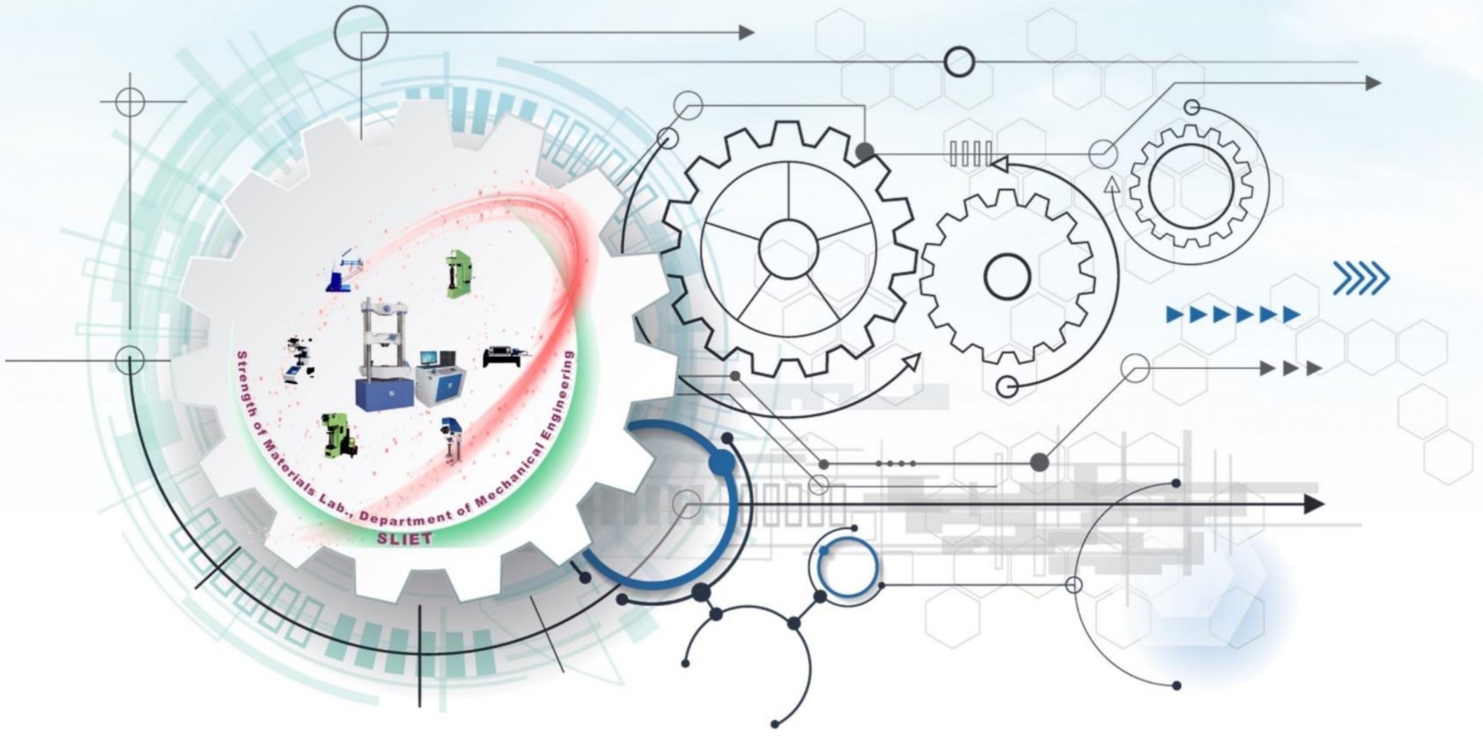
ICD

LAB MANUAL

Strength Of Materials Lab

Department Of Mechanical Engineering



संस्थान कुलगीत

जयति जयति विधा-संस्थान !

रावी-व्यास कल-कल अनुगुंजित

सृजन-मंत्र देता अविराम !!

'योग-कर्म-कौशल' नित मन में,

गुरु-वाणी अमृत कण-कण में,

ज्ञान-ज्योति जागृत जीवन में,

सन्त हृदय दर्पण अभिराम !

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

गौरव संस्कृति, दर्शन उज्ज्वल,

प्रगति-सन्देश प्रचारित पल-पल,

यांत्रिकी-शिक्षा नवयुग संबल,

युवाशक्ति चिर गरिमा-गान!

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

शिव-कामना चहूँ दिशि रंजित,

भ्रातृ-भावना नित अभिव्यंजित,

सर्व धर्म सम्भाव विधान !!

सृजन -मंत्र देता अविराम !!

उधोग-क्रान्ति आहवान करें हम,

नवयुग, नव निर्माण करें हम,

भू को स्वर्ग समान करें हम ,

अमृतमय शारद-वरदान!

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

PREFACE

This laboratory manual introduces students the various methods and techniques used in material testing, and various concepts of strength of materials in a way to study and improve process as well as productivity. Such knowledge and practice shall ensure that they master the lab skills necessary in the competitive job market. A brief outline of the constructional features of various systems of strength of materials laboratory is also given.

This manual is believed to cover the laboratory exercise requirements of ICD level students having this subject in their course curriculum. For better understanding sufficient number of schematic, diagrams and link sketches has been compiled from strength of materials laboratory books and internet etc.

Although the experiments and activities within the Laboratory manual have been trialed, care should be taken to perform the experiments in the specified manner following the safety norms.

Motivation and support/facilities extended by Prof. Rajesh Kumar, Head of Mechanical Engineering Department to bring the manual in the present form is thankfully acknowledged.

Lab-Incharge
(Strength of materials lab.)

FOREWARD

The Laboratory Manual of Strength of Material Lab indented to serve the need of students of ICD courses of Mechanical Engineering Department as well as the Institute. It is expected that the manual will facilitate smooth conduct of practical classes.

I wish to put on record my sincere appreciation to the highly motivated team of the laboratory including its lab In-charge, and Technician for compilation and making the manual in presentable form for the benefit of the students.

HOD

Mechanical Engineering Department

GENERAL INSTRUCTION

1. All the students are instructed to wear protective uniform, Shoes, and identity card before entering the laboratory.
2. Before starting the exercise, students should have a clear idea about the principal of that exercise.
3. All the students are advised to come with completed record and corrected observation book of pervious experiment.
4. Do not operate any instrument/machine without getting staff member's prior permission.
5. The entire instrument is costly. Hence handle them carefully, to avoid fine for any breakage.
6. Utmost care must be taken to avert any possible injury while on Laboratory work. In case, anything occurs immediately report to the staff members.
7. One student from each batch should put his/her signature during receiving the instrument in instrument issue Register.

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List of Experiments (Strength of Materials Lab)

Experiment No.	Name of Experiment	Page No.
1.	Study and demonstration of Universal Testing Machine (UTM) and its attachments.	8-14
2.	a) To conduct a tensile test on a mild steel, Aluminium specimen,	15-18
	b) To perform compression test on cast iron using UTM.	19-21
3.	Study of Direct Shear Test of mild steel on Universal Testing Machine.	22-23
4.	Study of Brinell Hardness test.	24-26
5.	Study of Rockwell Hardness test.	27-28
6.	a) Study of Impact Testing Machine (Charpy Impact Test).	29-31
	b) Study of Impact Testing Machine (Izod Impact Test).	32-34
7.	Study of Torsion Testing Machine.	35-37
8.	TO DETERMINE A MATERIAL'S FATIGUE BEHAVIOUR BY USING FATIGUE TEST MACHINE.	38-41

Strength of Materials lab: MEP-315

L	T	P	Credits	Weekly Load
0	0	2	1	2

Course Outcomes:
After successful completion of course, the students should be able to
CO1: Apply the basic concepts and principles of strength of materials.
CO2: Calculate stresses and deformations of the objects under different loadings.
CO3: Analyse and design structural members subjected to tension, compression, torsion, bending and combined stresses using the fundamental concepts of stress, strain and elastic behaviour of materials.
CO4: Utilize appropriate materials in design considering engineering properties, sustainability, cost and weight.
CO5: Perform engineering work in accordance with ethical and economic constraints related to the design of structures and machine parts.
Pre-requisite knowledge:

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

LIST OF PRACTICAL (ME-315)

1. Study and demonstration of Universal Testing Machine and its attachments.
2. Tension Test on mild steel, Aluminium, and compression test on cast iron on Universal Testing Machine.
3. Study of Direct Shear Test of mild steel on Universal Testing Machine.
4. Study of Brinell Hardness test.
5. Study of Rockwell Hardness test.
6. Study of Impact Testing Machine.
7. Study of Torsion Testing Machine.

AIM: - Study and demonstration of Universal Testing Machine and its attachments.

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

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

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

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

LOADING UNIT: - It consists of main hydraulic cylinder with robust base inside. The piston which moves up and down. The chain driven by electric motor which is fitted on left hand side. The screw column maintained in the base can be rotated using above arrangement of chain. Each column passes through the main nut which is fitted in the lower cross head. The lower table connected to main piston through a ball & the ball seat is joined to ensure axial loading. There is a connection between lower table and upper head assembly that moves up and down with main piston. The measurement of this assembly is carried out by number of bearings which slides over the columns. The test specimen is fixed in the job is known as 'Jack Job'. To fix up the specimen tightly, the movement of jack job is achieved helically by handle.

