For hard materials, thin abrasive cut off wheel may be used. The specimen must be kept cool during the cutting operation. It should be of a size that is convenient to handle.

2. Rough Grinding:

A soft sample may be made flat by slowly moving it across the surface of a flat smooth file. Both soft and had specimen may be rough ground on a belt sander. Water drops ma be added during the grinding operation for cooling. In all grinding and polishing operations the specimen should be moved perpendicular to the existing scratches. The rough grinding is continued until the surface is flat and free of nicks, burrs and scratches due to hacksaw or cut off wheel.

3. Mounting:

Specimen that are small or awkwardly shaped e.g. Wires, small rods, sheet metal specimens, thin sections, etc. must be appropriately mounted in a suitable material to facilitate intermediate and fine polishing. The mounts are in convenient size usually 2.54 cm, in diameter. These mounts when properly made are very resistant to attack by etching reagents.

The most common thermosetting resin for mounting is Bakelite. Molding powders are available in different colours for easy identification of mounted specimens. The correct amount of Bakelite powder is placed in the cylinder of the mounting press. A temperature of 150° C and molding presser of 275 kg / cm^2 are applied simultaneously. The specimen mount may be ejected from the molding die while it is still hot.

The most common thermoplastic resin for moulding is Lucite. This is transparent and hence the entire specimen in the mount can be seen. The specimen and a proper amount of Lucite powder are placed in the mounting press and are subjected to 150° C and 275 kg / cm^2. After this temperature has been reached, the heating coil is removed and cooling fins are placed around the cylinder to cool the mount to less than 75° C in about 7 min., while the molding pressure is maintained. Then the mount may be ejected from the mould.

Laboratory made clamping devices may be used for thin sheet specimens.

4. Intermediate Polishing:

After mounting, the specimen is polished on a series of emery papers containing successively finer abrasives. The first paper is usually No.1, then 1/0, 2/0,3/0 and 4/0. This operation is done dry. However when silicon carbide abrasive is used a lubricant may be applied as it has greater removal rate and it is resin bonded. Using a lubricant prevents overheating of the sample, minimizes smearing of soft metals and also provides a rinsing action.

5. Fine Polishing:

Finally the flat scratch free surface is obtained by the use of a rotating wheel covered with a special cloth that is charged with carefully sized abrasive particles. Gamma form of Aluminium oxide ($A1_2O_3$) is used for ferrous and copper based materials, cerium oxide for aluminium, magnesium and other alloys.

The choice of a proper polishing cloth depends upon the particular material being polished and the purpose metallographic study. Many cloths are available of varying pile (silk) to those having a deep pile (velvet). Synthetic polishing cloths are also available under trade names Gamely, Micro cloth for general polishing purposes. A properly polished sample will show only non - metallic inclusions and will be scratch free.

6. Etching:

The purpose of etching is to make most of the structural characteristics of the metal or alloy to be visible. This is accomplished by use of an appropriate reagent, and thus the polished surface is subjected t chemical action.

In alloys composed of two or more phases, the components are revealed during etching by a preferential attack of one or more of these constituents by the reagent, because of the difference in the chemical composition of the phases. In uniform single phase alloys or pure metals, the structure will be visible because of differences at the rate at which various grains are attacked by the reagent. This difference in the rate of attack is mainly associated with the angle of the different sections to the plane of the polished surface. Because of chemical attack by the etching reagent, the grain boundaries will appear as valleys in the polished surface. Light from the microscope hitting the side of these valleys will be reflected out of the microscope making the grain boundaries appear as dark lines. The metal determines the selection of the appropriate etching reagent or alloy and the specific structure desired for viewing.

