GOVERNMENT POLYTECHNIC COLLEGE
PERUMBAVOOR

MATERIAL TESTING LAB MANUAL

SEMESTER 4

DEPARTMENT OF MECHANICAL ENGINEERING

VISION AND MISSION OF THE INSTITUTION

VISION

Excel as a centre of skill education moulding professionals who sincerely strive for the betterment of society.

MISSION

1. To impart state of the art knowledge and skill to the graduate and moulding them to be competent, committed and responsible for the well-being of society.
2. To apply technology in the traditional skills, thereby enhancing the living standard of the community.

DEPARTMENT OF MECHANICAL ENGINEERING

VISION

Excel as a centre of skill education in mechanical engineering moulding professionals who strive for the betterment of society.

MISSION

1. Provide state of art knowledge ,skill and transform the students into responsible professionals for the sustainable development of society.
2. To have good infrastructure facilities so that students will gain hands on experience by using various equipment and software.

CONTENTS

STUDY/EXPERIMENTS

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GENERAL INSTRUCTIONS

Rough record and Fair record are needed to record the experiments conducted in the laboratory. Rough records are needed to be certified immediately on completion of the experiment. Fair records are due at the beginning of the next lab period. Fair records must be submitted as neat, legible, and complete.

INSTRUCTIONS TO STUDENTS FOR WRITING THE FAIR RECORD

In the fair record, the index page should be filled properly by writing the corresponding experiment number, experiment name, date on which it was done and the page number.

On the right side page of the record following has to be written:

1. Title: The title of the experiment should be written in the page in capital letters.

2. In the left top margin, experiment number and date should be written.

3. Aim: The purpose of the experiment should be written clearly.

4. Apparatus/Tools/Equipments/Components used: A list of the Apparatus/Tools/ Equipments /Components used for doing the experiment should be entered.

5. Principle: Simple working of the circuit/experimental set up/algorithm should be written.

6. Procedure: steps for doing the experiment and recording the readings should be briefly described (flow chart/programs in the case of computer/processor related experiments)

7. Results: The results of the experiment must be summarized in writing and should be fulfilling the aim. 8. Inference: Inference from the results is to be mentioned.

On the Left side page of the record following has to be recorded:

1. Circuit/Program: Neatly drawn circuit diagrams/experimental set up.

2. Design: The design of the circuit/experimental set up for selecting the components should be clearly shown if necessary.

3. Observations:

i) Data should be clearly recorded using Tabular Columns.

ii) Unit of the observed data should be clearly mentioned

iii) Relevant calculations should be shown. If repetitive calculations are needed, only show a sample calculation and summarize the others in a table.

4. Graphs: Graphs can used to present data in a form that show the results obtained, as one or more of the parameters are varied. A graph has the advantage of presenting large amounts of data in a concise visual form. Graph should be in a square format.

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GENERAL RULES FOR PERSONAL SAFETY

1. Always wear tight shirt/lab coat, pants and shoes inside workshops.

2. REMOVE ALL METAL JEWELLERY since rings, wrist watches or bands, necklaces, etc. make excellent electrodes in the event of accidental contact with electric power sources.

3. DO NOT MAKE CIRCUIT CHANGES without turning off the power.

4. Make sure that equipment working on electrical power are grounded properly.

5. Avoid standing on metal surfaces or wet concrete. Keep your shoes dry.

6. Never handle electrical equipment with wet skin.

7. Hot soldering irons should be rested in its holder. Never leave a hot iron unattended.

8. Avoid use of loose clothing and hair near machines and avoid running around inside lab.

TO PROTECT EQUIPMENT AND MINIMIZE MAINTENANCE: TO PROTECT EQUIPMENT AND MINIMIZE MAINTENANCE:

DO: 1. SET MULTIRANGE METERS to highest range before connecting to an unknown source.

2. INFORM YOUR INSTRUCTOR about faulty equipment so that it can be sent for repair.

DO NOT: 1. Do not MOVE EQUIPMENT around the room except under the supervision of an instructor.

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SYLLABUS

MODULE I

1.1. Study UTM & and its various uses.

1.2. Conduct Tension test on M.S. bar:

1.3. Compute the values yield point stress, ultimate stress, percentage elongation, and percentage reduction in cross sectional area and Young's modulus.

1.4. Study the behavior by plotting various graphs. Drawing stress strain graph.

MODULE II

2.1. Study of Impact Testing Machine.

2.2. Conduct Impact test: To find out impact values (Izod) of M.S bar specimen. Compute the values.

2.3. Conduct Charpy test of MS bar specimen. Compute the values.

2.4. Study the Brinnell testing Machine and its use:

2.5. To find Brinnell hardness values of M.S. bars.

2.6. To find Brinnell hardness values of aluminum.

2.7. Study Rock well hardness testing Machine.

2.8. Find out Rockwell hardness values of M.S. bars and Find out Rockwell hardness values of Aluminum.

2.9. Conduct Bending test on steel beam

2.10. Find out Young's modulus of steel by drawing deflection Vs load curve

2.11. Study Shear testing Machine and its use.

2.12. Find ultimate shear stress by conducting double shear test on MS bar

2.13. Study Torsion testing Machine and its use

2.14. Find modulus of rigidity, angle of twist and torque

2.15. Plot graph angle of twist Vs torque

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2.16. Find modulus of rigidity of steel wire from number of oscillation and torque

MODULE III

3.1. Find out modulus of rigidity of the material of the spring (both compression and tension)

3.2. Draw deflection Vs load graph

MODULE IV

4.1. Tension test on welded joint - Determine ultimate strength of lap and butt joint and the ultimate stress of the joint.

4.2. Determine the compressive strength of brittle material using UTM.

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MODIFIED SYLLABUS

1. STUDY OF MECHANICAL SPRING
2. EXPERIMENT ON SPRING TEST
3. STUDY OF UNIVERSAL TESTING MACHINES
4. EXPERIMENT ON UNIVERSAL TESTING MACHINES (TENSION TEST)
5. STUDY OF HARDNESS TEST
6. BRINELL HARDNESS TEST
7. STUDY OF IMPACT TEST
8. IMPACT TEST (IZOD & CHARPY)
9. STUDY DEFLECTION TEST
10. DEFLECTION TEST ON STEEL BEAM
11. TORSION TEST

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MECHANICAL TESTING OF MATERIALS

INTRODUCTION

When selecting a material for an engineering component, the properties of material have to be matched with the service conditions. To enable this, the service requirements are first analysed to determine the most important properties should posses by the material. That is, the properties like strength, hardness, rigidity, formability, toughness, and durability are indicating the materials ability for use in those applications. The mechanical properties of materials are determined by subjecting the prepared specimens to standard tests. This mechanical testing is the important step to judge the suitability of newer material for common engineering applications.

TYPES OF MECHANICAL TESTS

There are a number of mechanical test, which are carried out to determine the properties of a materials.

1. tensile test
2. compression test
3. impact test
4. hardness test
5. spring test
6. bend test
7. fatigue test
8. creep test

1. TENSILE TEST

The tensile test for a ductile material is carried out with the help of universal testing machine on the specimen made from material to be tested. In this test, the specimen is subjected to a gradually increasing uniaxial tensile load until it fractures.

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2. **COMPRESSION TEST**

Compression test is commonly used to test brittle material such as cast iron, concrete, stone, ceramics, etc. in many bulk metal-forming operations such as forging, rolling, and extrusion the work piece is subjected to compressive forces.

In compression test the load is applied is compressive in nature and the specimen contact along the direction of the applied stress. The compression test can be done on universal testing machine and is usually carried out by compression a solid cylindrical specimen between two flat dies.

3. **IMPACT TEST**

The ability of material to withstand an impact load without fracturing becomes an engineering importance. This ability is referred to as the toughness and it is a measure of the amount of energy, a material could absorb before fracture. The impact test is used to measure the toughness of material. Different types of impact tests are charpy test (beam test) and izod test (cantilever test)

The hardness test of material is generally performed to know its resistance against indention and abrasion. Different types of hardness tests are Brinnell’s hardness test, Rockwell’s hardness test and Vicker’s hardness test

4. **SPRING TEST**

Springs are elastic member, which distort under load and regain their original shape when load is removed. Stiffness is the one of the important characteristics of the spring. The stiffness is derived as the extent to which it resists deformation in response to an applied force. Spring test is used to find the stiffness of the spring and modulus of rigidity of material of the spring

5. **BEND TEST**

Material used for beams are elastic and hence under the action of loads the beam axes deflect. A designer has to decide about beam dimensions not only based on strength requirement but also from the consideration of deflections, which should be within the prescribed limits. In mechanical components, excessive deflection may cause mis-alignment and non-performance of machine. Deflection calculations are also required

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to impose consistency conditions in the analysis of indeterminate structures. Hence it is necessary to calculate beam deflections.