CONTROL PANEL: - It consists of oil tank having a hydraulic oil level sight glass for checking the oil level. The pump is displacement type piston pump having free plungers those ensure for continuation of high pressure. The pump is fixed to the tank from bottom. The suction & delivery valve are fitted to the pump near tank Electric motor driven the pump is mounted on four studs which is fitted on the right side of the tank. There is an arrangement for loosing or tightening of the valve. The four valves on control panel control the oil stroke in the hydraulic system. The loading system works as described below. The return valve is close, oil delivered by the pump through the flow control valves to the cylinder & the piston goes up. Pressure starts developing & either the specimen breaks or the load having maximum value is controlled with the base dynameters consisting in a cylinder in which the piston reciprocates. The switches have upper and lower push at the control panel for the downward & upward movement of the movable head. The on & off switch provided on the control panel & the pilot lamp shows the transmission of main supply.

METHOD OF TESTING: - Initial Adjustment: - Before testing adjust the pendulum with respect to capacity of the test i.e. 8 Tones; 10 Tones; 20 Tones; 40 Tones etc. For ex: - A specimen of 6 tones capacity gives more accurate result of 10 Tones capacity range instead of 20 Tones capacity range. These ranges of capacity are adjusted on the dial with the help of range selector knob. The control weights of the pendulum are adjusted correctly. The ink should be inserted in pen holder of recording paper around the drum & the testing process is started depending upon the types of test as mentioned below.

TENSION TEST: - Select the proper job and complete upper and lower check adjustment. Apply some Greece to the tapered surface of specimen or groove. Then operate the upper cross head grip operation handle & grip the upper end of test specimen fully in to the groove. Keep the lower left valve in fully close position. Open the right valve & close it after lower table is slightly lifted. Adjust the lower points to zero with the help of adjusting knob. This is necessary to remove the dead weight of the lower table. Then lock the jobs in this position by operating job working handle. Then open the left control valve. The printer on dial gauge at which the specimen breaks slightly return back & corresponding load is known as breaking load & maximum load is known as the ultimate load.

COMPRESSION TEST: - Fix upper and lower pressure plates to the upper stationary head & lower table respectively. Place the specimen on the lower plate in order to grip. Then adjust zero by lifting the lower table. Then perform the test in the same manner as described in tension test.

FLEXURAL OR BENDING TEST: - Keep the bending table on the lower table in such a way that the central position of the bending table is fixed in the central location value of the lower table. The bending supports are adjusted to required distance. Stuffers at the back of the bending table at different positions. Then place the specimen on bending table & apply the load by bending attachment at the upper stationary head. Then perform the test in the same manner as described in tension test.

BRINELL HARDNESS TEST: - Place the specimen on the lower table & lift it up slightly. Adjust the zero fixed value at the bottom side of the lower cross head. Increase the load slowly ultimate load value is obtained. Then release the load slowly with left control valve. Get the impression of a suitable value of five to ten millimetre on the specimen & measure the diameter of the impression correctly by microscope & calculate Brinell hardness.

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

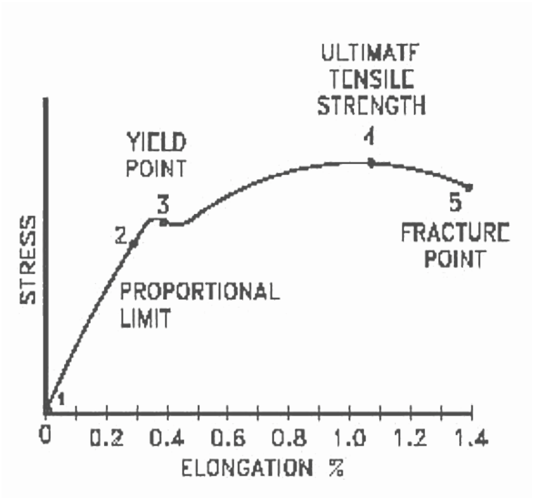
STUDY OF EXTENSOMETER: - This instrument is an attachment to Universal / Tensile Testing Machines. This measures the elongation of a test place on load for the set gauge length. The least count of measurement being 0.01 mm and maximum elongation measurement up to 5 mm. This elongation measurement helps in finding out the proof stress at the required percentage elongation.

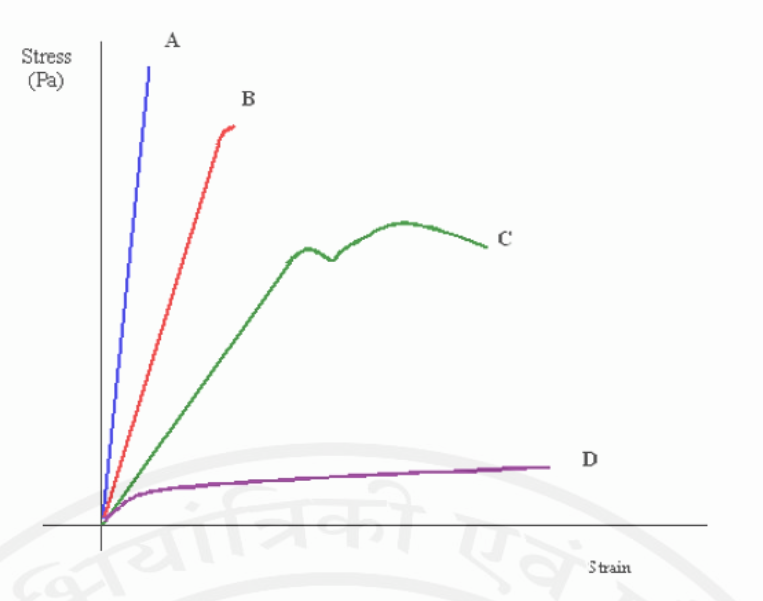
WORKING OF THE INSTRUMENT: - The required gauge length (between 30 to 200) is set by adjusting the upper knife edges, scale is provided for this purpose. Hold the specimen in the upper and lower jaws of Tensile / Universal Testing Machine. Position the extensometer on the specimen. Position upper clamp to press upper knife edges on the specimen. The extensometer will be now fixed to the specimen by spring pressure. Set zero on both the dial gauges by zero adjust screws. Start loading the specimen and take the reading of load on the machine at required elongation or the elongation at required load. Force setter accuracies mean of both the dial gauge readings should be taken as elongation. It is very important to note & follow the practice of removing the extensometer from the specimen before the specimen breaks otherwise the instrument will be totally damaged. As a safety, while testing the instrument may be kept hanging from a fixed support by a slightly loose thread.