Etching Reagents For Microscopic Examination:

S.No.	***Types of Etchant***	***Composition***		***Uses***
1.	Nital	1.Cone Nitric acid 2.Absolute methyl alcohol	2cc 98cc	For etching steels, gray cast iron and black heart malleable iron.
2.	Acid ammonium persulphate	1. Hydrochloric acid 2. Ammonium persulphate 3. Water	10cc 10gms 80cc	For etching stainless steels.
3.	Ammonia hydrogen peroxide	1. Ammonium hydroxide (0.880) 2. Hydrogen peroxide (3% solution) 3. Water	50 cc 20 – 50 cc 50cc	The best General etchant for copper, brasses and bronzes
4.	Dilute hydrofluoric acid	1. Hydrofluoric acid 2. Water	0.5cc 99.5 cc	A good general etchant for al and its alloys (apply by swabbing).
5.	Keller's reagent	1. Hydrofluoric acid 2. HCl 3. HNO_3 4. Water	CC 1.5 CC 2.5CC 95CC	For (immersion) etching of Duralumin type alloys
6.	Mixed nitric and acetic acids	1. Nitric acid 2. Glacial acetic acid	50cc 50cc	For etching Nickel and Monel metal

Procedure:

1. Choose any plane surface of the hardened specimen having wide area.
2. Polish the specimen using the series of emery sheets and alumina powder.
3. Do fine polishing using polishing machine.
4. Etch the polished surface.
5. Keep the etched specimen under the microscope and study it at suitable magnification level.

Inference:

The microstructure consists of needle like or cut straw like hard and brittle structure called Martensite.

Result:

The microscopic structure of the hardened specimen was observed and analysed.

Viva Questions:

1. What do you learn from this experiment?

Ex No : ***Date :***

Microscopic Examination of Hardened Specimen and Tempered Specimen

Aim:

To study to microstructure of the hardened and tempered specimen using metallurgical microscope.

Apparatus required:

Metallurgical microscope, emery paper No.1 1/0 , 2/0 , 3/0 and 4/0, polishing machine and alumina powder.

Specimen Preparation:

The ultimate objective of specimen preparation is to produce a flat, scratch free mirror like surface. The steps required to prepare a metallographic specimen are as follows: (Each step is detailed in the previous experiment)

1. Sampling 2. Rough Grinding 3. Mounting
4. Intermediate polishing 5. Fine polishing 6. Etching

Procedure:

1. Choose any plane surface of the hardened and tempered specimen having wide area.
2. Polish the specimen using the series of emery sheets and alumina powder.
3. Do fine polishing using polishing machine.
4. Etch the polished surface.
5. Keep the etched specimen under the microscope and study it at suitable magnification level.

Inference:

The microstructure consists of tempered martensite. During tempering martensite decomposes to low carbon martensite called tempered martensite.

Application:

This knowledge can be used during Heat – Treatment.

Result:

The microscopic structure of the hardened and tempered specimen was observed and analysed.

Viva Questions

1. Define Stress.

When an external force acts on a body, it undergoes deformation. At the same time the body resists deformation. The magnitude of the resisting force is numerically equal to the applied force. This internal resisting force per unit area is called stress.

2. Define strain.

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

3. State Hooke's law.

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

4. Define Modulus of Elasticity.

The ratio of tensile stress to the corresponding tensile strain is constant within its elastic limit. The ratio is known as Young's Modulus or Modulus of Elasticity.

5. State Bulk Modulus.

The ratio of direct stress to the corresponding volumetric strain is constant within elastic limit. The ratio is known as Bulk Modulus.

6. Define poison's ratio.

When a body is stressed, within its elastic limit, the ratio of lateral strain to the longitudinal strain is constant for a given material.

7. Define buckling factor and buckling load.

Buckling factor:

It is the ratio between the equivalent length of the column to the minimum radius of gyration.

Buckling load:

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

8. Define safe load.

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

Safe load = Buckling load /Factor of safety

9. Define Factor of Safety.

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

10. State the tensile stress & tensile strain.

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

11. Define: Strain Energy

When an elastic body is under the action of external forces the body deforms and work is done by these forces. If a strained, perfectly elastic body is allowed to recover slowly to its unstrained state. It is capable of giving back all the work done by these external forces. This work done in straining such a body may be regarded as energy stored in a body and is called strain energy or resilience.

12. Define: Column and strut.

A column is a long vertical slender bar or vertical member, subjected to an axial compressive load and fixed rigidly at both ends

A strut is a slender bar or a member in an y position other than vertical, subjected to a compressive load and fixed rigidly or hinged or pin jointed at one or both the ends.

13. What are the factors affect the strength column?

1. Slenderness ratio: Strength of the column depends upon the slenderness ratio, it is increased the compressive strength of the column decrease as the tendency to buckle is increased.
2. End conditions: Strength of the column depends upon the end conditions also

14. Define principal stresses and principal plane?

Principal Stresses:

The magnitude of normal stress, acting on a principal plane is known as principal stresses.

