Channabasaveshwara Institute of Technology
(An ISO 9001:2000 Certified Institution)
NH 206 (B.H. Road), Gubbi, Tumkur – 572 216. Karnataka.

Department of Mechanical Engineering

LAB MANUAL

(2015-16)

METALLOGRAPHY AND MATERIAL TESTING LABORATORY

(10MEL37A/47B)

III/IV A&B Semester

Name:_____

U.S.N:_____

Batch:_____ **Section:**_____

Caution

1. Do not play with electricity.

2. Carelessness not only destroys the valuable equipment in the lab but also costs your life.

3. Mere conductivity of the experiment without a clear knowledge of the theory is of no value.

4. Before you turn on a switch, think of the consequences.

5. Do not start the experiment until the experimental setup is verified.

'Instructions to the Candidates'

1. Students should come with thorough preparation for the experiment to be conducted.

2. Students will not be permitted to attend the laboratory unless they bring the practical record fully completed in all respects pertaining to the experiment conducted in the previous class.

3. Experiment should be started only after the staff-in-charge has checked the experimental setup.

4. All the calculations should be made in the observation book. Specimen calculations for one set of readings have to be shown in the practical record.

5. Wherever graphs are to be drawn, A-4 size graphs only should be used and the same should be firmly attached to the practical record.

6. Practical record should be neatly maintained.

7. They should obtain the signature of the staff-in-charge in the observation book after completing each experiment.

8. Theory regarding each experiment should be written in the practical record before procedure in your own words.

Syllabus

METALLOGRAPHY AND MATERIAL TESTING LABORATORY

Sub Code: 10 MEL 37A / 10 MEL 47A **IA Marks : 25**
Hrs/week : 03 **Exam Marks : 50**
Total Lecture Hrs: 48 **Exam Hours : 03**

PART – A

1. Preparation of specimen for Metallographic examination of different Engineering materials. Identification of microstructures of plain carbon Steel, tool steel, gray C.I, SG iron, Brass, Bronze & composites.

2. Heat treatment: Annealing, normalizing, hardening and tempering of steel. Hardness studies of heat-treated samples.

3. To study the wear characteristics of ferrous, non-ferrous and composite Materials for different parameters.

4. Non-destructive test experiments like,
   (a). Ultrasonic flaw detection
   (b). Magnetic crack detection
   (c). Dye penetration testing, to study the defects of Casted and Welded Specimens

PART – B

1. Tensile, shear and compression tests of metallic and non metallic Specimens using a Universal Testing Machine
2. Torsion tests
3. Bending Test on metallic and nonmetallic specimens.
4. Izod and Charpy tests on M.S. Specimen.
5. Brinell, Rockwell and Vickers's Hardness test.
6. Fatigue Test.

Scheme of Examination:
ONE question from part -A: 20 Marks
ONE question from part -B: 20 Marks
Viva -Voice: 10 Marks
Total: 50 Marks

Channabasaveshwara Institute of Technology

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DEPARTMENT OF MECHANICAL ENGG.

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Observations

- Least count of dial gauge = 0.01mm.
- Specimen Material = ……
- Initial length (l_i) = …….. ….. mm
- Initial diameter (d_i) = …….. ….. mm
- Original C/S Area (A_i or A_o) $= \frac{\pi \times d_i^2}{4}$ =…….mm^2
- Yield Load (p_Y) =……. KN
  Where 'p_Y' is the load at yield point
- Breaking Load (p_B) =……. KN
  Where 'p_B' is the load at breaking point.
- Ultimate Load (p_u) =……KN
  Where 'p_u' is the maximum load applied.
- Final length (l_f) =…….mm
- Final diameter (d_f) =……..mm
- Final Area (A_f) $= \frac{\pi \times d_f^2}{4}$ = ……mm^2

Experiment 1:

TENSION TEST

Objective: To study the behavior of the given material under tensile load and to determine the following:

- Percentage elongation in length
- Percentage reduction in area
- Working stress or permissible stress or safe stress
- Young's modulus
- Yield stress
- Ultimate stress or Maximum tensile stress
- Breaking stress or Failure stress

Practical importance: while designing a component, selection of metals for different applications is based on salient points such as limit of proportionality or elastic limit, yield strength, ultimate strength, and breaking strength. Therefore, from this tension test above said salient points can be calculated.

Apparatus Required:
Universal Testing machine, Dial gauge, Vernier caliper and scale.

Theory:
In engineering, tension test is widely used to provide basic design information on the strength of the materials. In the tension test a specimen is subjected to a continually increasing uniaxial tensile force while simultaneous observations are made of the elongation of the specimen. A stress-strain curve is plotted from the load-elongation measurements.

The parameters which are used to describe the stress-strain curve of a material are the tensile strength, yield strength or yield point, percent elongation and reduction of area. The first two are strength parameters; the last two indicate ductility.

Definitions:
Limit of proportionality (A): It is the limiting value of the stress up to which stress is proportional to strain.

Elastic limit: This is the limiting value of stress up to which if the material is stressed and then released (unloaded), Strain disappears completely and the original length is regained.

Tabular Column

Sl. No.	Load in KN	Load in N	Extension (δl) in mm	Stress in N/mm^2	Strain	Young's modulus N/mm^2
1						E = stress / strain
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						Result from the graph
12						
13						
14						
15						

Calculations

- Stress = $\frac{\text{Load}}{\text{Area}} = \frac{P}{A_i}$ =…….N/mm^2
- Strain = $\frac{\text{Change in length}}{\text{Original Length}}$ =……..
- Young's modulus = $\frac{\text{Stress}}{\text{Strain}}$ = ……N/mm^2 (obtained from the graph)
- Working stress = $\frac{\text{yield stress}}{\text{Factor of Safety.}}$ =……. N/mm^2
- % Elongation= $\frac{\text{Final length-Initial length}}{\text{Initial length}}$ X100 = $\frac{(l_f - l_i)}{l_i}$ x 100 =…%
- % reduction in Area = $\frac{\text{Initial area- Final area}}{\text{Initial area}} = \frac{(A_i - A_f)}{A_i}$ x 100 =…….%
- Yield strength = $\frac{\text{Yield load}}{\text{Initial area}} = \frac{p_Y}{A_i}$ = …… N/mm^2
- Ultimate Tensile strength = $\frac{\text{Ultimate load}}{\text{Initial area}} = \frac{p_u}{A_i}$ = …… N/mm^2

Upper Yield Point (B): This is the stress at which, the load starts reducing and the extension increases. This phenomenon is called yielding of material.

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

Ultimate Stress (D): This is the maximum stress the material can resist. At this stage cross sectional area at a particular section starts reducing very fast (fig.1). This is called *neck formation*.

Breaking Point (E): The stress at which finally the specimen fails is called breaking point.

Hooks law: Within the elastic limit, the stress is proportional to the strain for an Isentropic material.

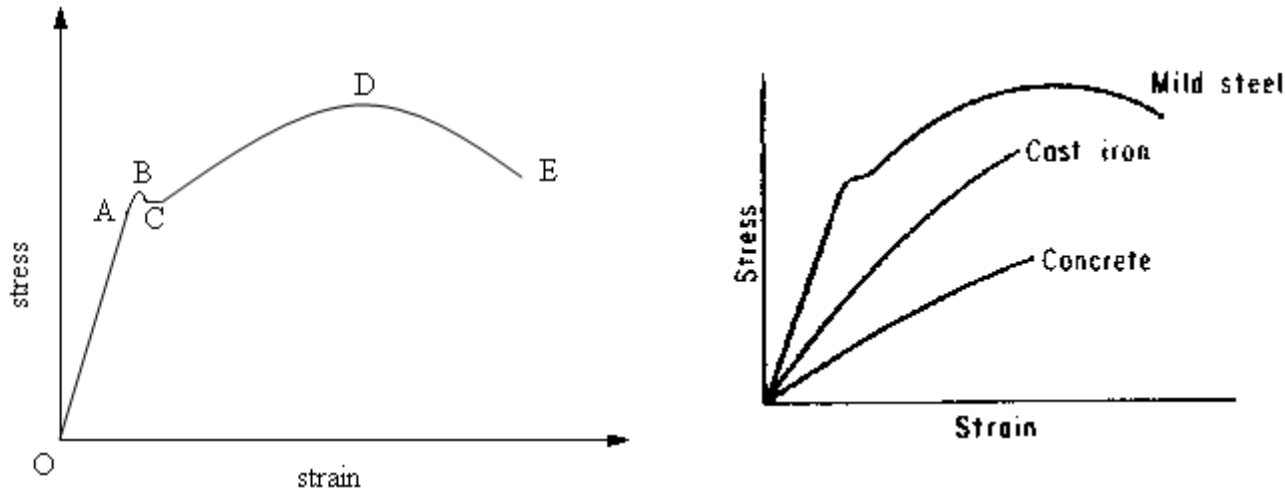
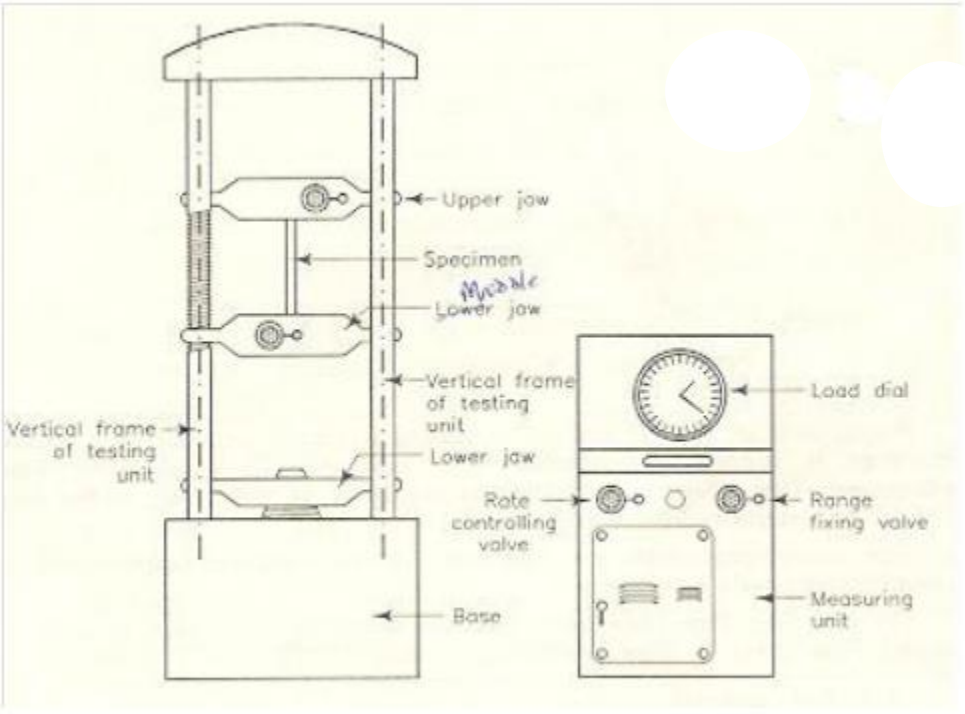