6. FATIGUE TEST

The failure of a material, under repeatedly applied stress, is called fatigue. The commonly used fatigue test is the rotating beam test, in which a specimen is subjected to alternating compression and tension stress of equal magnitude while being rotated. The test is carried out in a R.R Moore rotating beam fatigue testing machine. The fatigue life tells about how long a component survives at a particular stress level.

7. CREEP TEST

When a material is under a constant stress, it under goes a time dependent plastic deformation. This deformation is quite significant at elevated temperatures and is called creep. The creep test is used to determine the creep characteristics of a material. In creep test, the specimen is held in the furnace by special adopters and a static load is applied. The axial deformation is measured by dial indicator

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STUDY OF MECHANICAL SPRING

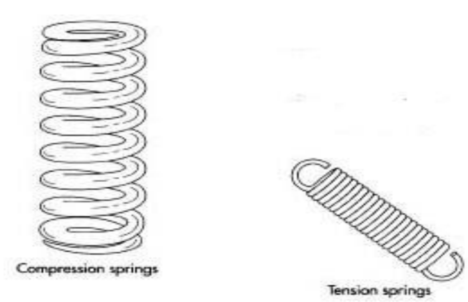
Springs are mechanical elements that deflect under load, absorb and store energy and release the energy when load is removed. They work as shock absorbers in automobiles, used for mechanical clamping in machine tools, used in inlet and outlet valves in IC engines. Torsion springs are used in watches and toys. Springs have been used in the field of machine design such as to cushion impact and shock loading to store energy to maintain contact between machine members, used in for measuring devices, spring balances and control of vibrations.

CLASSIFICATION OF SPRINGS

Springs are broadly classified as coil springs, leaf springs and disc springs. Coil springs are further classified as tension springs, compression springs, torsion springs and volute springs etc. Leaf springs are either cantilever type or sirnply supported type. If there are more than one leaf then they are called laminated springs. The semi-elliptical laminated springs are widely used in cars, trucks and buses. Disc springs are used where large loads are to be supported with small deflection. They are mainly used in machine tools for slide clamping. Figure 2.1 shows some typical springs.

HELICAL SPRINGS

Helical springs are made of circular cross-section, rectangular cross-section or square cross-section wires. Most commonly used cross-section is circular. When subjected to axial load, the springs will experience a torsional shear stress and a transverse shear stress. In addition, there is an additional stress effect due to curvature.



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EXPT NO:	

DATE:			

SPRING TEST

AIM:

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

APPARATUS REQUIRED:

spring test apparatus, vernier calipers, steel rule and spring specimen.

DESCRIPTION:

The spring test apparatus consists of graduated scale with a sliding vernier fitted to a metallic angle frame. One end of the spring is passed through the hook of the sliding vernier and the other end is suspended from a adjustable hook, fitted to the metallic frame. Another hook is provided at the bottom of the sliding arm on which a pan is attached to add the weight.

PRINCIPLE:

Modulus of rigidity, $N = 64\ WR^3n/Yd^4$ (for closed coil spring)

$$N = \frac{64 \times WR^3 n \sec\theta \left((\cos\theta)^2 + \frac{(\sin\ \theta)^2}{1+\frac{1}{m}} \right)}{Yd^4}$$ (for open coil spring)

1/m = poisson's ratio = 0.3

Stiffness = W/Y

Where,

W = load on the spring in (N)

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

n = number of turns on spring coil

d = diameter of the wire in mm

θ = angle of twisting (turns)

E = young's modulus, N = modulus rigidity, Y = deflection in mm

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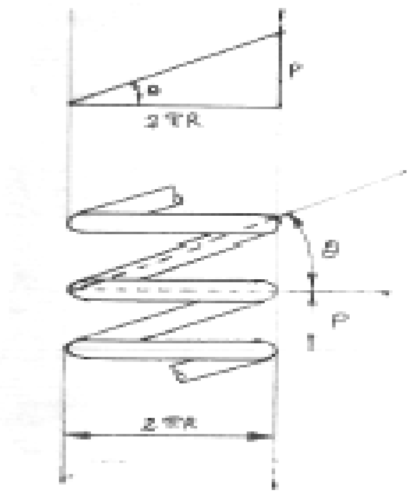

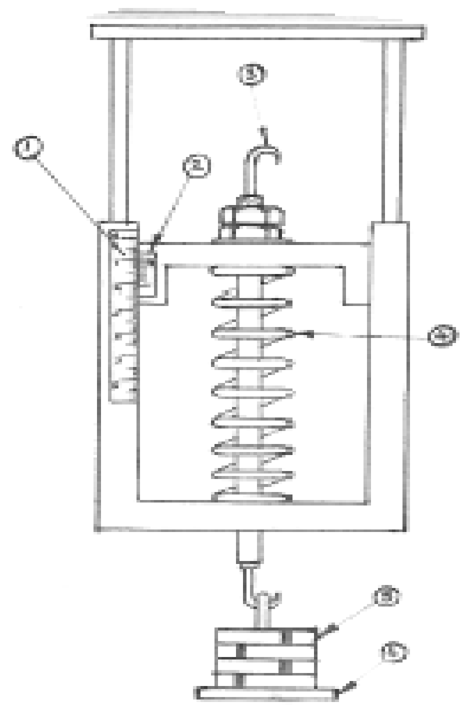

1. MAIN SCALE
2. VERNIER SCALE
3. 3ADJUSTABLE HOOK
4. SPRING
5. LOAD
6. PAN

PROCEDURE:

- Suspended the spring between the sliding vernier and adjustable hook.
- Adjust the top hook, so that the zero of the vernier coincide exactly with the zero of the graduated scale suspended the pan of known weight from bottom hook of the sliding vernier and note the corresponding deflection.
- Gradually add weight to the pan and note the corresponding deflection.
- Similarly note the deflection on removing one by one from the pan.
- Find the mean deflection and draw the curve load vs deflection.
- Measure the inner diameter (d) and the outer diameter (D) of the spring coil.
- Also find the number of turns and length of spring.

OBSERVATION AND CALCULATION

Open Coiled Spring:

Diameter of the wire d = ...mm.

Outer diameter of the coil, D = ...mm.

Mean radius of the coil R = (D – d)/2 = ...mm

Length of the coil, l = ……….mm

Number of turns on spring coil, n =…………nos

OUTER DIAMETER OF THE COIL (D)

Sl No.	MAIN SCALE READING (mm)	VERNIER SCALE READING (div)	TOTAL READING	AVERAGE DIAMETER (mm)
1				
2				
3				

DIAMETER OF THE WIRE (d)

Sl No.	MAIN SCALE READING (mm)	VERNIER SCALE READING (div)	TOTAL READING	AVERAGE DIAMETER (mm)
1				
2				
3				

TABULAR COLUMN

SL. NO	WEIGHT (W) N	COMPRESSION SCALE READING (mm)		MEAN DEFLECTION $(Y_2+Y_1)/2$ mm	MODOLUS OF RIGIDITY (N) N/mm^2
		LOAD (Y_1) INCREASING	LOAD (Y_2) DECREASING		
1					
2					
3					
4					
5					
6					
				MEAN (N)	

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SAMPLE CALCULATION (set no.)

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

Pitch(P) = l/n = = mm

Poisson's ratio (1/m) =

Tanθ = P/2πR=

Θ = $\tan^{-1}(\theta)$ = ^{0}

When θ > 5^0 spring is open coil, otherwise spring is closed coil.

Load on spring (W) = N

Then, $N = \dfrac{64 \times W R^3 n \sec\theta \left((\cos\theta)^2 + \frac{(\sin\theta)^2}{1+\frac{1}{m}} \right)}{Y d^4}$ =

N = N/mm^2

Stiffness of the spring (S) = W/Y = = N/mm

FROM GRAPH

Load (W) = N

Deflection (Y) = mm

$$Stiffness = \frac{W}{Y} =$$

$$= \quad N/mm$$

Modulus of rigidity $(N) = \dfrac{64 \times W R^3 n \sec\theta \left((\cos\theta)^2 + \frac{(\sin\theta)^2}{1+\frac{1}{m}} \right)}{Y d^4}$

N =

N = N/mm^2

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RESULT:

Modulus of rigidity of the given spring (N) =

Stiffness of the given spring (S) =

From graph,

Modulus of rigidity of the given spring =

Stiffness of the given spring =

INFERENCE:

The standard value of modulus of rigidity of the spring is 0.8×10^5 to 1×10^5 N/mm^2 . The obtained value of modulus of rigidity of given spring specimen is ....