TECHNICAL DATA: -

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

A) Stress-strain graph for Mild Steel

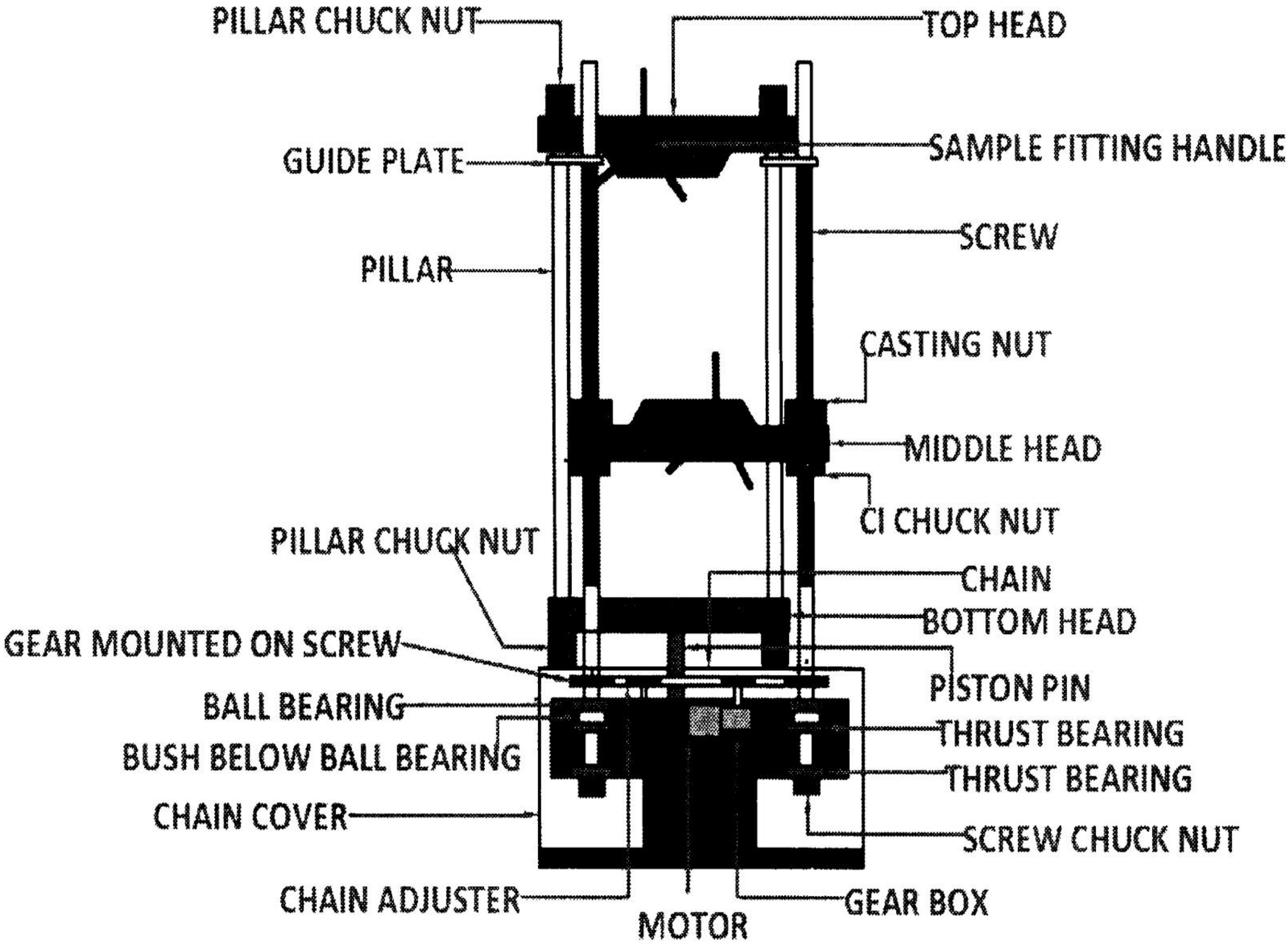




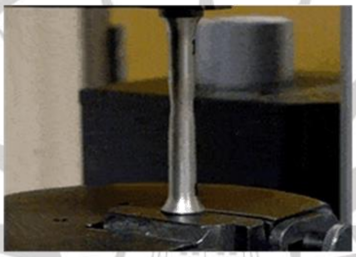
B) Stress-strain graph for Different materials

- Curve **A** shows a **brittle** material. This material is also strong because there is little strain for a high stress. The fracture of a brittle material is sudden and catastrophic, with little or no plastic deformation. Brittle materials crack under tension and the stress increases around the cracks. Cracks propagate less under compression.
- Curve **B** is a **strong** material which is not ductile. Steel wires stretch very little and break suddenly. There can be a lot of elastic strain energy in a steel wire under tension and it will "whiplash" if it breaks. The ends are razor sharp and such a failure is very dangerous indeed.
- Curve **C** is a **ductile** material Curve **D** is a **plastic** material. Notice a very large strain for a small stress. The material will not go back to its original length.

DIAGRAM OF MACHINE

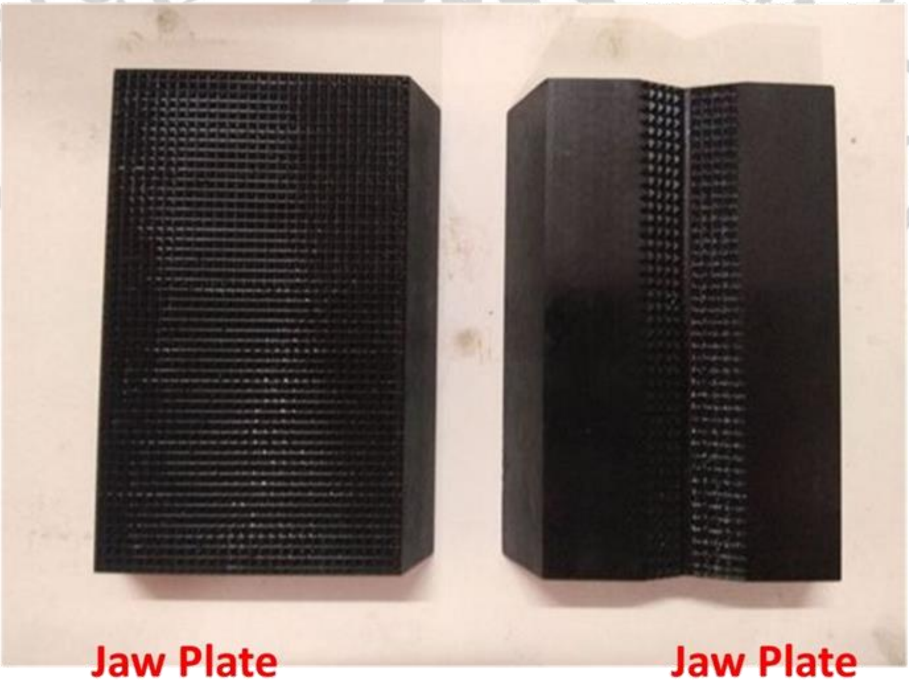


BRINELL HARDNESS TEST ATTACHMENT

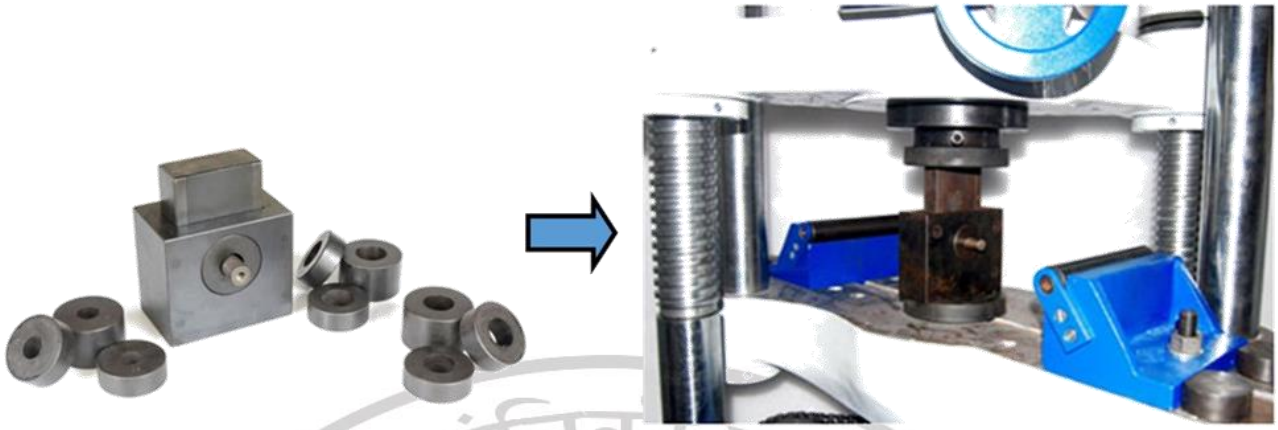


TENSION TEST

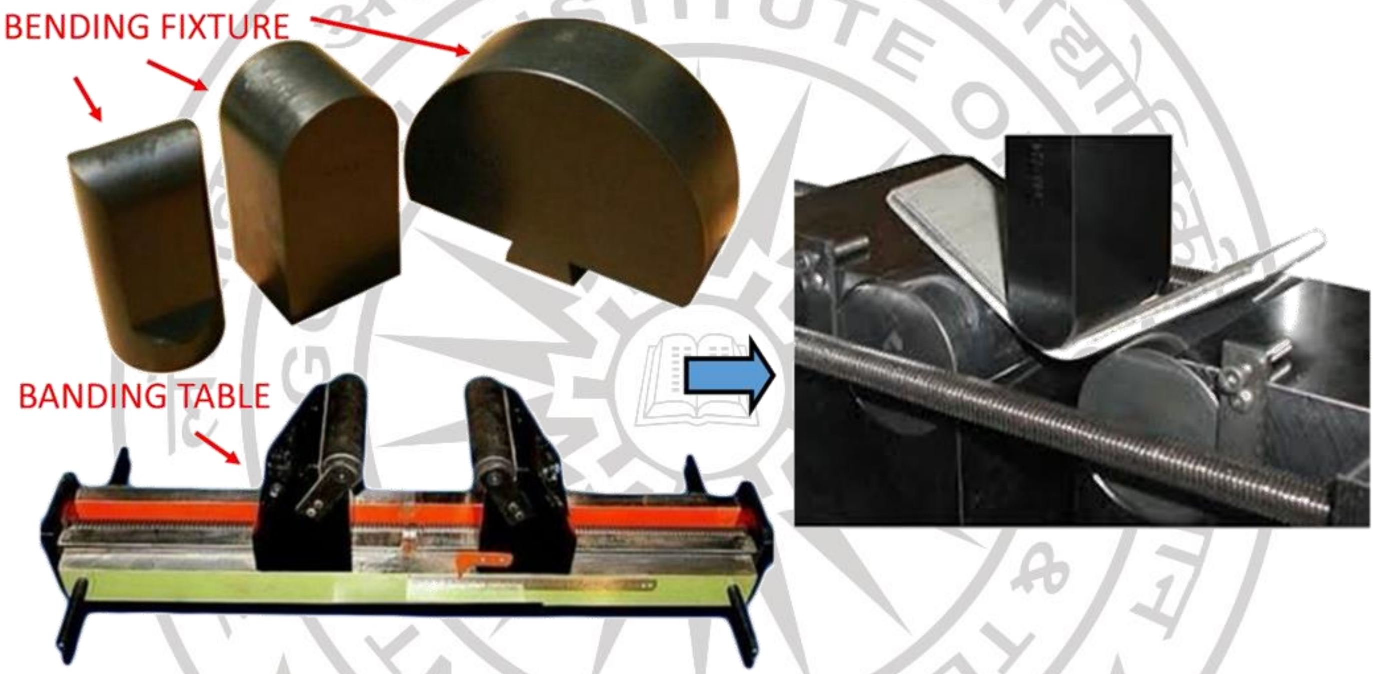
JAW HOLDER ARRANGEMENT



Jaw Plate (for plane sample) | Jaw Plate (For Round Sample)