Fig.1: Linear stress - strain Curve

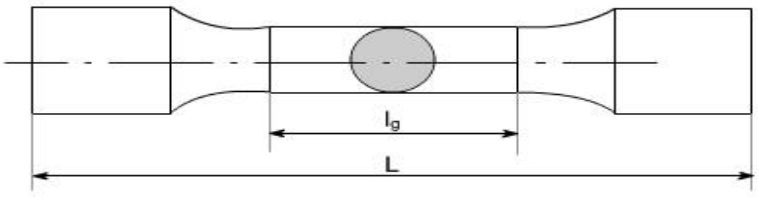
A - Elastic Limit
B - Upper Yield Stress
C - Lower Yield Stress
D -Ultimate Stress
E -Breaking Stress

- Breaking strength = $\frac{\text{Breaking load}}{\text{Final Area}} = \frac{p_B}{A_f}$ = …… N/mm^2

Graph: Stress v/s Strain



Universal Testing Machine



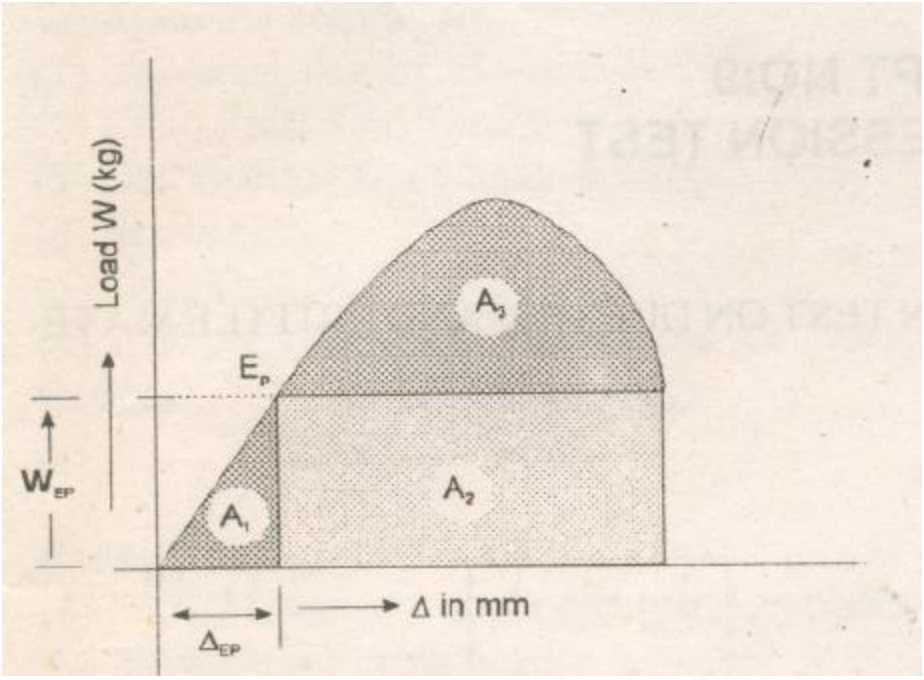
[specimen with circular X-section]

l_g = gauge length i.e. length of the specimen on which we want to determine the mechanical properties.
L= Total length of the specimen

Proof Resilience: It is defined as the "partial strain energy stored in the specimen from zero upto elasti.c point". Graphically, it is the area bounded below the graph from zero upto elastic point. Hence proof resilience=Approximately the Triangular area from zero upto elastic point (Fig: 1),

Proof resilience = [1/2 Δ*EP WEP] kg- cm.*

Modulus of Resilence: It is defined as the" Total strain energy stored in the specimen from 'zero upto the fracture point of the specimen". Graphically, it is the area bounded below the graph from zero upto the point of fracture From the Graph.
Modulus of Resilience=Triangular area Al + Rectangular area A2 + Remaining area A3
Modulus of Resilience = (AI+A2+A2) kg.cm



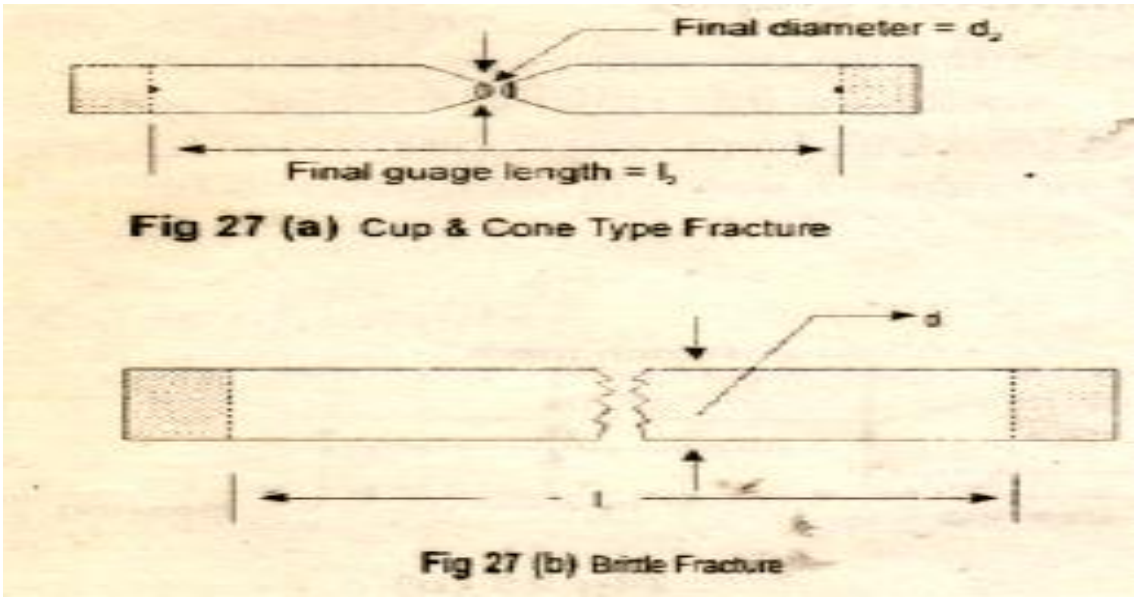


Fig 27 (a) Cup & Cone Type Fracture

Fig 27 (b) Brittle Fracture

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Procedure

- The original dimensions of the specimen like original diameter, gauge length etc. is to be measured.
- The specimen is mounted on the Universal Testing machine between the fixed and movable jaws.
- The load range in the machine is adjusted to its maximum capacity (160 tonnes)
- The dial gauge is mounted on the machine at the appropriate positions and adjusted to zero.
- The machine is switched on and the tensile load is applied gradually.
- For every 5 KN of load, the readings of dial gauge is noted and tabulated.
- Remove the dial gauge at slightly below the expected load at yield point.
- 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 2 or 3 divisions that point is lower yield point.
- The specimen is loaded continuously up to the ultimate load (red needle will stops) where there is formation of cup and cone at neck in the specimen, which is to be noted.
- With further loading the specimen breaks, and breaking load is noted.
- The specimen is removed and final dimensions are measured.

Results and Conclusions:

1. Working stress =
2. Young's Modulus of specimen =
3. Yield stress =
4. Ultimate stress =
5. Breaking stress =
6. % reduction in Area =
7. % Elongation=

Date…… **Signature of the Faculty**

Observations

1. Least count of dial gauge = 0.01mm.
2. Specimen Material = ……
3. Initial length (l_i) = …….. ….. mm
4. Initial diameter (d_i) = …….. ….. mm
5. Original C/S Area (A_i) = $\frac{\pi \times d_i^2}{4}$ =…….mm^2
6. Ultimate Load (p_u) =……KN
   i. Where 'p_u' is the maximum load applied.
7. Final length (l_f) =…….mm
8. Final diameter (d_f) =……..mm
9. Final Area (A_f) = $\frac{\pi \times d_f^2}{4}$ = ……mm^2

Tabular Column:

Sl. No.	Load in KN	Load in N	Compression (δl) in mm	Stress in N/mm^2	Strain	Young's modulus N/mm^2
1						E = stress / strain Result from the graph
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						
13						
14						
15						

Experiment 2:

COMPRESSION TEST

Objective: To study the behavior of the given material under Compressive load and to determine the following:

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

Principle: 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. 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 Fig.