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STATUS	DATE	MARK	SIGNATURE
ROUGH			
FAIR			

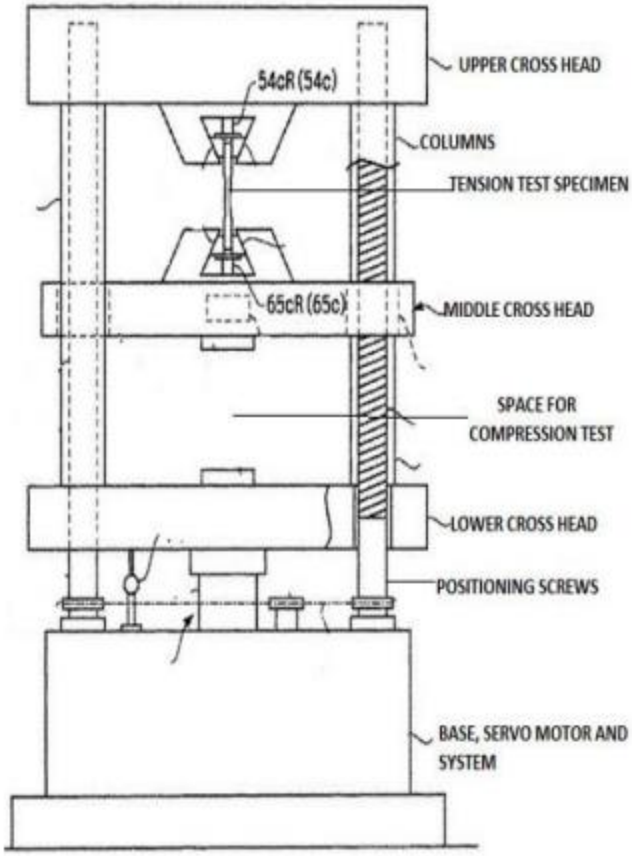
STUDY OF UNIVERSAL TESTING MACHINE

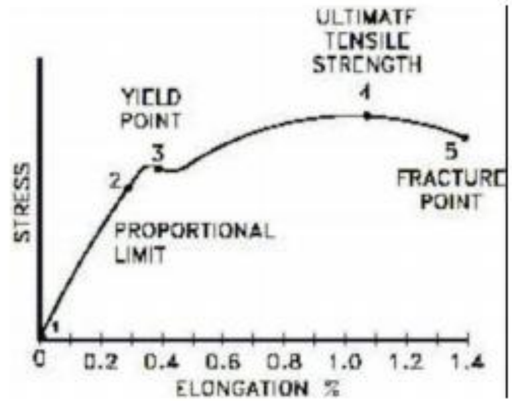
Universal testing machine is a machine suitable for testing materials especially for determining the tensile, compressive and bending strength of the specimen of any kind of material. The testing machine consists of 1) Testing machine and 2) Control panel .The machine and the control panel is connected with each other by means of pipes for hydraulic operation and cables for electric operation.

The Testing machine consists of 1) substructure 2) suspension gear along with crossheads 3) the middle crossheads being adjustable along column type spindle 4) the guide crosshead 5) the extension measuring and transmitting device and damping device. There are three crossheads namely, lower crosshead, middle crosshead, upper crosshead. The lower crosshead and upper crosshead assembly can move up and down with the main piston and is controlled hydraulically. The up and down movement of this assembly is guided by bearings which slide over the screwed columns. The lower crosshead is rigidly connected to the upper crosshead by two columns. The middle crosshead is controlled electrically. The space between the lower crosshead and middle crosshead is used for compression, bend, shear and hardness tests and the space between the middle and upper crossheads are used for tension test.

The following are installed in the housing of control panel: 1) hydraulic system 2) load maintain 3) dynamometer 4) control board 5) switch and fuse board.

The adjustable control crosshead may be raised or lowered. At the top there is movable crosshead while the bottom base is flat and movable. A bypass valve controls the amount of oil pumped into the tank and necessary switches and means are provided to control and understand the amount of oil supply. The rate of loading is adjusted by a screw and applied load may be measured from an approximately vertical circular scale. In addition to the sensitive hand the dial is provided with a dummy pointer, which helps us to access the maximum load applied accurately. There is also a vertical scale, which indicates deflection (in case of bending) or occurrence of slip (in the case of tension).The maximum load that can be measured is 40 KN in 40 UTM. The adjustable measuring ranges are 0 to 4KN, 0 to 20KN, and 0 to 40KN.





Stress-strain graph of Mild Steel

EXPT NO:	

DATE:			

TENSION TEST

AIM:

To study the behaviour of mild steel rod under tension to find out the following material properties, and graphs

1. Yield point stress
2. Ultimate stress
3. Percentage elongation
4. Young's modulus
5. Nominal breaking stress
6. Percentage reduction in area

Graphs;

1. Stress v/s Strain
2. Load v/s Extension

EQUIPMENTS:

Universal testing machine, vernier calipers, extensometer, punching tool, steel rule etc.

SPECIMEN:

The specimen used for the tension test is a mild steel rod of ....mm diameter, ...mm length

THEORY AND PRINCIPLE:

The specimen will be subjected to tensile load using an UTM and extension will be noted against the load using an extensometer within the elastic limit. Along with that loads at yield point, breaking point and ultimate point will be noted. Yield point is thepoint just beyond the elastic limit at which the specimen undergoes an appreciableincrease in length with out further increase in the load. During tension test at some pointthe load pointer will remain stationery. Load corresponding to this indicate yield load.Ultimate load is given by the maximum value of load shown by the load indicatorduring a tension test and the load shown by the load indicator at the point of failuregives breaking load. Stress - strain curve will be plotted for the specimen and followingresults can also be calculated.

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1. Modulus of elasticity $= \frac{\text{Stress ( )}}{\text{Strain ( )}}$ [within the elastic limit]

= Slope of the straight-line portion of the stress – strain graph.

2. Yield Stress $= \frac{\text{Load at yield point}}{\text{Original c/s area}}$

3. Ultimate stress $= \frac{\text{Ultimate Load}}{\text{Original c/s area}}$

4. Nominal breaking stress $= \frac{\text{Breaking Load}}{\text{Original c/s area}}$

5. Actual breaking stress $= \frac{\text{Breaking Load}}{\text{Neck area}}$

6. Percentage of elongation $= \frac{\text{Change in gauge length}}{\text{Original gauge length}} \times 100$

7. Percentage reduction in area $= \frac{\text{Change in area}}{\text{Original c/s area}} \times 100$

PROCEDURE:

1. Clean the given rod with sand paper. Measure the diameter of the rod at three different points and calculate the mean diameter
2. Calculate the gauge length using the formula5.65 $\sqrt{A}$, and mark the distance on the rod by punch mark so that one gauge length should come exactly at centre portion of the rod.
3. Assuming a tensile stress (working stress or yield stress) calculate the maximum expected load on the specimen and select the range of the machine. Adjust the machine for the above range by adjusting range-selecting knob.
4. If stress strain curve is to be recorded, the pen filled with ink, should be inserted in the recording paper around the drum
5. Select the proper jaw inserts. Then grip firmly the upper end of the test piece by operating the handle.
6. The left valve is kept in a fully closed position, open the right valve and close it after the lower table is slightly lifted. Now adjust the load pointer to zero with the zero adjusting knobs. This is necessary to remove the dead weight of the lower table, upper cross head and other connecting parts from the load.

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7. By operating the machine using electric motor lift the middle cross head up and grip lower part of the specimen. Then lock the jaws. Note that the specimen is gripped for equal length on both ends.

8. Fix the extensometer on the specimen and set the reading to zero. Also set the vernier scale on the vertical column of the machine to zero position to take reading on the plastic range.