Principal Plane:

The planes which have no shear stress are known as principal planes.

15. Define beam?

Beam is a structural member which is supported along the length subjected to external loads acting transversely. ie., perpendicular to the centre of the beam. Beam is sufficiently long as compared to external load.

16. How do you classify the beams according to its supports?

The beam may be classified according to the support

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

17. What is cantilever beam?

A beam with one end free and other end fixed is called Cantilever beam

18. What is simply supported beam?

A beam supported or resting freely on the supports at its both ends the its is called simply supported beam.

19. What is over hanging beam?

If beam one or both end extend beyond the support limit then it is called as over hanging beam.

20. Define shear force

Shear force

SF at any cross section of is defined as the algebraic sum of all the forces acting either side of a beam.

21. Define Bending Moment at a section.

BM at any cross section if the algebraic sum of the moments of all forces which are placed either side from the support.

22. Define hardening.

It is a heat treatment process to increase the strength and hardness.

23. Name some quenching mediums.

Air, water, oil.

24. Define tempering.

It is a heat treatment process to reduce the stress and brittleness.

MODEL QUESTION PAPER - I

1. Conduct tension test on mild steel specimen and determine modulus of elasticity, yield stress, ultimate stress, actual, normal breaking stress, percentage of elongation and percentage reduction in area. (100)
2. Conduct an experiment to determine Brinnel hardness number of the given specimen. (100)
3. Conduct torsion test on the given mild steel specimen and determine its rigidity modulus. (100)
4. Perform an experiment with the given open coiled helical spring and calculate the maximum strain energy stored in the spring. (100)
5. Conduct an experiment to determine the modulus of elasticity of rectangular steel Beam. (100)
6. Conduct an experiment to determine Young's modulus of given mild steel specimen and draw its stress-strain characteristics curves. Also calculate percentage of elongation and percentage reduction in area. (100)

MODEL QUESTION PAPER – II

1. Find the impact strength of the given steel by (Izod test and Charpy test) (100)
2. Determine the Rockwell hardness no. of the given specimens (100)

   (i) Brass (ii) Mild steel (iii) Cast iron
3. With the help of a Strain Rosette. Determine the Young's modulus of the given specimen (steel or wood) by measuring the strain. (100)
4. Determine the effect of hardening improvement in hardness of steels. (100)
5. Conduct a tensile test on a mild steel specimen and determine the following parameters (100)

   a. Limit of proportionality b. Ultimate strength

   c. Elastic limit d. Young's modulus of elasticity

   e. Yield strength f. Percentage reduction in area
6. Perform the compression test on the given spring wire and find out its stiffness and rigidity modulus. (100)

MODEL QUESTION PAPER – III

1. Determine the impact strength of the given specimen.(Charpy method), Find the shear strength of the given specimen under double shear method.

   (100)

2. Find hardness number and impact strength for unhardened, hardened specimen or Quenched and tempered specimen and compare mechanical properties.

   (100)

3. Determine the ultimate stress of the given specimen cube. Find the shear strength of the given specimen under double shear method.

   (100)

4. Find the improvement of mechanical properties in Quenched and tempered specimen. (100)

5. Microscopic Examination Of Hardened And Tempered Specimen.

   (100)

6. Deflection test on wood.
   (100)

PROGRAM OUTCOMES (POs)

Mechanical Engineering Graduates will be able to

1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals and an engineering specialization to solution of complex engineering problems.
2	**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.
3	**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 and safety, and the cultural, societal, and environmental considerations.
4	**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.
5	**Modern tool usage:** Create, select and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
10	**Communication:** Communicate effectively on complex engineering activities withthe engineering community andwith society atlarge, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
11	**Project management and finance:** Demonstrate knowledge and 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 in multidisciplinary environments.
12	**Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

K.L.N. COLLEGE OF ENGINEERING

VISION

To become a Centre of Excellence in Technical Education and Research in producing Competent and Ethical professionals to the Society.

MISSION

To impart Value and Need based curriculum to the students with enriched skill development in the field of Engineering, Technology, Management and Entrepreneurship and to nurture their character with social concern and to pursue their career in the areas of Research and Industry.

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