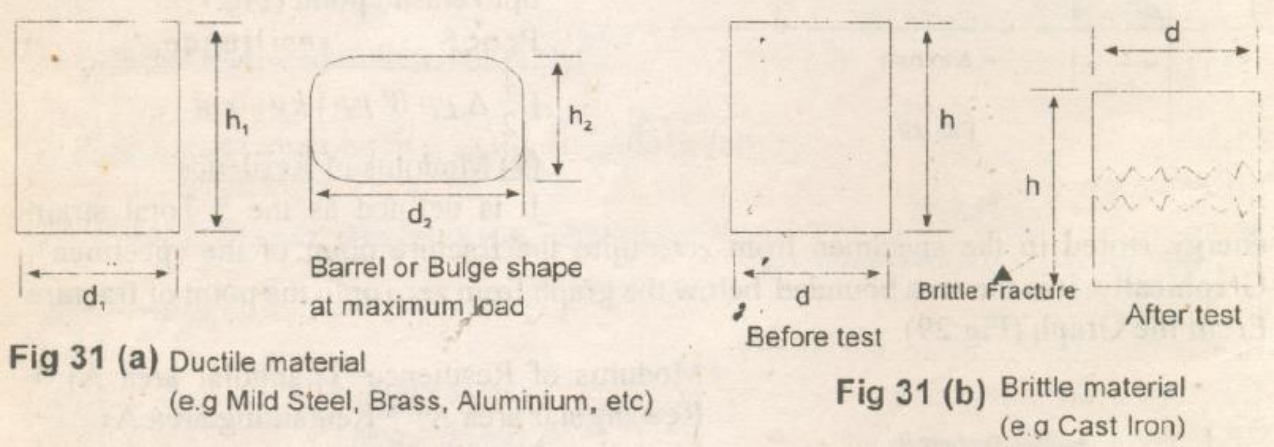


Fig 31 (a) Ductile material (e.g Mild Steel, Brass, Aluminium, etc)

Fig 31 (b) Brittle material (e.g Cast Iron)

Apparatus Required:

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

Theory:

The compression test is just opposite to tension test, with regard to 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)

Calculations

Stress = $\frac{\text{Load}}{\text{Area}} = \frac{P}{A_i}$ =…….N/mm^2

Strain = $\frac{\text{Change in length}\ (\delta l)}{\text{Original Length (l)}}$ = ……

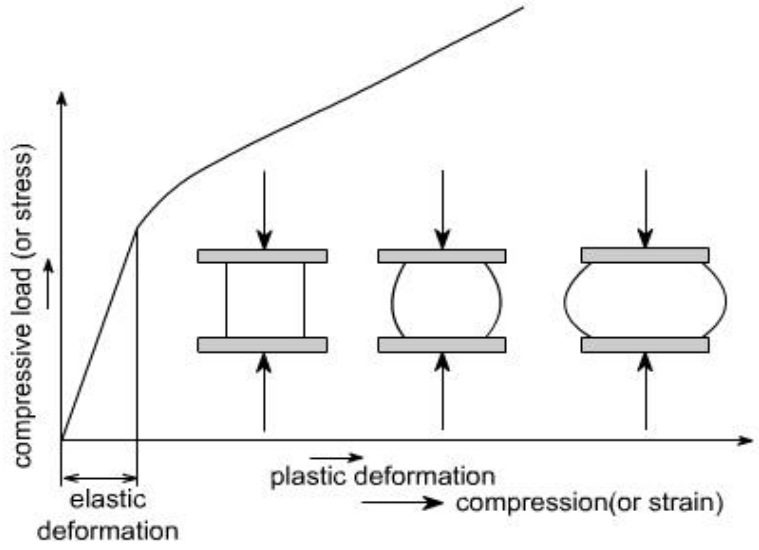
Young's modulus= $\frac{\text{Stress}}{\text{Strain}}$ =…… N/mm^2 (obtained from the graph)

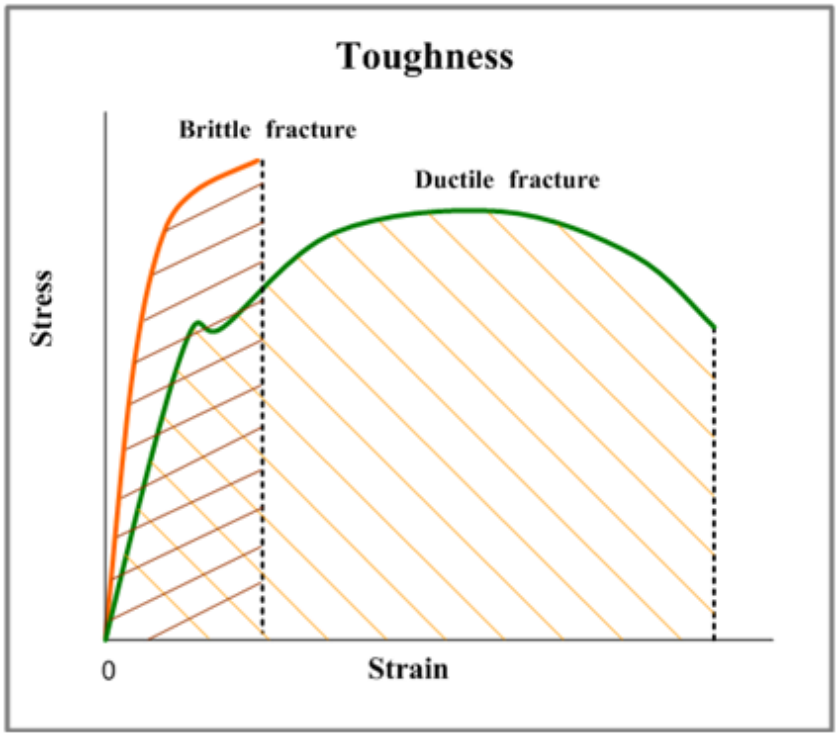
% Decrease in Length = $\frac{(l_i - l_f)}{l_i}$ x 100 =……%

% Increase in area = $\frac{(A_f - A_i)}{A_i}$ x 100 =……..%

Ultimate Compressive strength = $\frac{\text{Ultimate load}}{\text{Initial area}} = \frac{p_u}{A_i}$ = …… N/mm^2

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.





Graph: Stress v/s Strain

Procedure

- The original dimensions of the specimen like original dia., gauge length etc. is to be measured.
- The specimen is mounted on the Universal Testing machine between the fixed and movable jaws.
- The load range in the machine is adjusted to its maximum capacity (300 tonnes)
- The dial gauge is mounted on the machine at the appropriate positions and adjusted to zero.
- The machine is switched on and the compressive load is applied gradually.
- For every 10 KN of load, the readings of dial gauge is noted and tabulated.
- Remove the dial gauge at slightly below the expected load at yield point.
- 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.
- The specimen is loaded continuously up to the ultimate load (red needle will stops) which is to be noted.
- The specimen is removed and final dimensions are measured.

Results and Conclusions:

1. Modulus of elasticity =
2. Maximum Compressive strength or ultimate stress =
3. Percentage Decrease in length =
4. Percentage Increase in area =

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OBSERVATIONS

1. Diameter of specimen for single shear = _____ mm
2. Diameter of specimen for double shear = _____mm

TABULATION:

Sl.No.	Type of Shear	Load(P)		Cross Sectional Area mm^2	Shear Stress N/mm^2
		K_{gf}	N		

CALCULATIONS:

1. Shear Stress (single shear) = $\frac{\text{load}}{\text{c/s Area}}$ = _____ ____N/mm^2

2. Shear Stress (double shear) = $\frac{\text{load}}{\text{2 x c/s Area}}$ = _____ N/mm^2

Experiment 3:

SHEAR TEST

AIM: To determine the shear strength of the given standard specimen under single and double shear.

APPARATUS: UTM, Vernier Calipers, Standard MS Specimen

THEORY:

A shear stress acts parallel to a C/S plane where as tensile and compressive stresses act at normal to the C/S plane. For direct shear test of metals, a bar is usually sheared in the same device that changes the position of the specimen while the remaining position is subject to load by suitable dies.

PROCEDURE:

1. Measure the diameter of the specimen
2. Fix the shear Specimen in the Single/Double Shear fixture.
3. Keep the shear equipment on the fixed jaw of UTM and apply the load

   Slowly at right angles to the axis of piece through the central block.
4. Note the load at fracture.

Date…… **Signature of the Faculty**

Tabular Column

Sl. No	Load (p) KN	Deflection (δ) mm	(P/δ) value
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			

Observations

- Material =…….
- Span length(L) =……..mm
- Breadth (b) =…….mm
- Height (h) =…….mm
- Cross sectional area at centre= b x h=…….. mm^2
- Load at fracture, P_f =……..kN

Experiment 4:

BENDING TEST

Objective: To Conduct bending test for the given specimen and to determine the following:

- Modulus of elasticity
- Modulus of Rupture or flexure modulus (maximum bending stress at failure using bending equation).

Principle

A Bending test may be performed on actual beam cross-section by using the three point loading system. The bending fixture is supported on the platform of the hydraulic cylinder of the universal testing machine. The loading knife edge is held in the middle crosshead. At a particular load, the deflection at the centre of the beam is determined by using a dial gauge.

The deflection at the beam centre is given by $\Delta = WL^3/48EI$.