9. Turn the right control valve slowly to open position keeping theleft valve closed, until you get a desired loading rate. Usually the loading rate should not be more than 7.5M Pa/Sec. *[(7.5 X* Area of the specimen) N/sec]

10. When you find that the specimen is under load unclamp the loading handle.

11. Now go on increasing the load and note down extensometer dial gauge readings for particular value of load increment.

12. Remove the extensometer immediately as soon as the extension is beyond the proportionality limit, ie. Dial gauge pointer will rotate continuously. This will indicate the yield point. At this time we can observe that load pointer will remain stationary. Load corresponding to this indicate yield load.

13. After removal of load the extension is noted on the vernier scale on the vertical column.

14. Apply the load again and note the ultimate load before the pointer goes back ward. At this point a neck will be formed on the specimen. Then the pointer goes back ward and specimen breaks at a particular load. Note the breaking load.

15. After the specimen break remove it from the grips and close the loading valve and open the release valve until the oil is pumped back and machine is switched off.

16. Two broken pieces are placed together on a horizontal surface and the distance between the punch marks near to the breaking point is measured. The reduced diameter at the point of breaking is also measured.

17. Plot the load versus extension graph.

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OBSERVATIONS AND CALCULATIONS

Length of the specimen (l)	
Diameter of the specimen [d_0]	
Original c/s area [A_0]	
Gauge length distance [l_G] = $5.65\sqrt{A}$	
Approximate tensile strength [σft]	250N/mm^2 for MS rod
Maximum expected load [P]	= KN = N
Range selected	
Yield load	
Ultimate load	
Breaking load	
Neck diameter	
Initial gauge length [l_0]	
Final gauge length [l]	

Measurement of diameter of the rod

SL. NO.	MAIN SCALE READING (mm)	VERNIER SCALE READING (div)	TOTAL READING (mm)	AVERAGE DIAMETER (mm)
1				
2				
3				

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TABULAR COLUMN

SL. NO.	LOAD		EXTENSION (dl) mm	STRESS N/mm^2	STRAIN dl/l
	KN	N			

CALCULATION

1. Young's modulus (E) = $\frac{STRESS}{STRAIN}$ = = N/mm^2

2. Ultimate stress = $\frac{ULTIMATE\ LOAD}{ORIGINAL\ CROSS\ SECTION\ AREA}$ = = N/mm^2

3. Yield stress = $\frac{YIELD\ LOAD}{ORIGINAL\ CROSS\ SECTION\ AREA}$ = = N/mm^2

4. Nominal breaking stress = $\frac{NOMINAL\ BREAKING\ LOAD}{ORIGINAL\ CROSS\ SECTION\ AREA}$ = = N/mm^2

5. Actual breaking stress = $\frac{BREAKING\ LOAD}{NECK\ AREA}$ = = N/mm^2

6. % of elongation = $\frac{CHANGE\ IN\ GAUGE\ LENGTH}{ORIGINAL\ GAUGE\ LENGTH} \times 100$ = = %

7. % of Reduction in area = $\frac{CHANGE\ IN\ AREA}{ORIGINAL\ CROSS\ SECTION\ AREA} \times 100$ = = %

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RESULT:

1. Young's modulus E = N/mm^2
2. Ultimate stress = N/mm^2
3. Yield stress = N/mm^2
4. Breaking stress = N/mm^2
5. Actual breaking stress = N/mm^2
6. Percentage elongation= %
7. Percentage reduction in area = %

INFERENCE:

Here the extension corresponding to length …….. is taken instead of extension of gauge length ……... So calculated youngs modulus (E) varies than standard value.

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STATUS	DATE	MARK	SIGNATURE
ROUGH			
FAIR			

STUDY OF HARDNESS TESTING

Hardness is generally considered as resistance to penetration. The harder the materials have the greater the resistance to penetration. Hardness is directly related to the mechanical properties of the material. Factors influencing hardness include rnicrostrucrure, grain size and strain hardening etc. Generally, as hardness increases so does yield strength and ultimate tensile strength (UTS), thus specifications often require the results of hardness tests rather than tensile tests. The most popular methods are Brinell, Vickers and Rockwell hardness tests for metals and alloys.

Brinell Test

In a standard Brinell test 10 mm diameter hardened steel ball is forced to penetrate the material by 3000 kgf for steels and cast irons. The load and ball diameter selection is important depending on the hardness of materials and 500 kgf is used for softer materials with the same ball diameter. Keeping the ratio of load P to the square of diameter ‘D’ constant (30 for steels and cast irons and 5 for soft metals and alloys), different load and ball diameter combinations can be selected and used in Brinell hardness testing. The Brinell Hardness Number (BHN) is obtained by dividing the applied force P, in kgf; by the curved surface area of the indentation which is actually a segment of sphere. The geometry of indentation is in Figure-l and the hardness is determined according to the relationship.

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

where D is the diameter of the indenter ball and d is the average diameter of the indentation, both in mm.

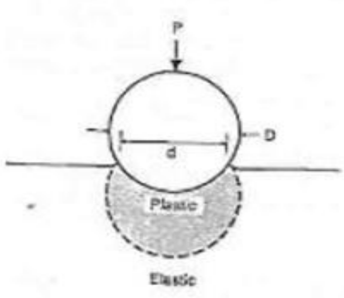

Figure-1: Geometry of deformation under a Brinell hardness indenter.

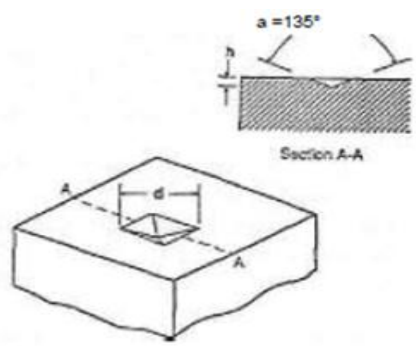

Figure-2: Vickers hardness indentation.

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Vickers Test

The Vickers hardness test is based on the same principle as the Brinell test. Except the indenter is a diamond pyramid with square base. The angle between the faces of pyramid is 136° as shown in Figure-2. The Vickers Hardness Number (VHN] of materials is obtained by dividing the applied force P, in kgf by the surface of the pyramidal depression yielding the relationship

$$VHN = \frac{1.8544P}{d^2}$$ (in some sources VHN is cited as DPH)

Where d' is the average length of diagonals in mm. Due to the shape and hardness of indenter the method is applicable to metals and alloys with wide variety of hardness. Test load is selected between l and 120 kgf depending on the hardness of materials. It is also possible to apply micro hardness testing by keeping the force between 5 grf and 2 kgf in Vickers scale.

Rockwell Test

In the Rockwell test a diamond cone or a hard steel ball is employed as the indenter depending on the hardness of materials. Diamond cone or Brale indenter with cone angle of 120° is used to test hard materials and the balls of sizes between 1.6 mm {1/16'') and 12.7 mm (1/2") are used in testing softer materials. Rockwell tests differ from other indentation hardness tests in that the depth of indentation determines the hardness rather than the indentation size (see Figure-3). Therefore surface condition of specimens is very important in Rockwell testing because of its high dependency on the accuracy in indentation depth measurements. In order to establish a reference position a minor load of 10 kgf is first applied and the major load is then applied. Additional penetration clue to major load is measured and readings are obtained from a calibrated scale (dial) directly which has a maximum value of 100 depending on the depth of penetration. The hardness numbers are designated HRX where X indicates the scale used (i.e. 50 HRC for 50 points on the C scale of dial). It should be noted that a Rockwell hardness number is meaningless unless the scale is not specified.

$$HR = E - e$$

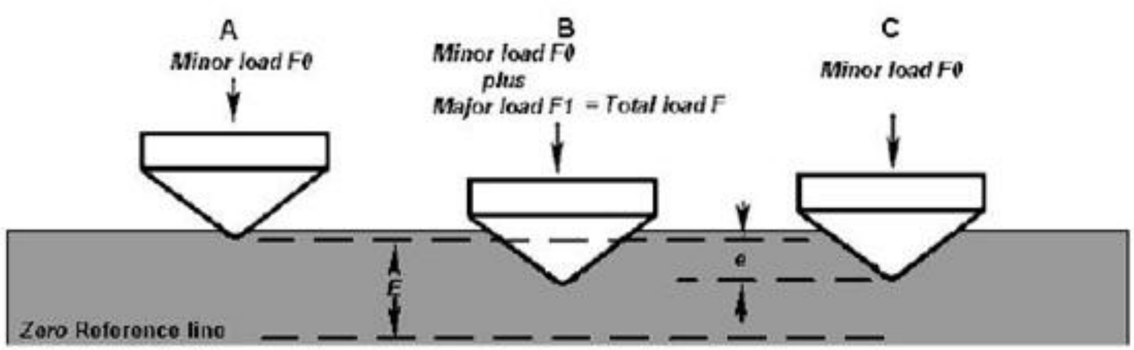


Figure-3: Increasing depth of penetration in the Rockwell test

EXPT NO:	

DATE:			

BRINELL HARDNESS TEST

AIM:

To determine the Brinell hardness number of the material of the specimen.