SHEAR TEST ATTACHMENT



FLEXURAL OR BENDING TEST ATTACHMENT

COMPRESSION TEST ATTACHMENT

AIM: To conduct a tensile test on a Mild steel / Aluminium specimen

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

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

APPARATUS:

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

M/C SPECIFICATIONS:

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

&

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

THEORY: -

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

PROCEDURE: -

1. Measure the original length and diameter of the specimen. The length may either be length of gauge section which is marked on the specimen with a preset punch or the total length of the specimen
2. Insert the specimen into grips of the test machine and attach strain-measuring device to it.
3. Begin the load application and record load versus elongation data.
4. Take readings more frequently as yield point is approached.
5. Measure elongation values with the help of dividers and a ruler.
6. Continue the test till Fracture occurs.
7. By joining the two broken halves of the specimen together, measure the final length and diameter of specimen.

OBESERVATION: -

A) Material: -

i) Original dimensions

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

Diameter = ---------

Area = ------

ii) Final Dimensions:

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

Diameter = ---------

Area = -------

OBESERVATION TABLE: -

To plot the stress - strain curve determine the following

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

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

RESULT: -

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

PRECAUTIONS: -

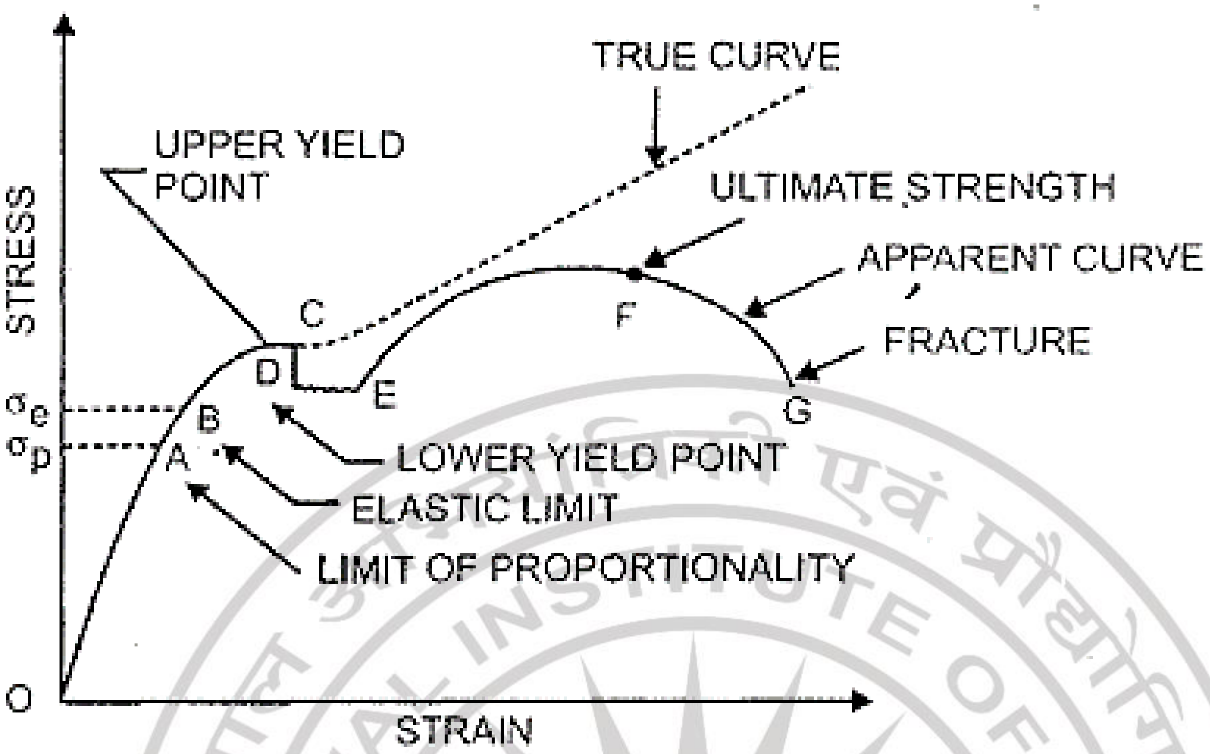
1. If the strain measuring device is an extensometer, it should be removed before necking begins.
2. Measure deflection on scale accurately & carefully

E 8M – 04

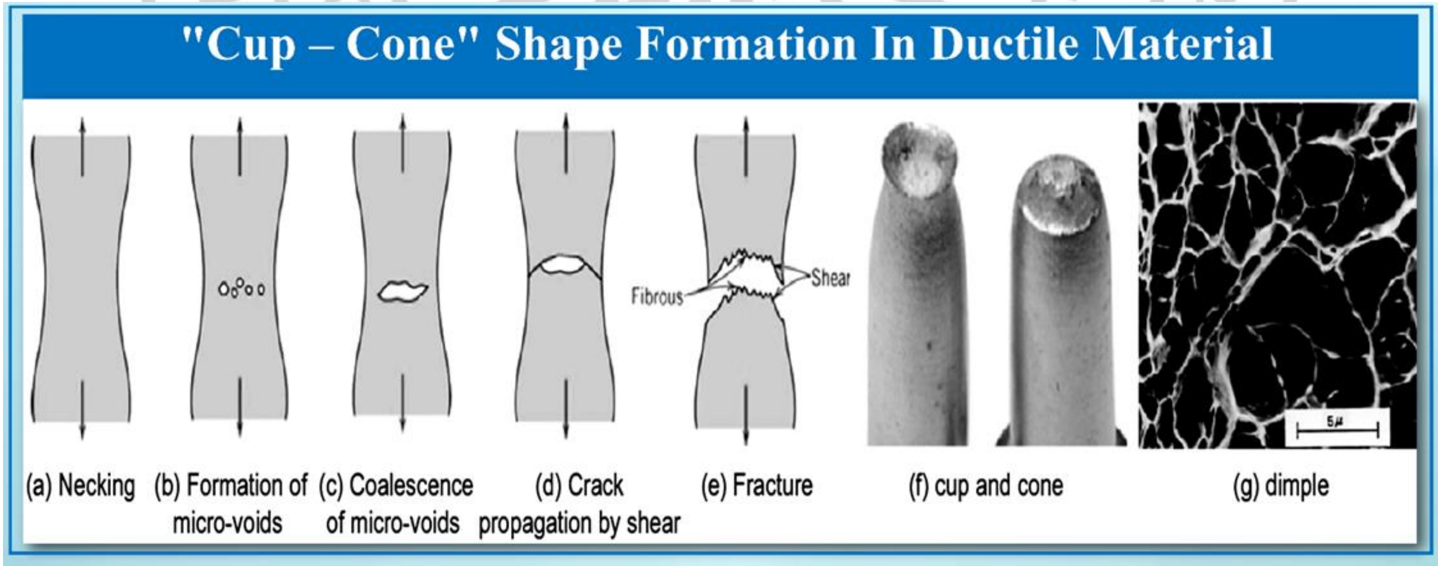
Dimensions, mm					
	Standard Specimen	Small-Size Specimens Proportional To Standard			
	12.5	9	6	4	2.5
G—Gage length	62.5 ± 0.1	45.0 ± 0.1	30.0 ± 0.1	20.0 ± 0.1	12.5 ± 0.1
D—Diameter (Note 1)	12.5 ± 0.2	9.0 ± 0.1	6.0 ± 0.1	4.0 ± 0.1	2.5 ± 0.1
R—Radius of fillet, min	10	8	6	4	2
A—Length of reduced section,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

E 8M – 04

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



Stress-strain diagram for mild steel.