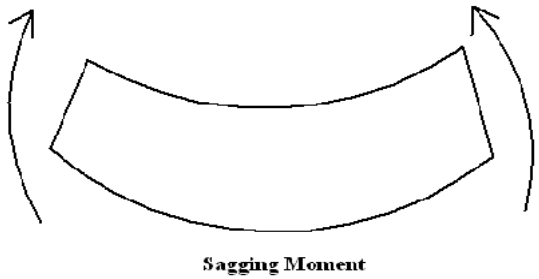
By knowing W, L, D and I, it is possible to obtain the modulus of elasticity of beam material.

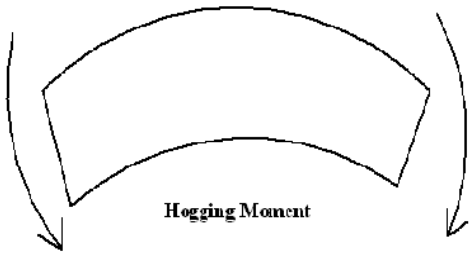
Apparatus Required:

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

Theory:

Application of a simple concentrated load at centre in the case of Bending associated with shear. Application of two concentrated loads will lead to pure bending without shear. Beams are usually subjected to bending moment and shearing forces which vary from section to section. *Bending moment at a section in a beam is the moment that is trying to bend it and is obtained as the algebraic sum of the moments about the section of all the forces acting on the beam either to the left or to the right of the section.* Due to the bending moment, beam sags or hogs as shown below;





Calculations

Moment of inertia, $I = \frac{b \times h^3}{12}$ =……. mm^4

Section modulus (Z) = $\frac{I}{Y} = \frac{bh^2}{6}$

From the graph, Load/ Deflection= P /δ=……

Deflection **(δ) =** $\frac{PL^3}{48EI}$

Young's Modulus, E= $\left(\frac{l^3}{48I}\right)$ *Slope of the load-deflection at yield point. (Obtained from the graph)

Maximum Bending moment= $M = \frac{P_f L}{4}$ =……N-mm

Where,

M = Bending moment in N – mm

I = Moment of Inertia in mm^4

σ_b = Bending Stress in N / mm^2 (Mpa)

y = Distance from neutral axis to the outer most fiber in mm.

E = Young's modulus in N / mm^2 (Mpa)

R = Radius of curvature in mm.

- Bending Stress, $\sigma_b = \left(\frac{M}{I}\right) y$ =……N / mm^2

  y = h / 2 =…….. mm

- Modulus of rupture(f) = $\frac{3P_f L}{2bh^2}$ =……N/ mm^2

  Or

  Modulus of rupture (f) = $\frac{M}{Z}$ = ……..N/ mm^2

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

Graph : Load v /s Deflection

Procedure:

- The dimensions of the specimen are noted.
- The specimen is placed on the supports and is fitted to the universal testing machine.
- Dial gauge is mounted on the UTM at the appropriate position and adjusted to read zero.
- The UTM is adjusted to have the suitable load range.
- The machine is switched on and bending load is applied gradually.
- For every 0.5 KN rise in load, the corresponding dial gauge and scale readings are noted.
- The load is applied until the specimen breaks and the breaking load is noted.

Results and Conclusions:

Modulus of Rupture =

Modulus of elasticity =

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CALCULATIONS:

Modulus of Rigidity C $= \frac{32\ l\ T}{\pi D^4\ \theta}$

Maximum Torsional Shear Stress ζ $= \frac{16\ T_{max}}{\pi D^3}$

OBSERVATIONS:

1. Length of the specimen (l) = _____mm
2. Mean diameter of a specimen (D) = _____mm

TABULAR COLUMN:

Sl. No.	Twisting Moment T Kg-m	Angle of Twist θ		Modulus of Rigidity Kgm	Torsional Shear Stress
		In degrees	In Radians		
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					

Experiment 5:

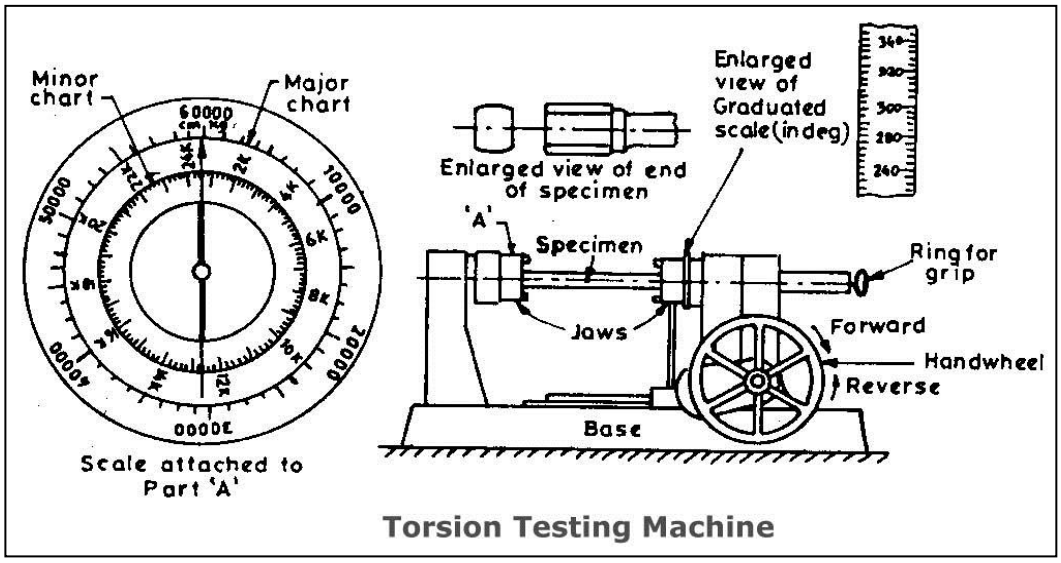
TORSION TEST

AIM: To determine the modulus of rigidity and torsional shear stresses developed

APPARATUS: Torsion Testing machine, Vernier Calipers, Measuring scale, Specimen etc.

PROCEDURE:

1. Measure the Dia of the test piece at three different places and note the Average dia.(D)
2. Measure its gauge length
3. Fix the specimen in the chucks and adjust the load range real and start the motors
4. Take readings of torsion and twist until failure occurs
5. Plot the graph T v/s θ
6. Calculate modulus of rigidity and torsional shear stress.



Torsion Testing Machine

Date……. **Signature of the Faculty**

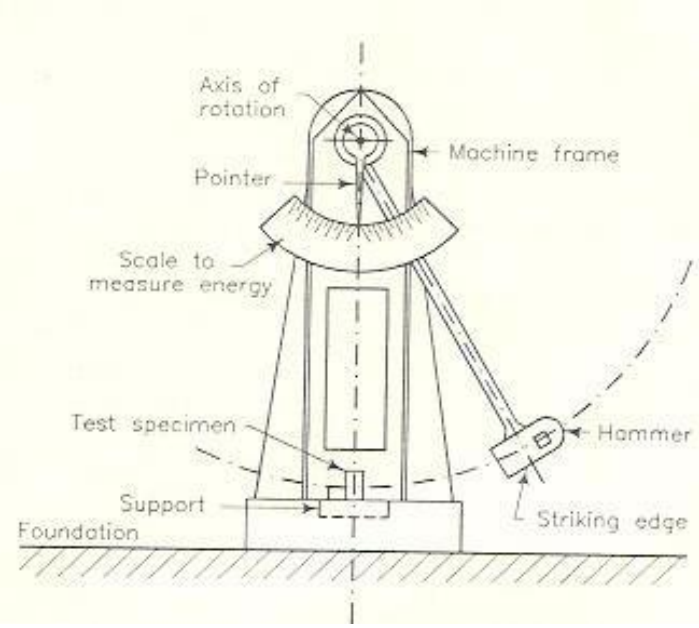


Fig: Izod Impact testing equipment

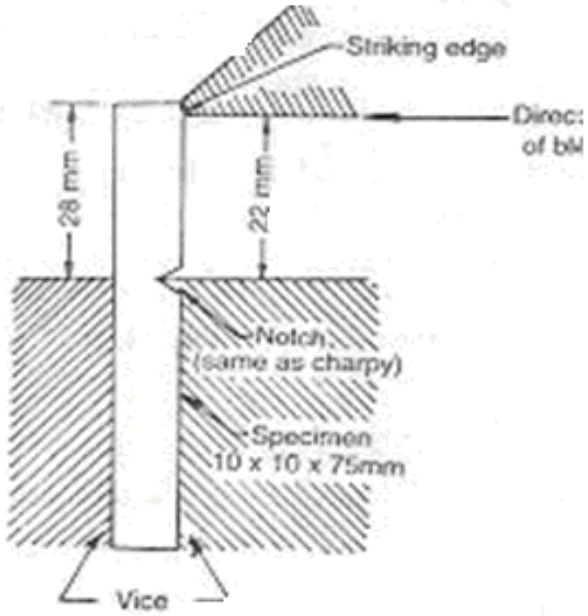


Fig: Position of specimen for Izod test

Experiment 6:

IZOD IMPACT TEST

Objective: To determine the Impact strength (Specific impact factor) through Izod test.

Principle: Static tests are not satisfactory in determining the resistance to shock or impact loads such as automobile parts are subjected to shock loads, and in the impact test a notched specimen of the material is fractured by a single blow from a heavy hammer, the energy required being a measure of the resistance to impact.

Materials and equipments required

Impact testing machine, MS Specimen

Theory

IZOD Impact Test:

A pendulum type single blow impact test in which the specimen, usually notched, is fixed at one end and free at other end. Specimen is broken by a falling pendulum. The energy absorbed as measured by the subsequent rise of the pendulum is a measure of impact strength or notch toughness.