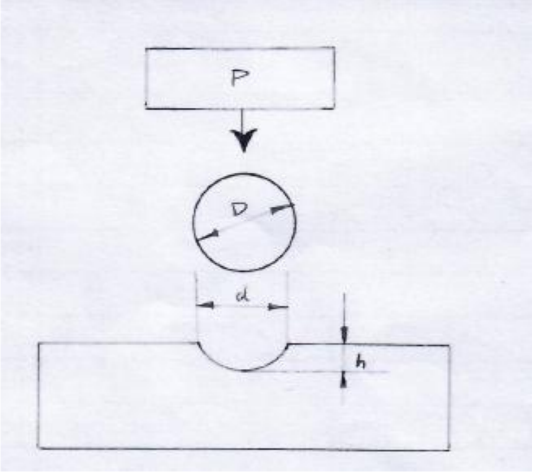
APPARATUS REQUIRED:

Brinell hardness testing machine, indicator microscope to measure the diameter of the ball indenter.

PRINCIPLE:

For a number of engineering materials which are subjected in fraction such as steel, cast iron etc. It is necessary to find out their resistance to wear and tear. Hardness of a surface can be increased by heat treatment or by chemical treatment and efficiency of the process can be checked by finding out the hardness. The brinell hardness test is carried out by forcing a hardened steel ball of diameter 'n' number under load 'p' into a test specimen and measuring the diameter 'd' of the indentation left on the surface after the removal of the load. Normally for hard material a ball of the diameter 10 mm shall be used, for soft material 5 mm, 2.5 mm, 2 mm and 1 mm are to be used depending upon the soft of the surface. The brinell hardness number H.B. is obtained by dividing the test load 'p' by curved surface over of the penetration which is assumed to be spherical with diameter'd'.

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



where

D= Diameter of ball in mm.

P= Test load in Kgf

d= Diameter of indentation in mm.

BHN= Brinell hardnessnumber =

$$\frac{Test\ load}{Surface\ area\ of\ indentation}$$

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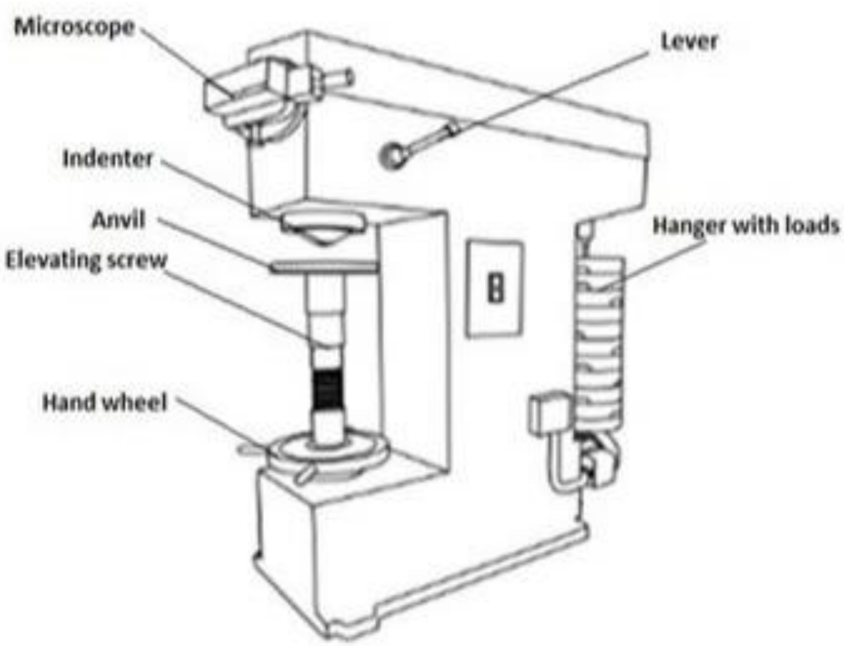
Standard instillation has recommended the following four different P/D^2 ratio for different material as follows.

1. Steel and cast iron = 30
2. Brass = 10 – 15
3. Copper and Aluminium = 5
4. Lead and Tin alloys = 1



PROCEDURE:

Polish the surface of the specimen with emery paper, the place the specimen on the work table and raise the table by turning the elevation screw till last hand points to the red mark on the dial indicator adjust the dial for the required weight. That is, if the penetration diameter is 25 mm and P/D^2 ratio is 30 then the load is 3000 kg apply the load by operating lever arm wait for 30 second for soft material and 15 second for hard material to make the load reach the specimen fully, till the pointer stops moving. Remove the specimen and measure the diameter of the indentation correct to 0.01 mm with brinell microscope. To do this, keep the block vertical line. For the microscope till comes tangential to the opposite side of the indentation using the following formula and calculate the Brinell hardness number.

Brinell hardness number, $BHN = \frac{P}{\frac{\pi}{2}D\left(D-\sqrt{D^2-d^2}\right)} = \frac{2P}{\pi D\left(D-\sqrt{D^2-d^2}\right)}$

Where,

P = The load adjust on the machine in Kgf

D = The diameter of indenter in mm

d = The diameter of the impression in mm

TABULAR COLUMN

Sl No.	Materials	Load (p) KgF	Diameter of Indentor (D) mm.	Diameter of Indentation			Mean $\frac{d1+d2+d3}{3}$ (mm)	BHN = $\frac{2P}{\pi D\ (D-\sqrt{D^{2}-d^{2}}}$
				d1 (mm)	d2 (mm)	d3 (mm)		
1	Aluminium							
2	Brass							
3	Copper							
4	Mild steel							

SAMPLE CALCULATION

BHN. OF ALUMINIUM

Applied load (P) = kgf

Diameter of indentor (D) = mm

Diameter of impression (d) = mm

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

BHN OF BRASS

Applied load (P) = kgf

Diameter of indentor (D) = mm

Diameter of impression (d) = mm

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

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BHN OF COPPER

Applied load (P) = kgF

Diameter of indentor (D) = mm

Diameter of impression (d)= mm

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

BHN OF MILD STEEL

Applied load (P) = kgF

Diameter of indentor (D) = mm

Diameter of impression (d) = mm

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

RESULT:

Hardness number of **mild steel** = ………. / ……….. / ……….. / …………

Hardness number of **copper**= ………. / ……….. / ……….. / …………

Hardness number of **Aluminium**= ………. / ……….. / ……….. / …………

Hardness number of **brass**= ………. / ……….. / ……….. / …………

INFERENCE:

Brinell hardness number is different for different metals. In this test the H.B. of is in the order is Copper < Aluminium < Brass< Mild steel