AIM: To study the behaviour of the given material under Compressive load and to following

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

APPARATUS:

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

MATERIAL: Wood/Cast Iron

THEORY:

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

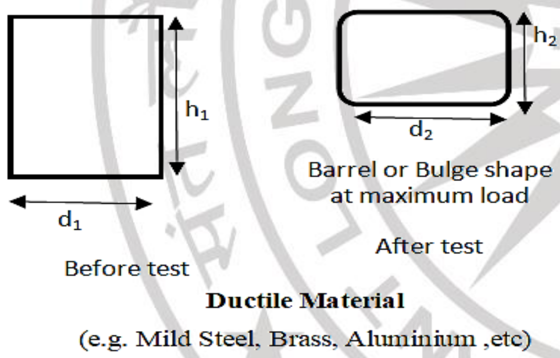


Fig.1

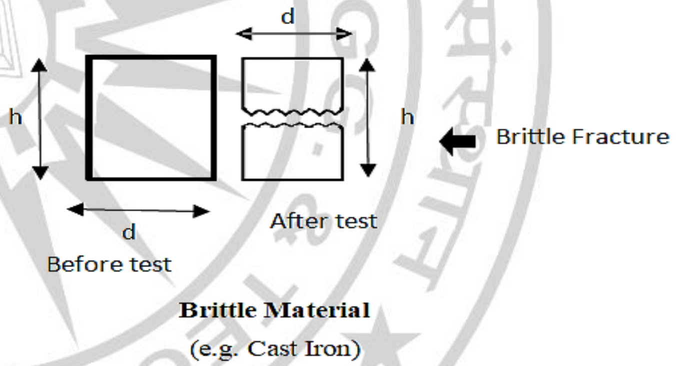
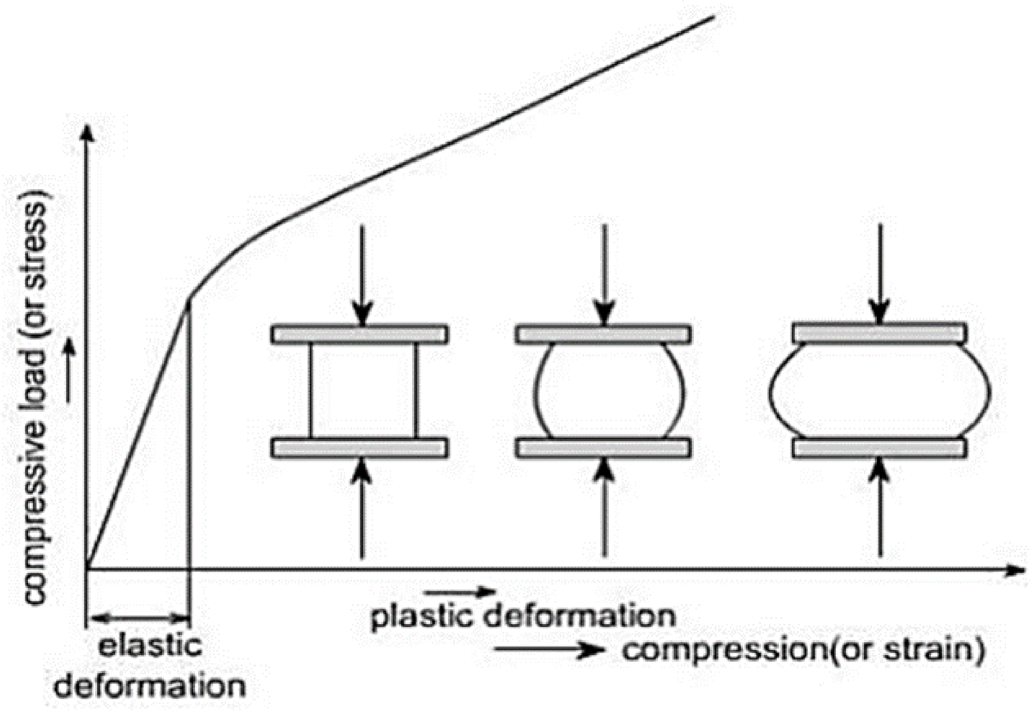


Fig.2

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



Procedure:

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

TABULAR COLUMN:

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

CALCULATIONS:

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

RESULTS:

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

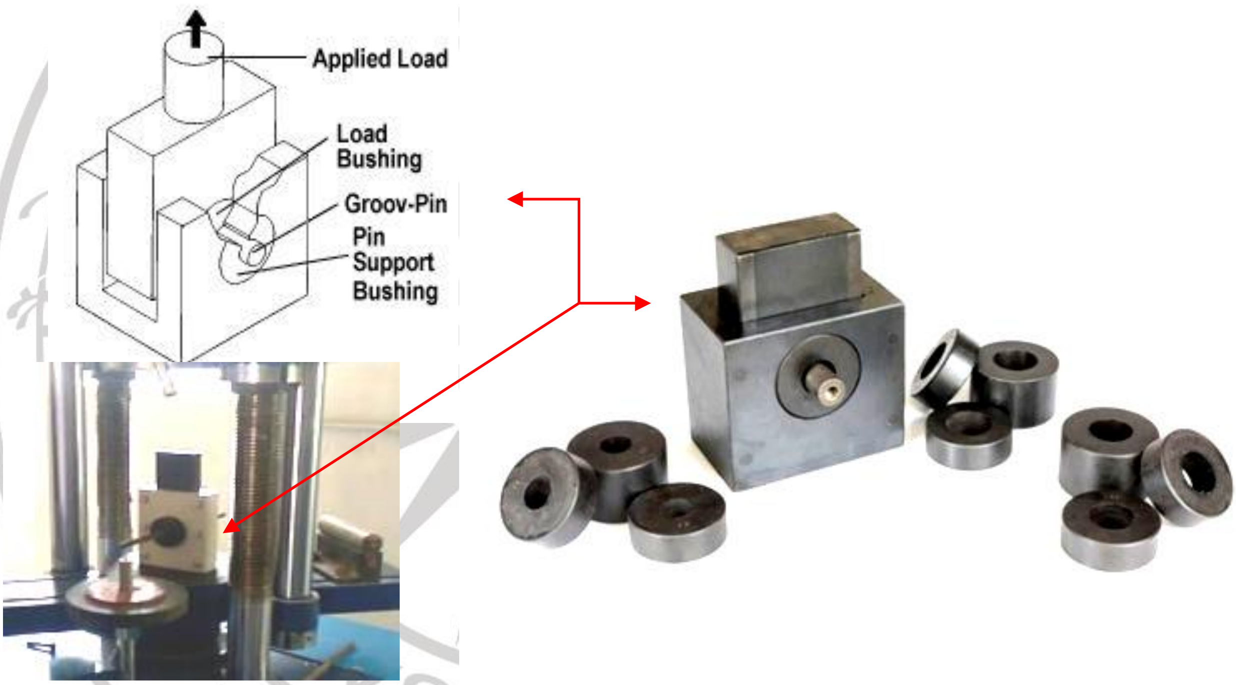
AIM: -Study of Direct Shear Test of mild steel on Universal Testing Machine.

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

THEORY:

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

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



PROCEDURE:

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

OBSERVATION:

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

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

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

PRECAUTIONS:

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

RESULT: The Shear strength of mild steel specimen is found

i) In single shear = …... N /mm^2
ii) In double shear = …... N /mm^2

	Sant Longowal Institute of Engineering & Technology Longowal-148106 (Govt of India)	**LAB MANUAL** Strength of Materials Lab
	Practical Experiment Instruction sheet **Experiment No.04**	Subject Code: MEP-315 Class: ICD Programme

AIM: - Study of Brinell Hardness test.

OBJECTIVE: -

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

APPRATUS: -

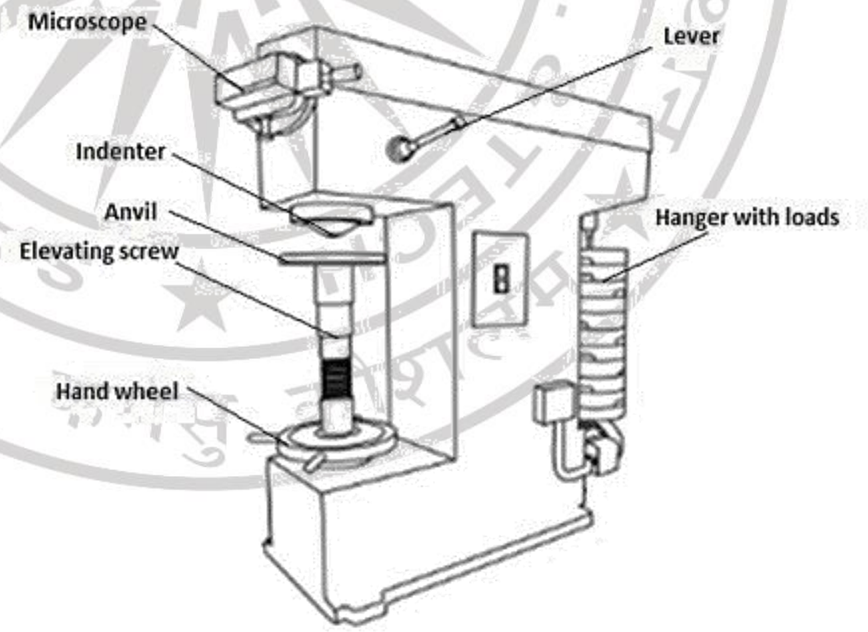
Brinell hardness testing machine, given specimen and a low power microscope.