Notch: A slot or groove of specified characteristics intentionally cut in a test piece so as to concentrate the stress localizing the rupture.

Notch Toughness: The high resistance of the material to fracture under suddenly applied loads at any Stress raiser such as notch.

Toughness: The ability of the material to absorb energy and deform plastically before fracture. It is usually measured by the energy absorbed in a notched impact test like Charpy and Izod tests. The area under the stress -strain curve in a tensile test is also a measure of toughness and as such is proportional to the combined effects of tensile strength and ductility.

The Izod impact energy (I) i.e, the energy required to break the specimen is obtained directly from the test. The depth below the notch and the breadth of the specimen is measured (i.e d and b). The effective cross-sectional area below the notch is obtained (A=bd mm^2) hence, specific Impact factor=I_f=I/A Joules /mm^2

Tabular Column

Sl. No.	Specimen	Trials	Initial Reading K_1 in J	Final Reading K_2 in J	Izod Impact Value $K=K_1-K_2$ J	Izod impact Strength $I=K/A$ (J/Cm^2)
1.	M.S	1				
2.	M.S	2				

Specification

Specimen size= 75*10*10

Type of notch = V- Notch

Angle of notch= 45^o

Depth of notch= 2mm

Procedure

1. Fix the charpy striker in its respective position; place the charpy test specimen on supports.
2. Align the centre at the specimen notch with respect to centre of support by means of setting gauge.
3. Touch the striker to the test specimen and adjust the indicating pointer to 170J.
4. Lift the pendulum till it gets latched in its position at 90^0 from its vertical axis.
5. Allow the pendulum to swing freely and break the specimen.
6. After rupture apply the break to the pendulum slowly by operating break lever.
7. Note down the reading at observed energy directly on the dial as indicated by the indicating pointer.
8. Before proceeding for next test, remove the broken piece of the tested specimen and bring indicating pointer, striker to its original position at 170J.

Results and Conclusion

Average impact value of Mild Steel = ----------Joules

Average impact strength = ----------Joules/cm^2

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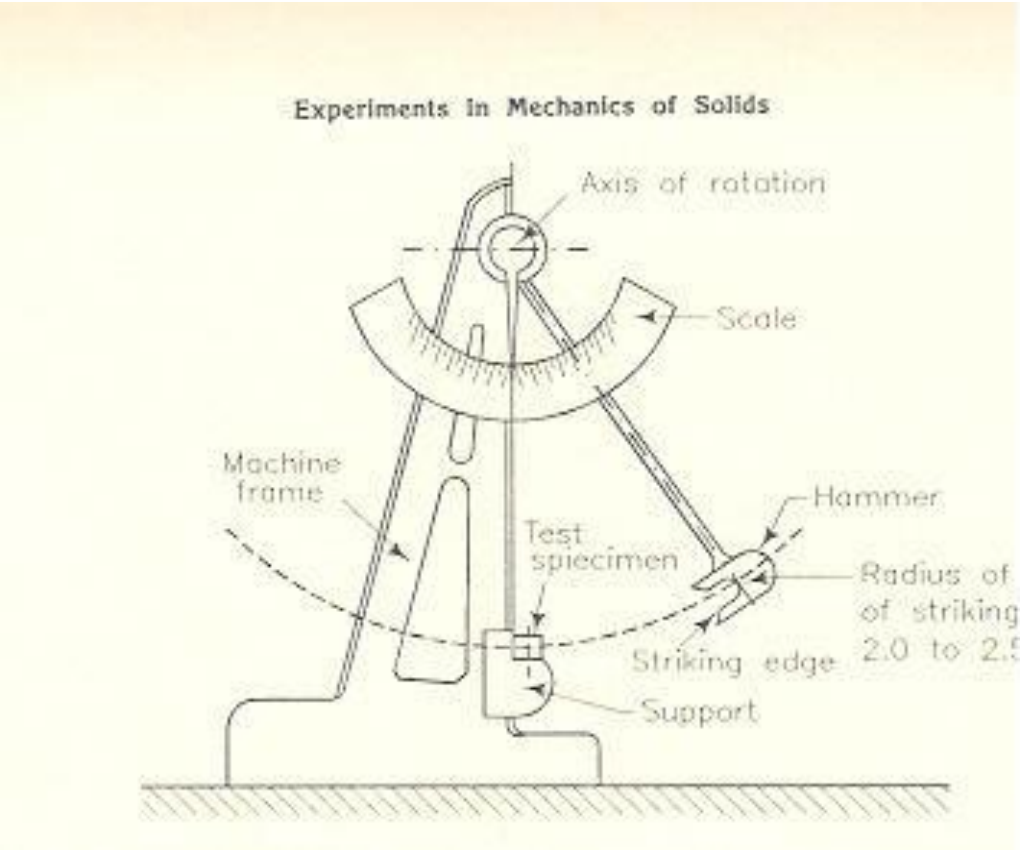


Fig: Charpy impact testing equipment

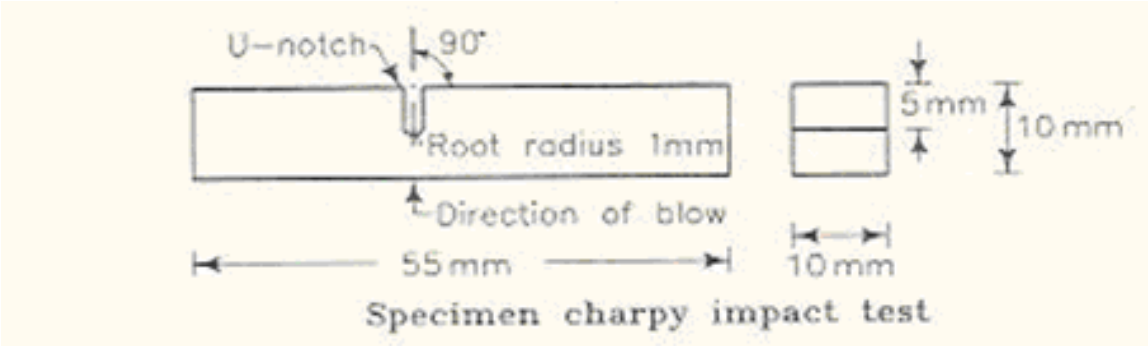


Fig: Specimen for Charpy test

Experiment 7:

CHARPY TEST

Objective: To determine the Impact strength (Specific impact factor) through Charpy test.

Principle:

The Charpy Impact Test is similar in principle to the Izod, but the notched specimen is supported at each end as a beam and struck by the hammer in the centre.

Materials and equipments required

Impact testing machine, MS Specimen

Theory

In an impact test a specially prepared notched specimen is fractured by a single blow from a heavy hammer and energy required being a measure of resistance to Impact. Impact load is produced by a swinging of an impact weight (hammer) from a height. Release of the weight from the height swings the weight through the arc of a circle, which strikes the specimen to fracture at the notch. Here it is interesting to note that height through which hammer drops determines the velocity and height and mass of a hammer combined determine the energy. Energy used can be measured from the scale given. The difference between potential energies is the fracture energy. In test machine this value indicated by the pointer on the scale. This energy value called impact toughness or impact value, which will be measured, per unit area at the notch.

Specification

Specimen size= 55*10*10

Type of notch = U - Notch

Angle of notch= 45^{o}

Depth of notch= 2mm

Tabular Column

Sl. No.	Specimen	Trials	Initial Reading K_1 in J	Final Reading K_2 in J	Charpy Impact Value $K=K_1-K_2$ J	Charpy impact Strength I=K/A (J/Cm^2)
1.	M.S	1				
2.	M.S	2				

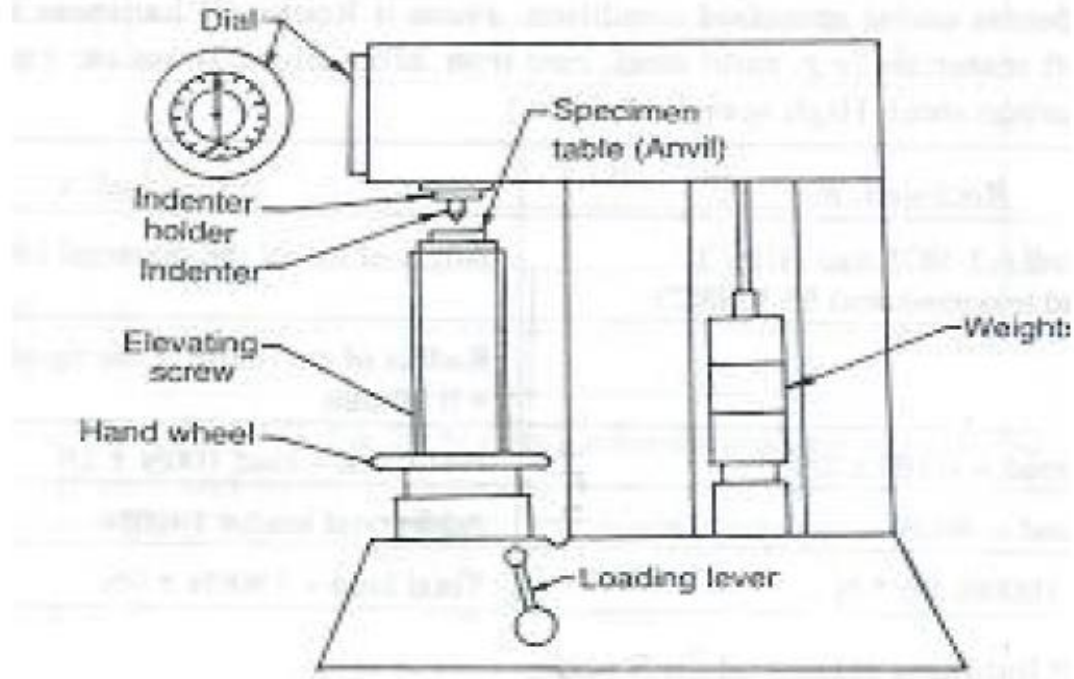
Procedure

1. Fix the charpy striker in its respective position; place the charpy test specimen on supports.
2. Align the centre at the specimen notch with respect to centre of support by means of setting gauge.
3. Touch the striker to the test specimen and adjust the indicating pointer to 300J.
4. Lift the pendulum till it gets latched in its position at 140^0 from its vertical axis.
5. Allow the pendulum to swing freely and break the specimen.
6. After rupture apply the break to the pendulum slowly by operating break lever.
7. Note down the reading at observed energy directly on the dial as indicated by the indicating pointer.
8. Before proceeding for next test, remove the broken piece of the tested specimen and bring indicating pointer, striker to its original position at 300J.