STATUS	DATE	MARK	SIGNATURE
ROUGH			
FAIR			

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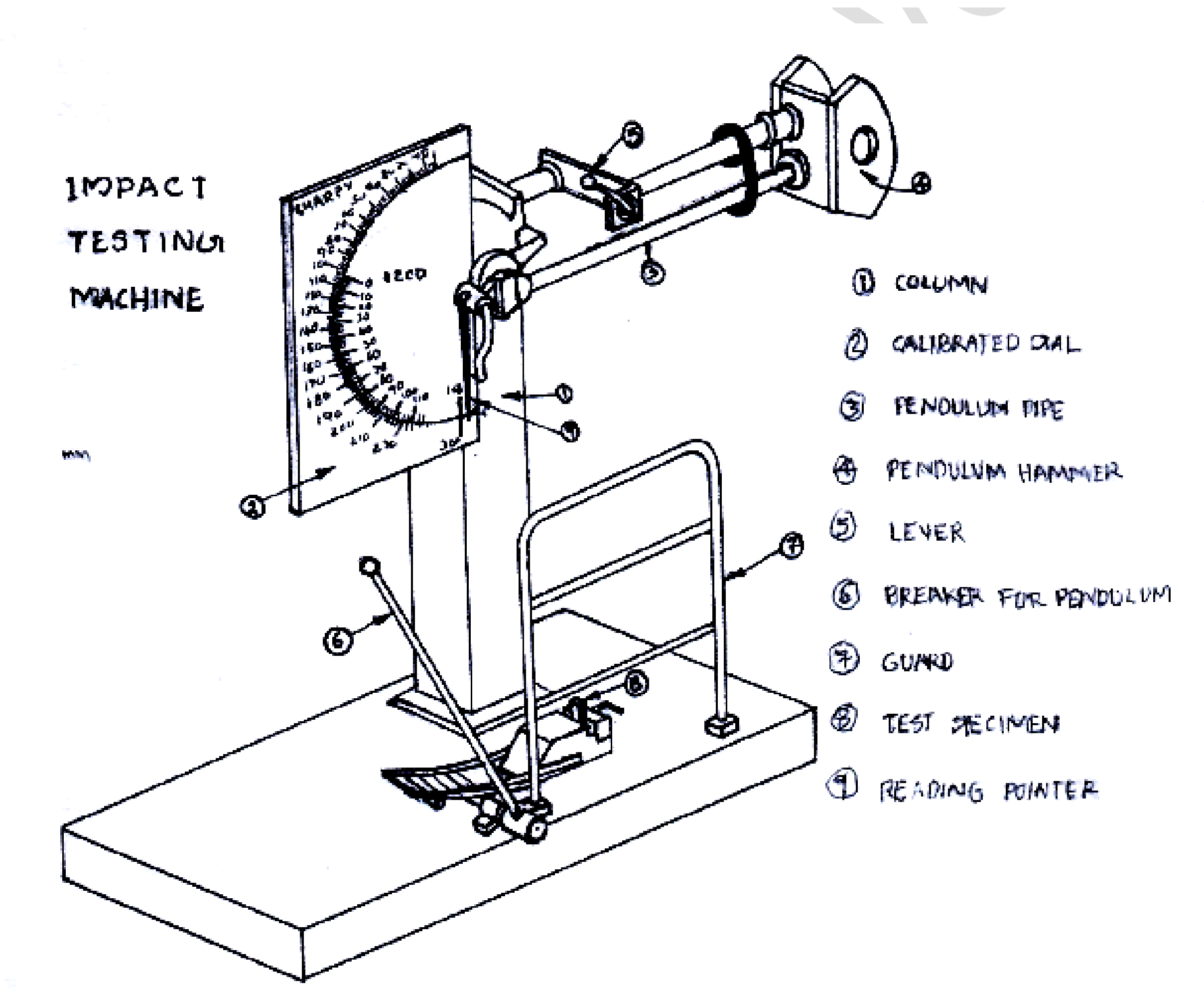
STUDY OF IMPACT TEST

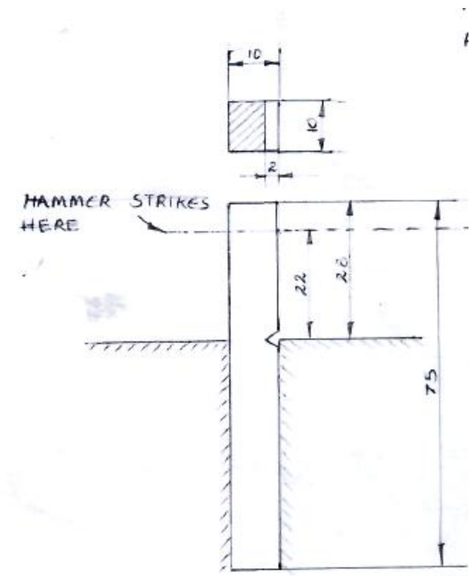
Impact is a very important phenomenon in governing the life of a structure. For example, in the case of an aircraft, impact can take place by a bird hitting a plane while it is cruising, or during takeoff and landing the aircraft may be struck by debris that is present on the runway, and as well as other causes. It must also be calculated for roads if speed breakers are present, in bridge construction where vehicles punch an impact load, etc.

Impact tests are used in studying the toughness of material. A material's toughness is a factor of its ability to absorb energy during plastic deformation. Brittle materials have low toughness as a result of the small amount of plastic deformation that they can endure. The impact value of a material can also change with temperature. Generally, at lower temperatures, the impact energy of a material is decreased. The size of the specimen may also affect the value of the Izod impact test because it may allow a different number of imperfections in the material, which can act as stress risers and lower the impact energy.



Izod impact testing

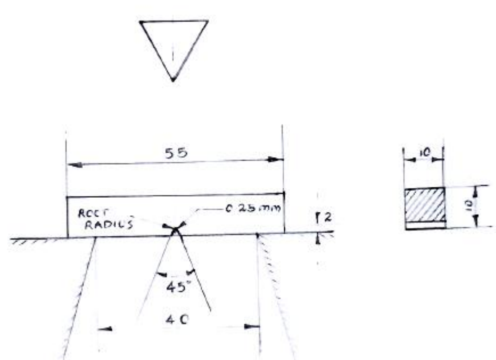
It is an ASTM standard method of determining the impact resistance of materials. A pivoting arm is raised to a specific height (constant potential energy) and then released. The arm swings down hitting a notched sample, breaking the specimen. The energy absorbed by the sample is calculated from the height the arm swings to after hitting the sample. A notched sample is generally used to determine impact energy and notch sensitivity. The test is similar to the Charpy impact test but uses a different arrangement of the specimen under test. The Izod impact test differs from the Charpy impact test in that the sample is held in a cantilevered beam configuration as opposed to a three-point bending configuration.



Izod specimen

Charpy impact test

The Charpy impact test, also known as the Charpy V-notch test, is a standardized high strain-rate test which determines the amount of energy absorbed by a material during fracture. This absorbed energy is a measure of a given material's notch toughness and acts as a tool to study temperature-dependent ductile-brittle transition. It is widely applied in industry, since it is easy to prepare and conduct and results can be obtained quickly and cheaply. A disadvantage is that some results are only comparative.



Charpy specimen

EXPT NO:	

DATE:			

IMPACT TEST : IZOD AND CHARPY

AIM:

a) To draw calibration curves for the machine used.

b) To find the impact values of the materials of the standard specimens.

APPARATUS REQUIRED:

Impact testing machine and setting gauges

PRINCIPLE:

For deciding the stability of material, which is expected to resist repeated shocks, the ordinary static tensile test is not formed satisfactory. Testing machines have been decided so that a specimen can be subjected to shock loads. The energy required to break the specimen is taken as a measure of the resistance of the material against shock loading. The property of a material relating to the work required to cause rapture has been termed as Toughness.

DESCRIPTION:

IMPACT TESTING MACHINE

The machine consists of a pendulum with a hammer having a striker at the end. The length of the pendulum is 825 mm with a hammer weight of 21 kg. The machine has two capacity ranges 0 - 16.71 kgm for izod test (cantilever test) and 0 – 30.58 kgm for charpy test (beam test). Two control levers are fitted one for releasing the pendulum and other for clamping the specimen. The angle of rise of pendulum after impact is read from the dial. A stop fitted to support the pendulum in the rest portion. Two ratchets fitted to the pendulum lock at the 16.71 kgm or 30.58 kgm height whichever is selected.

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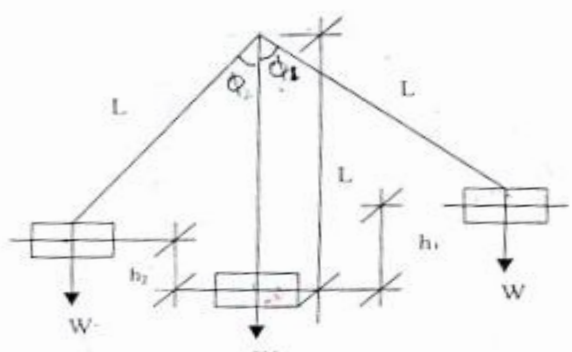

PROCEDURE:

Initial energy , $(E_1) = Wh_1 = WL(1\text{-COS } \emptyset_1)$

Final energy, $(E_2) = Wh_2 = WL(1\text{- COS } \emptyset_2)$

Loss of energy or impact value $(E_L) = E_2 - E_1$

Length of the pendulum(L) = 825 mm

Hammer weight (W) = 21 kg

E_1 = 17.13 kgm (IZOD) E_1 = 30.58 kgm (CHARPY)

The value in corresponding equation (1) and find $Ø_1$. To find a relation between $E_L$and $Ø_1$ substitutes for W,L and Ø for varying values of $Ø_1$. Calculate the corresponding values of E_L and draw a curve of E_L vs Ø, which is the calibration curve. Now during a test if the pointer indicates an angle of $Ø_2$ after impact, the corresponding impact value can be read from the calibration curve.