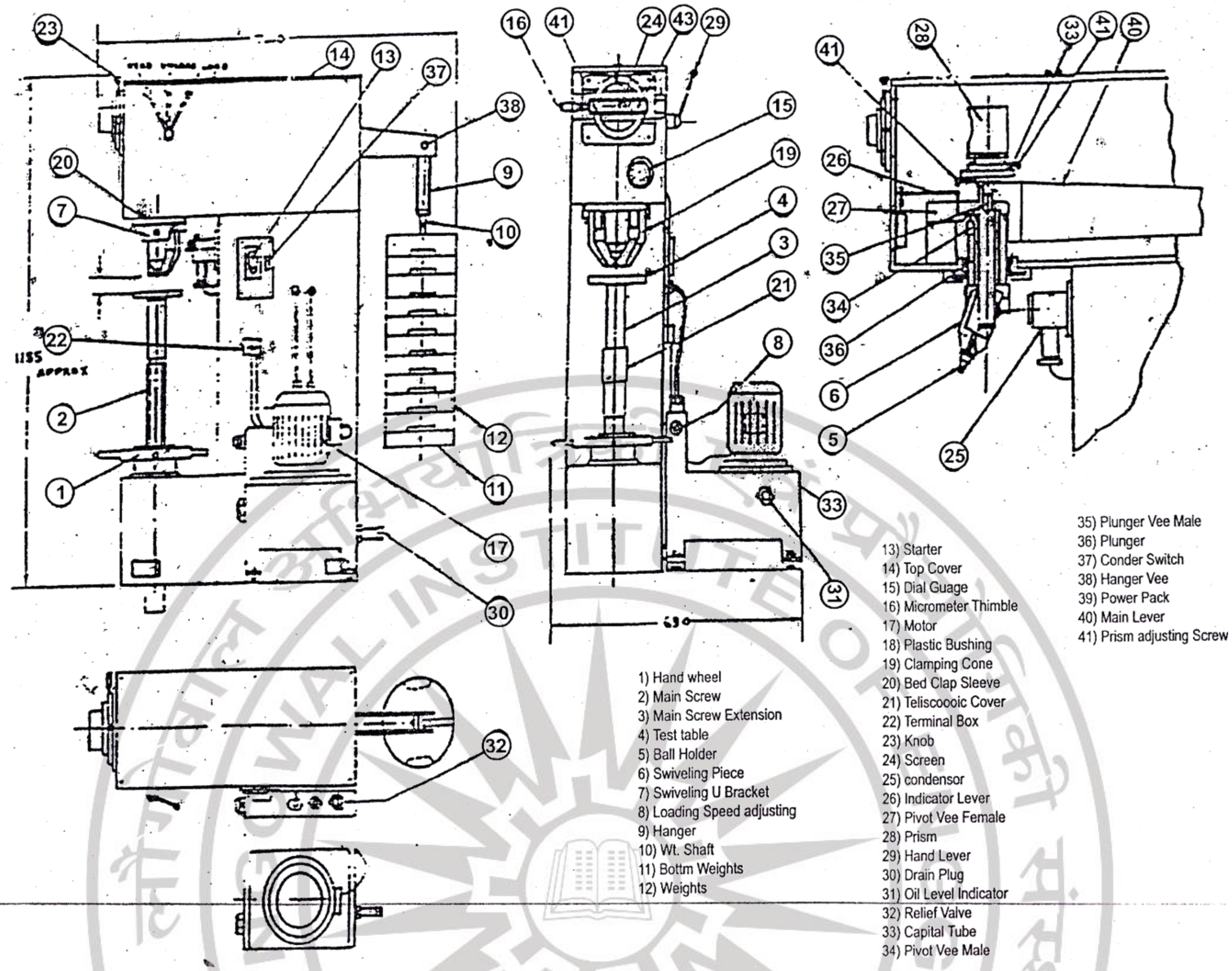
INTRODUCTION: -

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

THEORY: -

This test is applicable for a material having B.H.N. up to 630 only. This test consists in pressing a hardened steel ball into a test specimen. In Brinell hardness testing for slandered test a small ball of dia. 10 mm is used as indenter. A load of 3000 Kg. is used for hard metals, 1500 Kg for metals having intermediate Hardness and 500 Kg. Or even as low as 100 Kg. of soft metals. Full Load is applied for a period of 15 sec., as 30 sec. for softer metals, after the period as started the load is removed, and the dia. Of indention is measured is by microscope up to an accuracy of 0.02 mm. Then BHN is determined by either given table or by following formula.





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

P= load applied in Kg.

D= Dia. Of steel ball in mm

D= Dia. Of indentation in mm

DESCRIPTION OF MACHINE: -

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

PROCEDURE: -

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

OBSERVATION:

1) Test load (P) =____________________Kg.
2) Dia. Of the ball (D) =____________________mm.

Table, for measurement of dia. Indentation and BHN

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

PRECAUTIONS: -

1) The specimen should be free from dirt and scale.
2) Select the proper load to suit the material under test.
3) The test should not be made on these specimens.
4) The BHN using the standard ball is limited to app. 500 HB. As the material tested becomes harder, there is a tendency for the indenter itself to start deforming, and the reading will not be accurate. Using a tungsten carbide ball rather than a hardened steel ball may extend the upper limit of the scale. In that case, it is possible to go to app. 650 HB.
5) Load applied should be gradual.
6) Observation should be made at sufficient distance from previous reading a (at least 4d) and from edge at least 2.5d.
7) This should be conducted at room temperature. (~ 20^{o}C)
8) Plane of top and bottom surface of the specimen should be parallel. The ratio d/D should preferably be between 0.3 and 0.5 and should not exceed 0.6 in any case. To maintain it load may be selected accordingly.

AIM: - Study of Rockwell Hardness test.

OBJECTIVE: -

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

APPRATUS: -

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

INSREACTION: -

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

THEORY: -

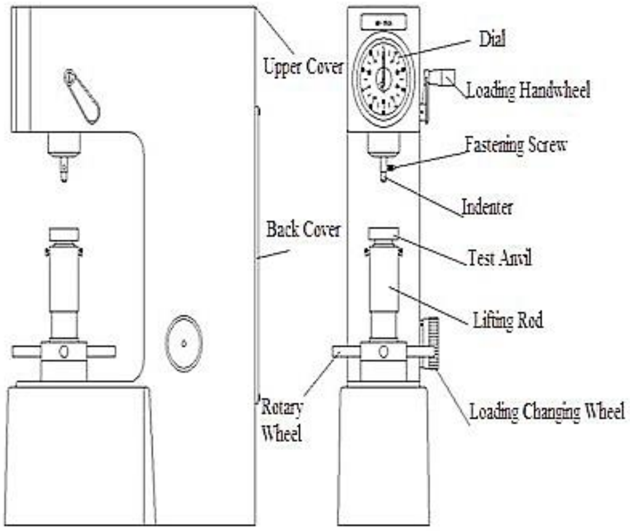
Rockwell hardness test uses a direct reading instrument based on differential depth measurement. The test is performed by slowly raising the specimen against the indenter until a fixed minor load has been applied. This is indicated on the dial gauge. Then major load is applied through a loader lever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

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

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

DESCRIPTIONOF MACHINE: -

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



PROCEDURE: -

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

OBSERVATION: -

For measurement of Rockwell hardness number.

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

PRECAUTION: -

1) The specimen should be free from dirt, scale, and oil.
2) The new indentation should be marked away from old penetration mark.
3) Thick of the specimen should be at least 10 times the depth of depth of the indentation.
4) Check the performance of the machine frequently with standard specimens.
5) Speed of application of load should be standardized. This is done by adjusting the dashpot of the machine 4 to 5 sec. period.
6) Table of machine should be stationary.
7) If the curved plates are to be tested, concave side should be preferably facing the indenter.
8) Check the intender shape for making a test.
9) Reading must be taken immediately after removing the additional load.

AIM: - CHARPY IMPACT TEST

OBJECTIVE: -

To perform the Charpy Impact test on the given test specimen.

DESCRIPTION:

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

To determine the notched beam impact strength of three type of notches are used i.e. V-notch, U-notch, Key-hole notch. These notches are shown in fig. the test field should be machine all over and 55 long and of square cross section with 100 mm sides. The notch is made up at the centre of the test specimen. The plane of symmetry of the notch should be perpendicular to the longitudinal axis of the test piece. The distance of the plane of symmetry of the notch from the end of the test shall be 27.5 ± 0.42 mm and the angle between the plane of the symmetry of the notch and longitudinal axis of the test piece shall be 90 ± 2^{o}.

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

EQUIPMENT: -

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

PROCEDURE: -

1) Lift the hammer to an appropriate knife -edge position and the note the energy stored in the hammer. For the standard test. It should be 30 kgf (300 Joules).
2) Locate the test piece on the machine support as showed.
3) Release the hammer. The hammer will break the specimen and shoot up to the other side of the machine.
4) Note the residual energy indicated on the scale by hammer.
5) The impact strength of the test piece is the difference of the initial energy stored in the hammer and the residual energy.
6) Calculate the impact module given by the ratio of rupture to the volume of the test piece below the notch.