Results and Conclusion

Average impact value of Mild Steel = ----------Joules
Average impact strength = ----------Joules/cm^2

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Rockwell hardness test equipment

Experiment 8:

ROCKWELL HARDNESS TEST

Objective: To determine the Rockwell hardness number of the given Specimen using "Rockwell Hardness tester".

Principle: A standard load (Based on type of material) is applied through a standard indentor (cone or ball indentor) for a standard duration of time. The hardness number is directly obtained in the experiment.

Practical importance: Hardness is the property of the material by which it offers resistance to scratch or indentation. It is the most important property, as the material is subjected to friction and scratch. By this experiment we can determine the Hardness of the given material.

Materials and equipments required:

- Rockwell hardness testing machine.
- Diamond cone indentor, ball indentor.
- Specimens (Hardened steel, Mild steel, Brass, Copper, Aluminium)

Theory:

Hardness of a material is generally defined as Resistance to the permanent indentation under static and dynamic load. When a material is required to use under direct static or dynamic loads, only indentation hardness test will be useful to find out resistance to indentation.

Rockwell test is developed by the Wilson instrument co U.S.A in 1920. This test is an indentation test used for smaller specimens and harder materials. In this test indentor is forced into the surface of a test piece in two operations, measuring the permanent increase in depth of an indentation from the depth increased from the depth reached under a datum load due to an additional load.

Measurement of indentation is made after removing the additional load. Indentor used is the cone having an angle of 120 degrees made of black diamond.

Observation

Type of specimen	Type of Indentor	Scale	Total load(P) Kg-F
Hard Metals	Diamond cone	C (Black graduations)	150
Soft Metals	Ball (1/16”)	B (Red graduations)	100

Tabular Column

Sl.No	Specimen	Type of Indentor	RHN			Average RHN
			1	2	3	
01	Hardened steel	Diamond cone				
02	Mild steel	Ball (1/16”)				
03	Brass	Ball (1/16”)				
04	Copper	Ball (1/16”)				
05	Aluminium	Ball (1/16”)				

Specification:

Rockwell hardness tester gives the direct reading of hardness number on a dial provided with the machine. The specimen may be cylinder, cube, thick or thin metallic sheets.

Specifications are as follows.

1. Ability to determine hardness up to = 100 RHN
2. Maximum application of load = 150 Kgf
3. Method of load application = Lever type
4. least measuring hardness number= 1 RHN

Procedure:

1. Keep the loading and unloading lever at position "A" which is unloading position.
2. Select the suitable indentor & weights according to the scale.
3. Place the specimen on testing table anvil.
4. Turn the hand wheel to raise a job until it makes contact with indentor & continue turning till the longer pointer at the dial gauge makes 2 ½ rotations. Then it stops at zero continue turning slowly till the small pointer reaches the red spot at '3', this is automatic zero setting dial gauge.
5. Turn the lever position 'A' to 'B' i.e. from unloading to loading position. So that the total load will act.
6. When the longer pointer of the dial gauge reaches steady position, take back the lever to the unloading position 'A'. [Avoid sudden release at the lever]
7. Now note down the reading in the last dial indicator by notifying the large pointer
8. Turn back the hand wheel and remove the job.
9. Similarly repeat the step from 1-9 for different trials and for different metals.

Results & Conclusion:

Rockwell hardness Number of given specimen is

1. Hardened steel =
2. Mild steel =
3. Brass =
4. Copper =
5. Aluminium =

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Observation

Type of Indentor	Total load(P) Kg-F	Suitable for
Ball Indentor 2.5mm dia.	187.5	Non ferrous soft metals, Soft iron, steel castings, Cast iron, malleable iron.
Ball Indentor 5mm dia.	250	Light alloys casting, forging alloys, die casting alloys.

Tabular Column

Sl.No	Specimen	Indentor Diameter(D) In mm	Total load(P) Kg-F	Diameter of Indentation(d) in mm			Average dia	BHN
				1	2	3		
01	Mild steel							
02	Brass							
03	Copper							
04	Aluminium							

Experiment 9:

BRINELL HARDNESS TEST

Objective: To determine the Brinell hardness number of the given Specimen using Brinell hardness tester.

Principle: Brinell hardness number (BHN) is obtained by the ratio of the calculated load and the spherical area of the Indentation or Impression made on the specimen by the corresponding Indentor Ball.

Practical importance: This Brinell Hardness Test is used to determine the Hardness Number of hard, moderately hard, and soft material Eg: Brass, Bronze, Aluminum, Gold, Copper, Etc. Very hard material and Brittle material cannot be tested by Brinell hardness tester.

Materials and equipments required

- Brinell hardness testing machine and Brinell Microscope.
- Ball Indentor of diameter 2.5mm and 5mm
- Specimens (Mild steel, Brass, Copper, Aluminium)

Specification

In Brinell hardness test, a steel ball of diameter (D) is forced under a load (F) on to a surface of test specimen. Mean diameter (d) of indentation is measured after the removal of the load (P).

Specifications are as follows.

1. Ability to determine hardness up to =1411 BHN
2. Maximum application of load =250 Kgf
3. Method of load application = Lever type
4. least measuring hardness number= 1 BHN3

Calculations

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

Where,

D = Diameter of ball indentor in mm
d= Diameter of Indentation in mm
P= Load applied in Kgf

d=MSR+ (CVSD×LC)

Least Count of Brinell Microscope=0.01mm

Procedure

1. Keep the loading and unloading lever at position "A" which is unloading position.
2. Select the suitable indentor & weights according to the scale.
3. Place the specimen on testing table anvil.
4. Turn the hand wheel to raise a job until it makes contact with indenter & continue turning till the longer pointer at the dial gauge makes 2 ½ rotations. Then it stops at zero continue turning slowly till the small pointer reaches the red spot at '3', this is automatic zero setting dial gauge.
5. Turn the lever position 'A' to 'B' i.e. from unloading to loading position. So that the total load will act.
6. When the longer pointer of the dial gauge reaches steady position, take back the lever to the unloading position 'A'. [Avoid sudden release at the lever]
7. Remove the job from the platform and note down the diameter of the indentation using Brinell microscope.
8. Using appropriate formula calculate BHN.
9. Similarly repeat the step from 1-8 for different trials and for different metals.

Results & Conclusion: Brinell hardness number of given specimen is

1. Mild steel =
2. Brass =
3. Copper =
4. Aluminium =

Conclusion: Based on BHN for Mild Steel, the Relation between the tensile strength and Hardness Number is given as follows,

Tensile Strength of Mild Steel = K*BHN for MS

Where K= constant between 3.4 to 3.9 for types of steel.

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Observation

Type of indentor = Diamond cone

Tabular column

Sl. No	Specimen	Load applied in Kgf	Length of Indentation in mm(l)			Average length in mm	VHN= $\frac{1.854P}{l^2}$
			1	2	3		

Experiment 10:

VICKER'S HARDNESS TEST

Objective: To determine the hardness of the given Specimen using Vicker's hardness test.

Principle: The required load as calculated by P/D^2 ratio is applied on the specimen for a standard time of 8-10 Sec's and BHN is calculated by the ratio of load and the spherical area of indentation. The diameter of the indentation is measured on the focusing screen of the machine.

Practical Importance :
Same as in Experiment NO.8 (i.e., Rockwell Hardness Test).

Materials and equipments required:
Vicker's Hardness Testing Machine.
Diamond cone indentor,
Specimen.

Theory:
Very Hard materials (e.g. Mild steel, case hardened steel, etc,) can be tested by the Vicker's method. If the moderately hard materials like Brass, Copper and Aluminium are tested in this machine, the indentor makes a deep impression. Hence, a proper indentation cannot be made on the specimen and a correct value of the hardness cannot be obtained for these materials by V. H. Test.

VHN = Load Sloping or pyramidal area of indentation

This test is similar to Brinell hardness test similar relationship and eliminates most of the errors. A regular pyramid having a square base and smoothened off diamond point is pressed in the material to be tested under a load 'F'. The produced impression is projected onto a focusing screen and the diagonals of the impression are measured by means of the measuring equipment.
Due to small impressions, it is very suitable for testing polished and hardened material surfaces. This test is rapid, accurate.