<u>CANTILEVER TEST (IZOD)</u>

Fit the striker with the horizontal face in the striker position. The appropriate grips are positioned after inserting the test piece with notch to the right , set the specimen for the correct height with the setting gauge and lock the grips with right hand lever with the safety lever in the izod position. Rise the pendulum to 17.13 kg position. Rotate the pointer maximum anticlockwise until it contact the fixed pointer attached to the pendulum. Release the pendulum by left hand lever. After pendulum has passed the test piece, it will carry the maximum pointer and leave it indicating the angle of rise of the pendulum after impact. Arrest the pendulum by catching the handle with right hand, after pulling the pendulum back rise the stop to allow the top of the pendulum to rest on it. Repeat the test by using the remaining two notches of the specimen. Take the average of these three values as the impact value of the specimen.

<u>BEAM TEST (CHARPY)</u>

In this case fit the striker with the central vertical edge in the striking position and lock the anvil. Place the testing piece across the anvil with the notch to the left. Locating it centrally with the centering gauge with the safety lever in the charpy position, raise the pendulum to 30.58 kgm position and release the load, read the value indicated on the dial. Repeating the test by using the remaining two specimen. Take the average of these three values as the impact charpy value of the specimen.

OBSERVATION AND CALCULATION

W = kgf

L =mm

E_1 (IZOD) = 17.13 jule = $168 \times \frac{1}{9.81} =$ 17.13 kgm

E_1 (CHARPY) = 30.58 jule = $300 \times \frac{1}{9.81} =$30.58 kgm

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TABULAR COLUMN

SL. NO.	NAME OF TEST	ANGLE $\O_2$		MEAN ANGLE $\O_2$	E_1 kgm
1	IZOD				
2	CHARPY				

CALCULATION

(CHARPY)

Find the value of $\O_1$ in degrees,

$E_1 = WL\,(1- \cos \O_1)$ =

$\cos \O_1$ =

$\O_1 = \cos^{-1}$…… $(\O_1)$= = ……^{0}

CALIBRATION CURVE

For calibration curve substitute the various values of Ø in the given equation,

$WL\,(\cos \O - \cos \O_1)$

For,

Ø= 0 , $E_L = WL\,(\cos \O - \cos \O_1)$ = = kgm

Ø= 10 , $E_L = WL\,(\cos \O - \cos \O_1)$ = = kgm

Ø= 20 , $E_L = WL\,(\cos \O - \cos \O_1)$ = = kgm

Ø= 30 , $E_L = WL\,(\cos \O - \cos \O_1)$ = = kgm

Ø= 40 , $E_L = WL\,(\cos \O - \cos \O_1)$ = = kgm

Ø= 50 , $E_L = WL\,(\cos \O - \cos \O_1)$ = = kgm

Ø= 60 , $E_L = WL\,(\cos \O - \cos \O_1)$ = = kgm

Ø= 70 , $E_L = WL\,(\cos \O - \cos \O_1)$ = = kgm

Ø=80 , $E_L = WL\,(\cos \O - \cos \O_1)$ = = kgm

Ø= 90 , $E_L = WL\,(\cos \O - \cos \O_1)$ = = kgm

Ø= 100 , $E_L = WL\,(\cos \O_1 - \cos \O_1)$ = = kgm

$\O = \O_1$, $E_L = WL\,(\cos \O_1 - \cos \O_1)$ = = kgm

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$E_2 = WL (1 – \cos Ø_2) =$ = kgm

Loss of energy or Impact value (E_L) = $E_2 – E_1$= kgm

or

$WL (\cos Ø_1 – \cos Ø_2) =$ = kgm

(IZOD)

Find the value of $Ø_1$ in digrees,

$E_1= WL (1- \cos Ø_1)$

=

$\cos Ø_1 =$

$Ø_1 = \cos^{-1}$ ……. ($Ø_1$) = = ……..^{0}

CALIBRATION CURVE

For calibration curve substitute the various values of Ø in the given equation,

$WL (\cos Ø – \cos Ø_1)$

For,

Ø= 0 , $E_L = WL (\cos Ø – \cos Ø_1) =$ = kgm

Ø= 10 , $E_L = WL (\cos Ø – \cos Ø_1) =$ = kgm

Ø= 20 , $E_L = WL (\cos Ø – \cos Ø_1) =$ = kgm

Ø= 30 , $E_L = WL (\cos Ø – \cos Ø_1) =$ = kgm

Ø= 40 , $E_L = WL (\cos Ø – \cos Ø_1) =$ = kgm

Ø= 50 , $E_L = WL (\cos Ø – \cos Ø_1) =$ = kgm

Ø= 60 , $E_L = WL (\cos Ø – \cos Ø_1) =$ = kgm

Ø= 70 , $E_L = WL (\cos Ø – \cos Ø_1) =$ = kgm

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$\text{Ø} = \text{Ø}_1$, $E_L = WL(\cos \text{Ø} - \cos \text{Ø}_1) =$ = kgm

$E_2 = WL(1 - \cos \text{Ø}_2) =$ = kgm

Loss of energy or Impact value (E_L) = $E_2 - E_1$ = kgm

or

$WL(\cos \text{Ø}_1 - \cos \text{Ø}_2) =$ = kgm

CALIBRATION CURVE

CHARPY

Ø	0	10	20	30	40	50	60	70	80	90	100	Ø_1
E_L												0

IZOD

Ø	0	10	20	30	40	50	60	70	Ø_1
E_L									0

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RESULT:

a) Calibration curve plotted.
b) Impact value of the material of standard specimen (mild steel)

By Izod value = kgm

By Charpy value= kgm

INFERENCE:

In case of impact test (charpy and izod) the machine has the capacity between 0- 17.13 kgm for Izod and 0- 30.58 kgm for charpy. Experimental impact value of the material is in the standard range.

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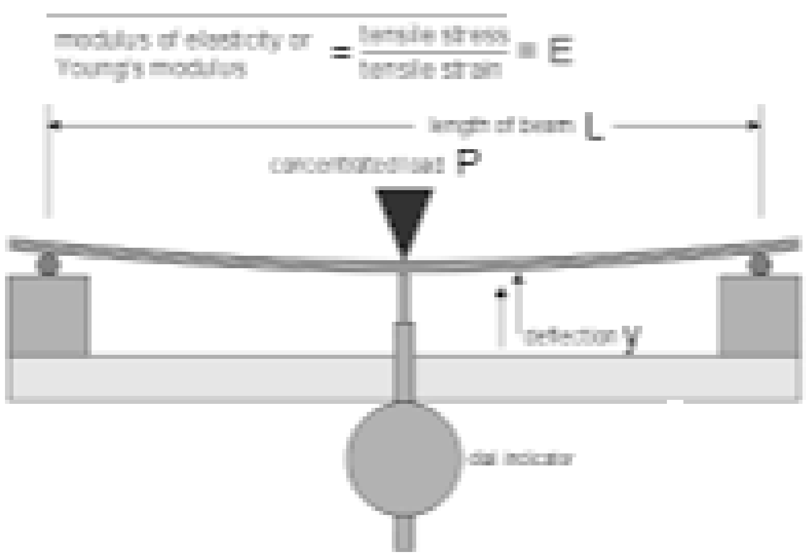
STATUS	DATE	MARK	SIGNATURE
ROUGH			
FAIR			

STUDY OF DEFLECTION ON STEEL BEAM

In all practical engineering applications, when we use the different components, normally we have to operate them within the certain limits i.e. the constraints are placed on the performance and behavior of the components. For instance we say that the particular component is supposed to operate within this value of stress and the deflection of the component should not exceed beyond a particular value.

In some problems the maximum stress however, may not be a strict or severe condition but there may be the deflection which is the more rigid condition under operation. It is obvious therefore to study the methods by which we can predict the deflection of members under lateral loads or transverse loads, since it is this form of loading which will generally produce the greatest deflection of beams.



EXPT NO:	

DATE:			

DEFLECTION TEST ON STEEL BEAM

AIM:

To determine the young's modulus of the material of the given specimen, and plotted the graph Load v/s Deflection.

APPARATUS REQUIRED:

Deflection measuring unit, weight, dial gauge etc.

PRINCIPLE:

Hook's law state that when a material is loaded with in the elastic limit, the stress is proportional to the strain.

Mathematically, $\frac{STRESS}{STRAIN}$ = constant

The constant is called young's modulus and denoted by 'E'.