OBSERVATIONS: -

Material of the test piece =

Type of the notch =

Dimensions of the test piece =

Room temperature =

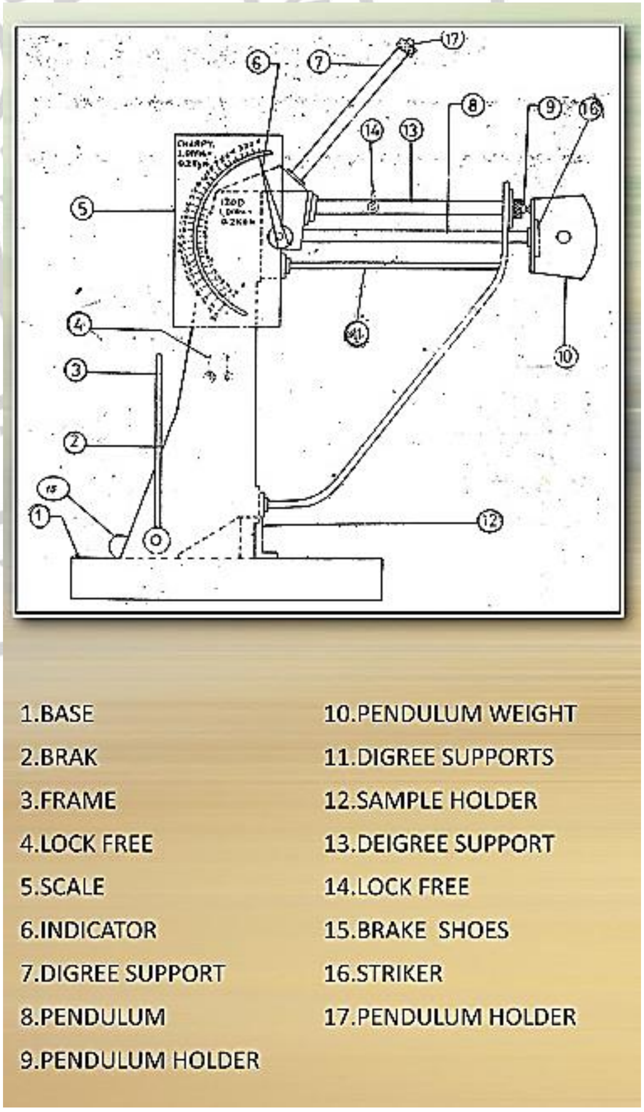
Velocity of striking =

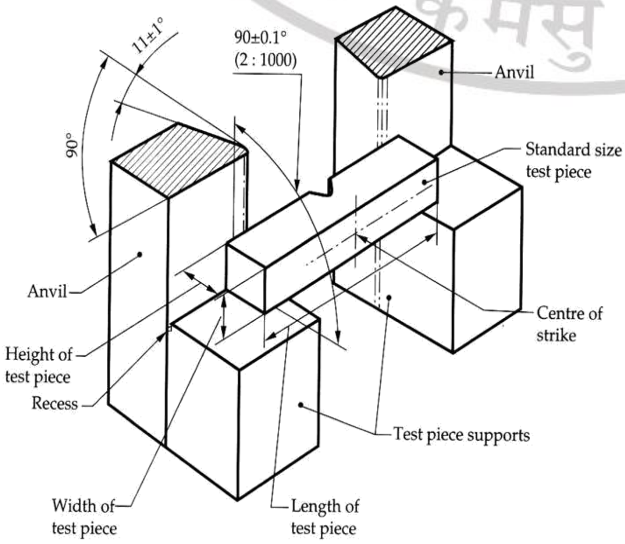
Test No.	Initial energy (Joules)	Residual energy (Joules)	Energy absorbed (Joules)
1)			
2)			

Mean value of impact strength= _______Joules.

PRECAUTIONS: -

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





SOURCE OF ERRORS: -

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

AIM: IZOD IMPACT TEST ON METALS.

OBJECTIVE: To perform the Izod impact test on given specimen of metal.

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

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

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

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

Angle of tip of hammer= 75^o

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

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

Striking energy = 162.4 ± 3.33 Nm

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

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

EQUIPMENT

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

PROCEDURE: -

1) Lift the hammer to an appropriate knife -edge position and the note the energy stored in the hammer. For the standard test. It should be 30 kgf (300 Joules).
2) Locate the test piece on the machine support as showed.
3) Release the hammer. The hammer will break the specimen and shoot up to the other side of the machine.
4) Note the residual energy indicated on the scale by hammer.
5) The impact strength of the test piece is the difference of the initial energy stored in the hammer and the residual energy.
6) Calculate the impact module given by the ratio of rupture to the volume of the test piece below the notch.

OBSERVATIONS: -

Material of the test piece =

Type of the notch =

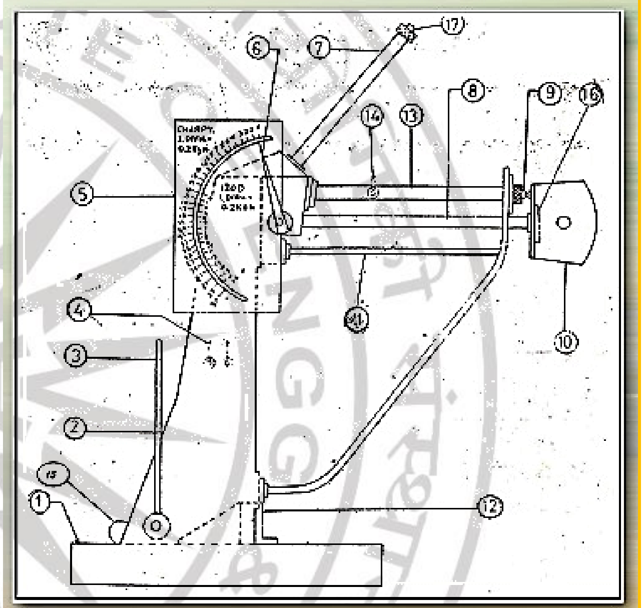
Dimensions of the test piece =

Room temperature =

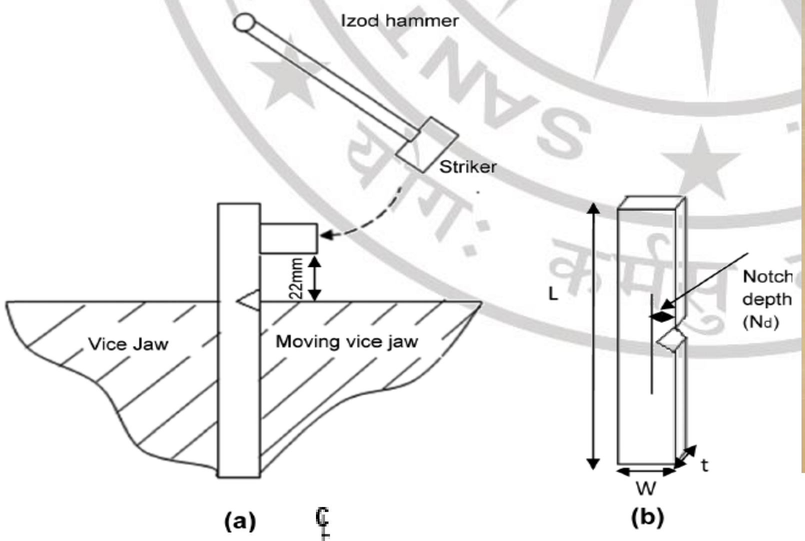
Velocity of striking =

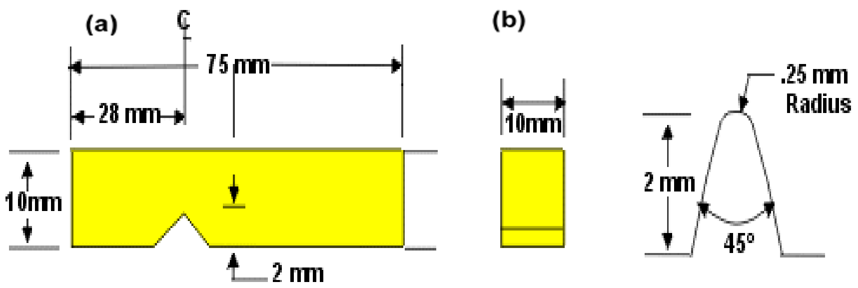
Test No.	Initial energy (Joules)	Residual energy (Joules)	Energy absorbed (Joules)
1)			
2)			

Mean value of impact strength= _______Joules.