Calculations

Vicker's Hardness Number **(VHN) =** $\frac{1.854P}{l^2}$

Where,

P= Load applied in Kg
l= Average length of the diagonal L in mm

Least count of microscope=0.001mm
1st scale each division =0.1mm
2nd scale each division =0.01
3rd scale each division =0.001mm

Specification

1 Maximum application of load = 120 kgf
2 Method of load application = Push button
3 Least measuring indentation length= 0.001mm

Procedure:

1. Clean the surface at the specimen
2. Fix the indentor in the hardness tester and switch on the power supply.
3. Place the specimen with cleaned surface facing the indentor on the anvil at work table.
4. Focus the work piece surface for clean visibility by rotating the hand wheel at the work table upwards and downwards.
5. Select the load specified (P) push button available on the right side at the hardness tester.
6. Actuate the electric push button (Green Button) at the front for loading, the loading lever starts moving up words and reaches the study position.
7. Now release the loading lever slowly and bring it to the downward position.
8. For major reading adjust the display at the indentation made by the indentor to co inside with the micrometer on the display screen.
9. For major (minor) reading adjust the movable side at the micrometer and note down the total reading.
10. The measurement is to be made for two opposite corners of the diagonal indentation denoted as (l).
11. Repeat the above procedure for different material.

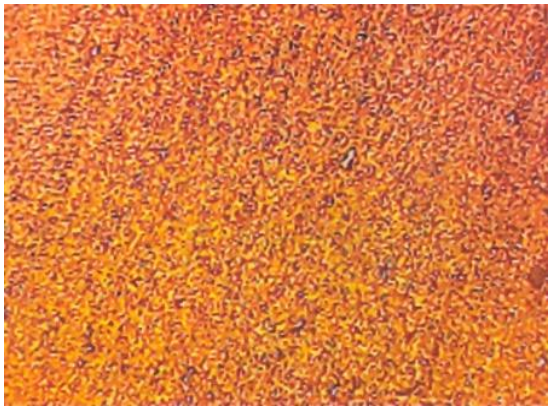
Results and Conclusion: Vicker's hardness Number of given specimen is

1. Mild steel =

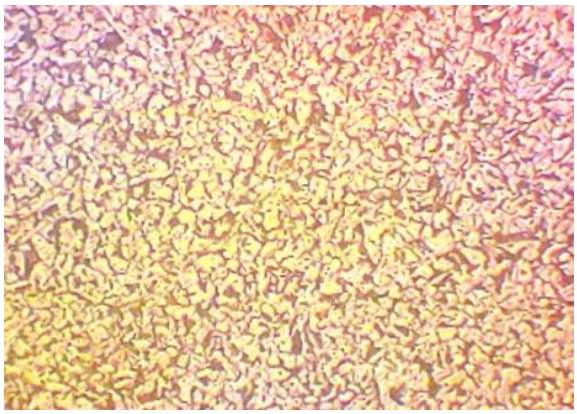
2. Hardened mild steel =

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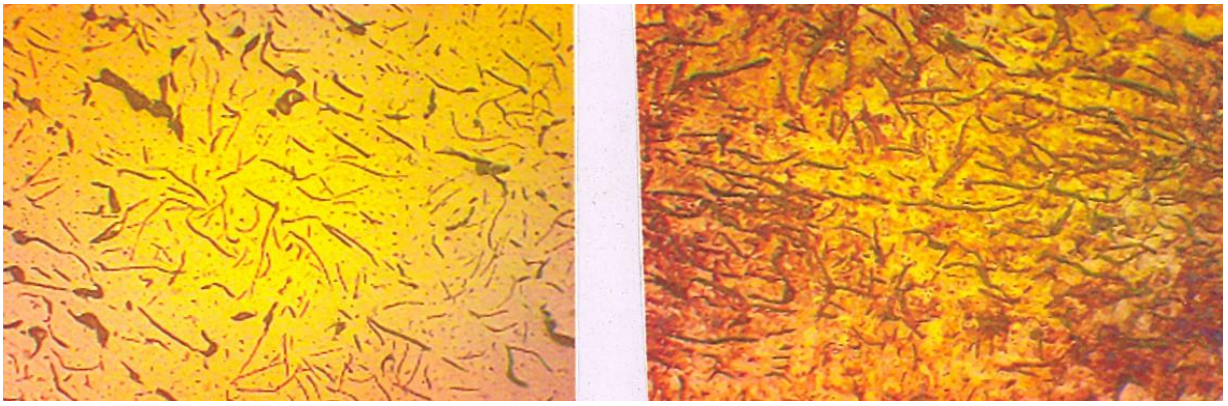
MICROSTRUCTURAL STUDIES OF MATERIALS



Mild Steel



High Speed Steel



Grey Cast Iron

Experiment 11:

PREPARATION OF THE SPECIMEN TO STUDY UNDER METALLURGICAL MICROSCOPE

Introduction:

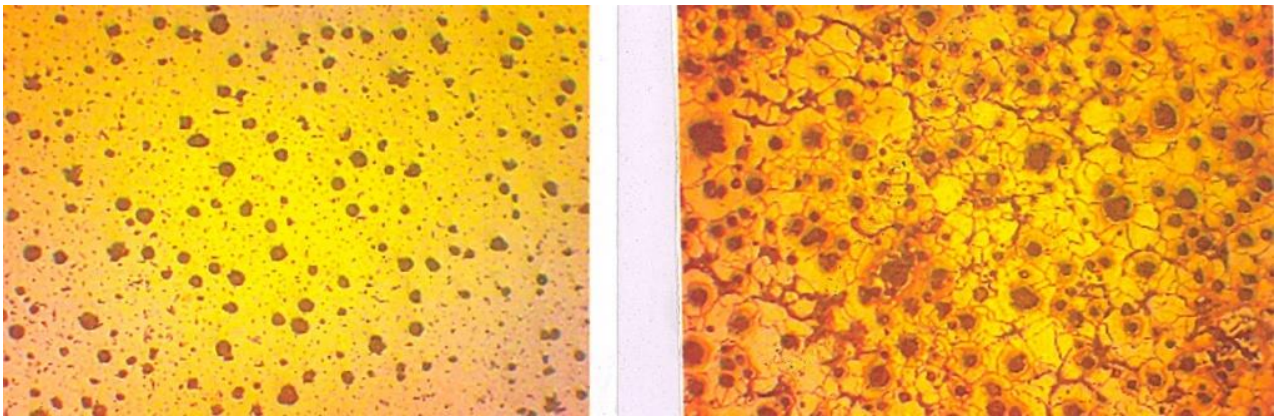
- The credit for originating Metallographic examination goes to Alloys Beck Von Widmanstatten (between 1808 & 1840).
- Microscope was employed for the purpose in 1841, when Paul Annosow used the instrument to examine the etched surfaces of oriental steel blades.
- It was around 1890 when metallographic technique received general recognition, largely as a result of the work of Professor Henry C. Sorby in England.
- ***Metallography*** is the general study of metals and their behavior, with particular reference to their microstructure and macrostructure.
- ***Microstructure*** is the characteristic appearance and physical arrangement of metal molecules as observed with a microscope.
- ***Macrostructure*** is the appearance and physical arrangement as observed with the naked eye.
- ***Metallurgical Microscope*** is by far the most important tool of the metallurgist from both the scientific and technical stand point. It helps determining:
  - **a)** Grain size and shape.
  - **b)** Size, shape and distribution of various phases and inclusion.
  - **c)** Mechanical and thermal treatment of the alloys.

Preparation of Specimen:

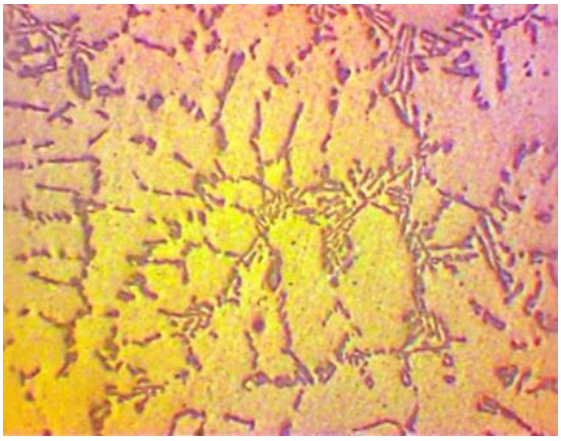
Preparation of specimen is necessary to study its microstructure, because the metallurgical microscope discussed earlier makes use of the principle of reflection of light from the specimen to obtain the final image of the metal structure. Following are the steps involved in the preparation of specimen:

1) Selection of specimen: When investigating the properties of a metal or alloy, it is essential that the specimen should be selected from that area (of the alloy plate or casting) which can be taken as representative of the whole mass.

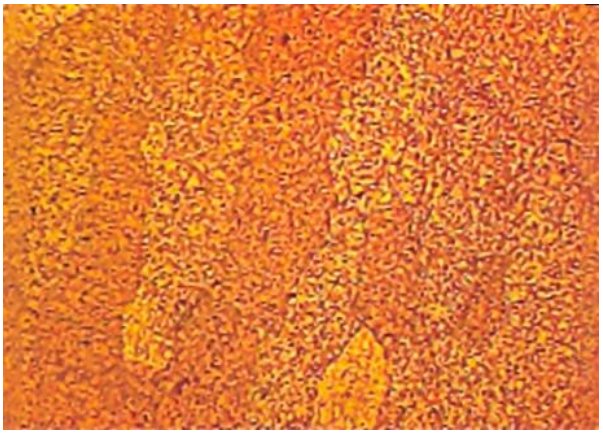
2) Cutting of the specimen: After selecting a particular area in the whole mass, the specimen may be removed with the help of appropriate cutting tools.