That is , Young's modulus (E) = $\frac{Wl^3}{48dI}$

Where,

W = load in N

l = length of the beam in mm

I =$\frac{bd^3}{12}$ =moment of inertia in mm^4

$\boldsymbol{\delta}$= deflection in mm

E = modulus of elasticity in N/mm^3

b = breadth of the beam in mm

d = thickness of the beam in mm

PROCEDURE:

Clean the beam specimen using emery paper. Level the universal frame with the help of the leveling screw. Measuring the dimension of the beam , that is length , breadth and thickness using steel rule and vernier caliper. Mark the centre exactly and place the beam on the support with equal overhangs. Load the beam at the centre using loading arrangement. Attach the dial gauge before loading. Applied the central load 4.9 N at every interval and record the corresponding dial gauge reading up to maximum load of 24.5 N. note the time of unloading at

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4.9 N intervals and record the dial gauge reading up to zero load. Plot the graph between load and deflection.

GRAPH :- Draw a graph showing load in x axis and deflection in y axis. Draw an average graph Calculate the value of young's modulus of material given from the relation,

$$E = \frac{Wl^3}{48\delta I}$$

OBSERVATIONS AND CALCULATIONS

TABULAR COLUMN

SL. NO.	LOAD N	CENTRAL DEFLECTION		CENTRAL DEFLECTION mm	MODULUS OF ELASTICITY $E = \frac{Wl^3}{48dI}$ N/mm^2
		LOADING mm	UNLOADING mm		
1					
2					
3					
4					
5					
6					
				Mean	

Mean load= N

Mean central deflection = mm

SAMPLE CALCULATION (Set no.)

Breadth of the beam (b) = mm

Thickness of the beam (d) = mm

Length of the beam (l) = mm

Moment of inertia of rectangular section (I) = $\frac{bd^3}{12}$ = = mm^4

Stiffness = $\frac{LOAD}{DEFLECTION}$ = = N/mm

Modulus of elasticity (E) = $\frac{Wl^3}{48\delta I}$= =N/mm^2

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FROM GRAPH

AB (Load) = N

BC (Deflection) = mm

Modulus of elasticity E = $\frac{Wl^3}{48\delta I}$ = = N/mm^2

Stiffness = w/δ = = N/mm

RESULT:

Modulus of elasticity of given steel beam

1. By calculation = N/mm^2
2. From graph = N/mm^2

Stiffness of the given steel beam

1. By calculation = N/mm
2. From graph = N/mm

INFERENCE:

The standard value of modulus of elasticity of mild steel is between 2×10^5 N/mm^2 and 2.2×10^5 N/mm^2. The obtained value of given specimen of mild steel is …………

STATUS	DATE	MARK	SIGNATURE
ROUGH			
FAIR			

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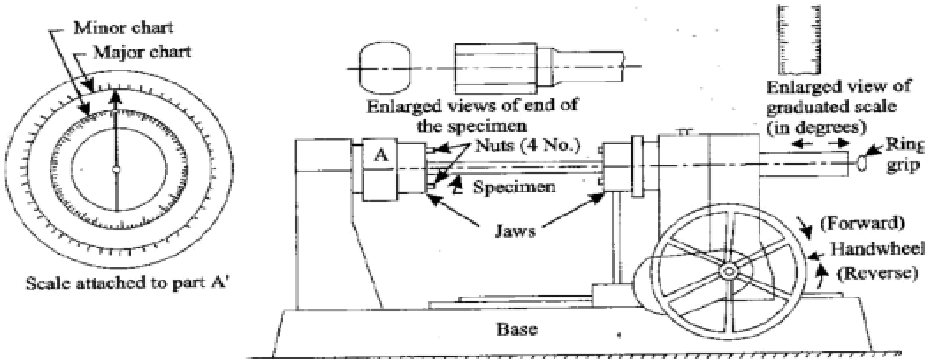
STUDY OF TORSION TEST



Torsion tests twist a material or test component to a specified degree, with a specified force, or until the material fails in torsion. The twisting force of a torsion test is applied to the test sample by anchoring one end so that it cannot move or rotate and applying a moment to the other end so that the sample is rotated about its axis. The rotating moment may also be applied to both ends of the sample but the ends must be rotated in opposite directions. The forces and mechanics found in this test are similar to those found in a piece of string that has one end held in a hand and the other end twisted by the other.

Purpose of torsion testing:

The purpose of a torsion test is to determine the behavior a material or test sample exhibits when twisted or under torsional forces as a result of applied moments that cause shear stress about the axis. Measurable values include: the modulus of elasticity in shear, yield shear strength, torsional fatigue life, ductility, ultimate shear strength, and modulus of rupture in shear. These values are similar but not the same as those measured by a tensile test and are important in manufacturing as they may be used to simulate the service conditions, check the product's quality and design, and ensure that it was manufactured correctly.

Types of materials:

Many materials experience torques or torsional forces in their applications and so will benefit from or require torsion testing. Materials used in structural, biomedical and automotive applications are among the more common materials to experience torsion in their applications. These materials may be composed of metals, plastics, woods, polymers, composites, or ceramics among others and commonly take the forms of fasteners, rods, beams, tubes and wires.

EXPT NO:	

DATE:			

TORSION TEST ON STEEL ROD

AIM: To determine the modulus of rigidity of the given specimen by conducting a torsion test, and the plot the graph Torque Vs Angle of twist.

APPARATUS: Torsion testing machine, scale, vernier callipers etc.

THEORY:

The modulus of rigidity of the material can be determined from the relation

$T/J = G\theta / l$

where,

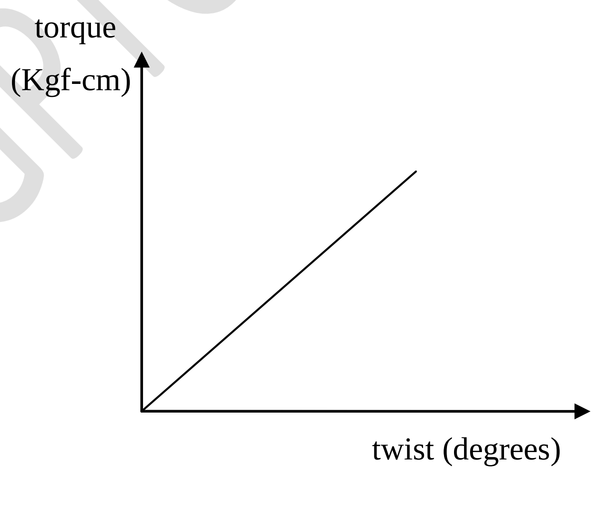
T = torque applied in N-mm

J = polar moment of inertia in mm^4

G= modulus of rigidity N/mm^2

θ = angle of twist in radians

l = gauge length of the specimen in mm



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PROCEDURE:

Measure the gauge length and dimensions of the specimen. Fix the specimen in between the driving and driven chucks. Set the reading on the angle-measuring disc to zero. Apply the torque on the specimen by rotating the hand wheel manually in the anticlockwise direction. As the torque is applied, there will be some reading for torque. Note the torque reading for equal intervals of angular deformation. Repeat till we get ten sets of readings. After taking the readings, release the torque gradually. Using the readings of torque and angular deformation, a graph is plotted.

OBSERVATION AND TABULATION:

Measurement of diameter of the rod

SL. NO.	MAIN SCALE READING mm	VERNIER SCALE READING div	TOTAL READING mm	AVERAGE DIAMETER mm
1				
2				
3				

Length of the specimen, *1* = ...mm

Diameter of the specimen, d = ...mm

Tabular column

Sl. No.	Torque		Angle of twist		Modulus of rigidity, G	Average, G
	Kgf-cm	N-mm	degrees	Radian	N/mm^2	N/mm^2

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CALCULATION:

From the graph, T= .... Kgf-cm

= ………...N-mm.

Angle of twist, Ø = ... degrees

= …………radians.

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

=.............. mm^4

Length of the specimen = ... mm

Substituting the values,

Modulus of rigidity, G = T*l*/Jθ

= .... N/mm^2

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RESULT:

Modulus of rigidity of the material = ... N/mm^2.

INFERENCE:

The modulus of rigidity of mild steel is the range 0.8×10^5 N/mm^2 to 1×10^5 N/mm^2. For the given material of specimen the obtained value of …………

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STATUS	DATE	MARK	SIGNATURE
ROUGH			
FAIR			