1.BASE	10.PENDULUM WEIGHT
2.BRAK	11.DIGREE SUPPORTS
3.FRAME	12.SAMPLE HOLDER
4.LOCK FREE	13.DEIGREE SUPPORT
5.SCALE	14.LOCK FREE
6.INDICATOR	15.BRAKE SHOES
7.DIGREE SUPPORT	16.STRIKER
8.PENDULUM	17.PENDULUM HOLDER
9.PENDULUM HOLDER	





PRECAUTIONS: -

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

SOURCE OF ERRORS: -

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

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

OBJECTIVE:

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

DESCRIPTION:

Torsion test is generally performed to determine the modulus of rigidity, torsion yield, strength, and the modulus of rupture in torsion. The modulus of rupture is equal to the nominal surface stress corresponding to maximum torque. Now, the torsion formula is given by

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

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

Where

T = torque or twisting moment, [N×m, lb×in]
J = polar moment of inertia or polar second moment of area about shaft axis, [m4, in4]
τ_s = shear stress at outer fiber, [Pa, psi]
r = radius of the shaft, [m, in]
G = modulus of rigidity (Pan Global and Reed's) or shear modulus (everybody else), [Pa, psi]
θ = angle of twist, [rad]
l = length of the shaft, [m, in]

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

For a bar of circular cross – section

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

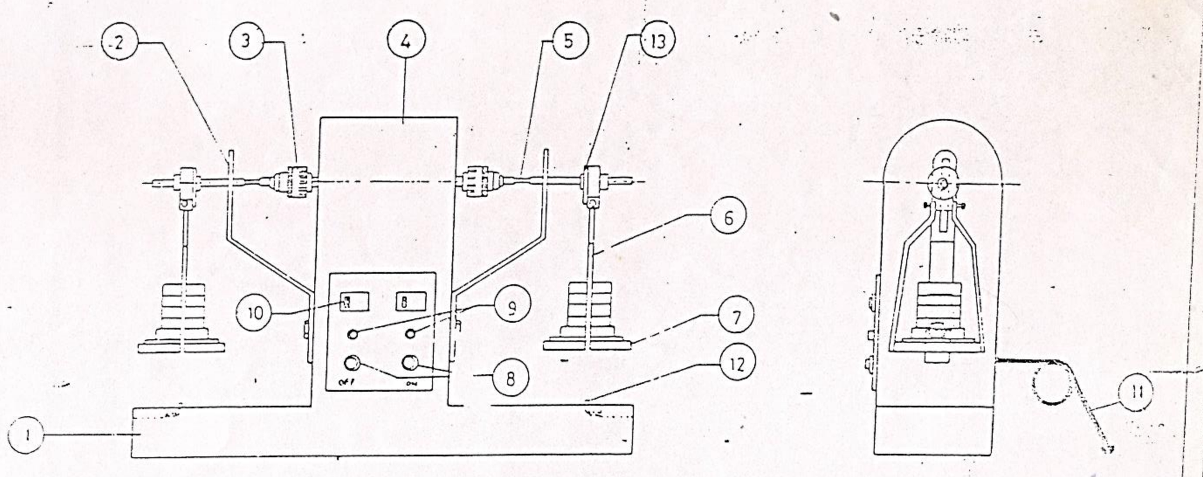
$$G = \left(\frac{T}{\theta}\right) . \left(\frac{2l}{\pi r^4}\right)$$

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

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

EQUIPMENT:

1) Torsion testing machine,
2) Test pieces,
3) Micrometre,
4) Foot rule,
5) Slide wrench.



FATIGUE TESTING MACHINE

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

PROCEDURE: -

1) Measure the dia. of the test piece at for different places on its parallel angles to each other.
2) Measure the parallel length of the test piece.
3) Insert the test piece in the grip of the machine.
4) Select a suitable scale on the machine and adjust the initial torque and angle of twist reading to new position.
5) Apply the torque initial by hand up to 10^o angle of twist. The angle of twist and torque may be noted at an internal of 1^o from 10^o to 20^o, the reading and may be noted at 2^o interval. After this the machine may be operated electrically and the reading may be noted at an interval of 5^o to 10^o which even is convenient.
6) Continue noting three reding until the specimen breaks.
7) Initially a line may be marked parallel to the length of test piece to see the helix formation.

OBSERVATION: -

Material of test =

Least count of micrometre =

Parallel length of test piece =

Average dia. Of different places =

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

Maximum torque =…………………………………

RESULT: -

Dia. Of test pieces =………… m

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

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

Maximum torque =………… N/m

Modulus of rupture =………… N/m^2

Modulus of rigidity =………… N/m^2

Total angle of twist to fracture =………… ^{o}

PRECAUTIONS: -

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

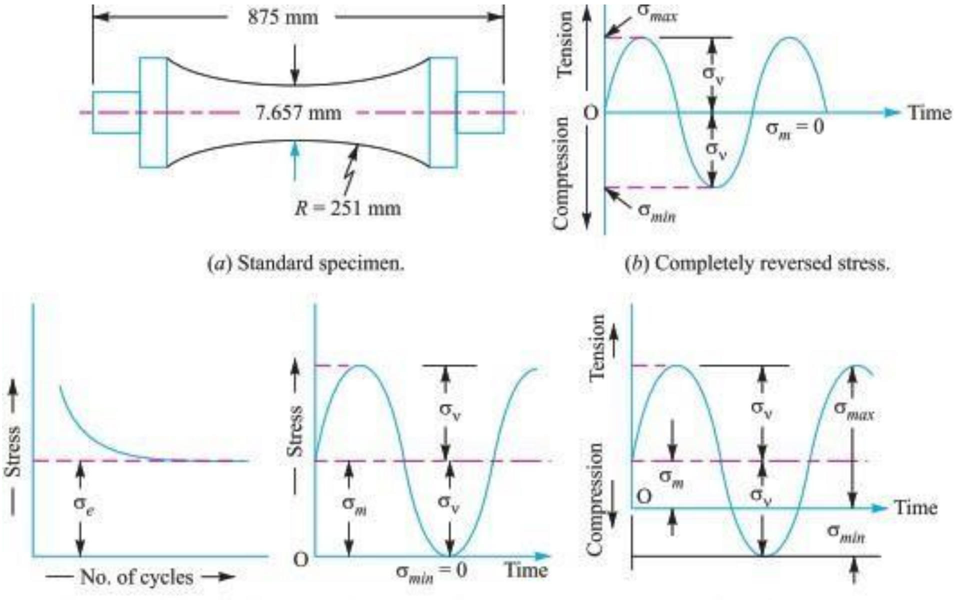
AIM: TO DETERMINE A MATERIAL'S FATIGUE BEHAVIOR BY USING FATIGUE TEST MACHINE.

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

MATERIAL: Standard polished specimen

THEORY:

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



(a) Standard specimen. (b) Completely reversed stress.

(c) Endurance or fatigue limit. (d) Repeated stress. (e) Fluctuating stress.

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

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

The following relations are

derived from Fig. 6.2 (e):

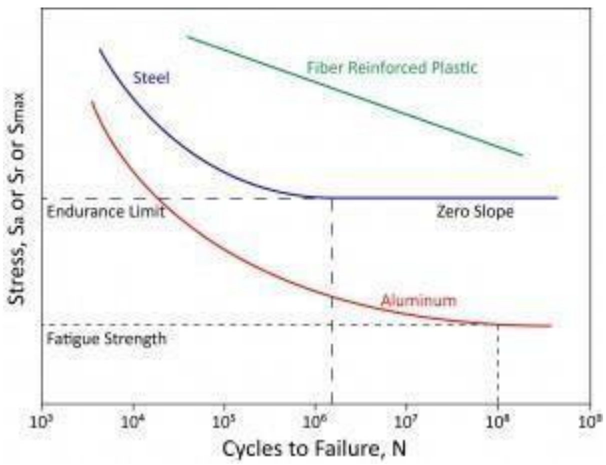
1. **Mean or average stress,**

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

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

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

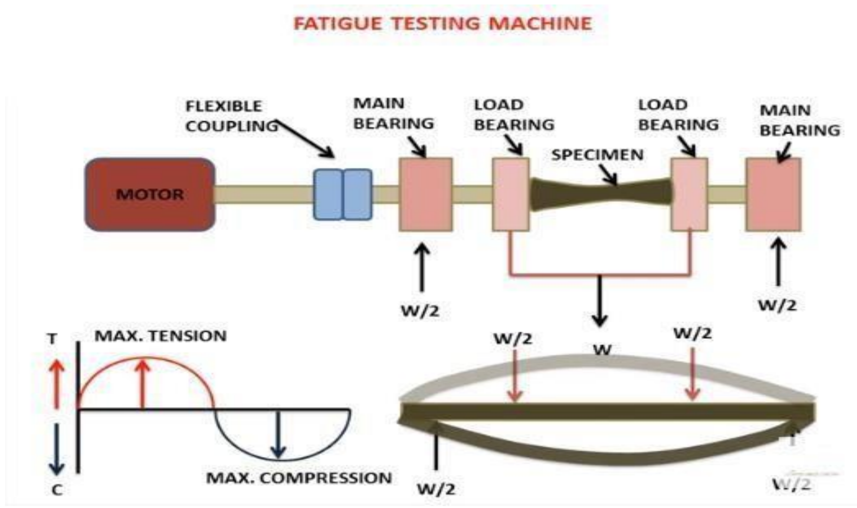
S-N Curve: An S-N curve, also known as a Wöhler curve, is a graph that shows a material's fatigue behavior and endurance limit if it is distinct. As the stress applied to the sample decreases, the number of cycles to failure will increase. The graph shows the stress amplitude (S), the difference between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



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

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

DIAGRAM:



PROCEDURE:

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

PRECAUTIONS:

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

RESULT:

VIVA QUESTIONS:

1. Define fatigue?
2. Define Endurance strength?
3. What is the use of S-N curve?
4. Bending stress means?
5. Cyclic stress means?

INDUSTRIAL APPLICATION:

1. **Fatigue Testing Spine Implant**
2. **Aircraft Structural Testing | Equipment**