S G Iron



Aluminium Alloy



Copper Alloy

3) Mounting the specimen: If the specimen is too small to be held in hand for further processing, it should be mounted on a thermoplastic resin disc or some other low melting point alloy.

4) Obtaining flat specimen surface: It is first necessary to obtain a reasonably flat surface on the specimen. This is achieved by using a fairly coarse file or machining or grinding.

5) Intermediate and Fine Grinding: Intermediate and fine grinding is carried out using emery papers of progressively finer grade.

6) Rough polishing: A very small quantity of diamond powder (particle size about 6 microns) carried in a paste that is oil-soluble is placed on the nylon cloth-covered surface of a rotating polishing wheel. The specimen is pressed against the cloth of the rotating wheel with considerable pressure and is moved around the wheel in the direction opposite to rotation of the wheel to ensure a more uniform action.

7) Fine polishing: The polishing compound used is alumina (Al_2O_3) powder placed on a cloth covered rotating wheel. Distilled water is used as a lubricant. Fine polishing removes fine scratches and very thin distorted layer remaining from the rough polishing stage.

8) Etching:

Necessity-Even after fine polishing, the granular structure in a specimen usually cannot be seen under the microscope; because grain boundaries in a metal have a thickness of the order of a few atom diameters at best, and the resolving power of a microscope is much too low to reveal their presence.

In order to make the grain boundaries visible, after polishing the metal specimens are usually etched. Etching imparts unlike appearances to the metal constituents and thus makes metal structure apparent under the microscope.

Method- Before etching, the polished specimen is thoroughly washed in running water. Then, the etching is done either by,

(i) Immersing the polished surface of the specimen in the etching reagent or by

(ii) Rubbing the polished surface gently with a cotton swab wetted with the etching reagent.

After etching, the specimen is again washed thoroughly and dried. Now, the specimen can be studied under the microscope.

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Experiment 12:

HEAT TREATMENT PROCESSES

In general, heat treatment can be defined as an operation, or the combination of operations that involve heating and cooling of a metal in solid phase to obtain certain required properties.

The ferrous materials can be heated to above transformation temperature and can be heat – treated to obtain different structure.

The different heat treatment processes are based on heating the material to certain temperature and employing different cooling rates.

In this process, heating temperature and rate of cooling adopted plays an important role.

The different processes are:

- Annealing
  - Stress-relief annealing.
  - Process annealing.
  - Spheroidising.
  - Full annealing.
- Normalizing
- Hardening
- Tempering

Annealing:

Annealing primarily is the process of *heating* a metal which is in a metastable or distorted structural state, to a temperature which will remove the instability or distortion and then *cooling* it to the room temperature so that the structure is stable and/or *strain free*.

Purpose of Annealing:

1. Removal of residual stress.
2. Refining and homogenizing the structure and to give a coarse pearlite structure.
3. Improving machinability.
4. Improving cold working characteristics for facilitating further cold work.
5. Producing desired microstructure.
6. Removing residual stresses.
7. Improving mechanical, physical, electrical and magnetic properties.
8. Reducing hardness.

Normalizing:

This process involves heating the metal above the transformation temperature up to 900° C and cooling from that temperature adopting the required rate of cooling. This process involves:

- Heating the metal to around 900º C so that the metal transforms completely into austenite.
- Holding at that temperature for some times (3minutes / mm of thickness)
- Cooling at a rate of 80° C to 90° C per hour up to 700°C
- Then air – cooled from 700° C to room temperature.

Purpose of Normalizing:

- Refining the grain structure and giving a fine pearlite structure.
- Producing a uniform structure.
- Achieving the required strength and ductility in a steel that is too soft and ductile for machining.
- Improving structures in welds.
- In general, improving engineering properties of steels.

Hardening: (By Quenching)

Hardening is performed on metals to obtain desired hardness and structure. It involves:

- Heating the metal above transformation temperature, around 900°C
- Holding at that temperature for 15 to 30 minutes per 25mm of cross-section.
- Quenching it immediately in a suitable cold medium (brine solution,

Water, oil etc.)

Hardness obtained will depend upon the Composition of the material, nature and properties of quenching medium and quenching temperature.

Properties obtained by hardening are:

- Desired hardness can be obtained.
- Strength of material is increased.
- Wear resistance is increased.
- Martensite structure is obtained.

Tempering:

Hardening of metal produces Martensite structure with some retained austenite. The martensite structure makes the metal very hard and brittle. The retained austenite is unstable and it will change with time. This transformation of retained austenite even at room temperature leads to distortion of metal. Due to these factors the hardened metal cannot be used as it is. Hence tempering is carried out on the metals.

Tempering treatment involves:

Heating the metal just above Martensite structure temperature (50^{O} C), Holding it at that temperature for some time and then cooling either rapidly or slowly. The purpose of tempering is to remove brittleness and improve ductility in the material.

The Properties obtained after Tempering are:

- Improvement in ductility and toughness.
- Slight reduction in hardness.
- Increase in tensile strength.
- Reduction in internal stress.

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Tabulation:

Sl.No.	Specimen Material	Load on Pin(P)		Wear (µm)	Frictional Force(F)		Co-efficient of friction (F/P)
		Kg.	N		Kg.	N	

Calculation:

$$\text{Co-efficient of Friction at 40N} = \frac{\text{Frictional force (F)}}{\text{Load on Pin (P)}}$$

Graph: Draw a graph of Wear Vs Load

Experiment 13:

WEAR TESTING (Pin-on-disk)

Aim: To determine wear and co-efficient of friction of a standard specimen using pin-on-disk wear testing machine.

Apparatus: Pin-on-disk wear testing machine with control unit, Weights, Align key, Spanner, acetone , cotton and a standard specimen pin.

Procedure:

1. Clean the steel disk with acetone to free it from any debris from the earlier usage.
2. Remove the existing loads if any on the machine.
3. Fix the specimen in the pin holder using align key.
4. Note down the track radius.
5. Apply a load of 1Kg in the Pan.
6. Switch on the power of the control unit and set the timer to 5minutes.
7. Set the wear and frictional force to zero.
8. Start the wear testing machine and set RPM to 500.
9. Note down the readings of wear and frictional force at the end of 5 minutes.
10. Repeat the experiment with 2Kg, 3Kg and 4kgs.
11. Tabulate the results and calculate the co-efficient of friction.
12. Draw a graph of Wear (μm) Vs Load (N).

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Experiment 14:

NON – DESTRUCTIVE TESTING

A *non- destructive* test is an examination of a component in any manner which will not impair its future use. These tests are conducted on various castings and welded joints, to find the defects inside the castings and the welded joints, without breaking them. Defects like hair – line crack, sub – surface defect, flaws, internal blow holes etc., can be determined using these techniques. Some of the non-destructive testing techniques available are:

- Magnetic Particle Inspection.
- Liquid (Dye) Penetrant Test. Etc.,
- Ultrasonic Inspection.

Magnetic Particle inspection:

Principle of Operation:

When a piece of metal is placed in a magnetic field and the lines of magnetic flux get intersected by a discontinuity, such as a crack or slag inclusion in a casting, magnetic poles are induced on either side of the discontinuity. A surface crack is indicated by a line of fine particles following the crack outline and a subsurface defect by a fuzzy collection of the magnetic particles on the surface near the discontinuity.

Technique:

Procedural steps involved are:

- Magnetizing the component part.
- Applying magnetic particles on the component part.
- Locating the defects.

Advantages:

- ✓ Magnetic particle inspection is a relatively simple and easy technique.
- ✓ It is almost free from any restriction as to size, shape, composition and heat-treatment of a ferromagnetic specimen.

Limitations:

- ✘ Suitable only for testing magnetic materials.
- ✘ Deeper subsurface defects are not satisfactorily detected by this method of testing.

Liquid (Dye) Penetrate Test:

Principle of Operation:

- The principle of liquid penetrate test is that the liquid used enter the small openings such as cracks or porosities by *Capillary* action. The rate and extent of this action are dependent upon such properties as surface tension, cohesion, adhesion and viscosity.
- For the liquid to penetrate effectively, the surface of the material must be thoroughly cleaned of all material that would obstruct the entrance of the liquid into the defect.
- After cleaning, the liquid penetrant is applied evenly over the surface and allowed to remain long enough to permit penetration into possible discontinuities.
- The liquid is then completely removed from the surface and either a wet or dry *developer* is applied. The liquid that has penetrated the defect will bleed out onto the surface, and the developer will help delineate them.
- This will show the location and general nature and magnitude of any defect present.

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TYPICAL VIVA QUESTION WITH ANSWERS

Define :

1) Homogeneity: Material should be of same type and uniformly distributed through out the body.
2) Arthotropy: Materials have different properties in different directions, e.g. orthotropic Plates.
3) Isotropy: Properties is same or identical at all points in the body of the material.
4) Anisotropy: Properties will not be identical at all points in the body of the material.
5) Elasticity: It is the property by which the deformations caused in a body by external force disappears on removal of the forces. The resulting forces are with in the elastic limit. It is determined from the tension test in graph.

6) Plasticity: It is the property by which the deformation caused in a body by external forces do not disappear on removal of forces. We say there is permanent set in material. In a tension test, the material enters the plastic region after the elastic region is passed .

7) Ductility: Property by with the materials can be drawn into thin wires. The percentage elongation or contraction gives a measure of Ductility. In this case, large deformations occur before rupture.

8) Brittleness: If the Fracture in a material occurs when the stress exceeds the elastic limit. Tendency to break under Impact loads. It is opposite to ductility.

9) Tenacity: The property of a material to resist tension or tensile stress is called Tenacity.
10) Malleability: It is the property by which the material can be beaten into sheets. E.g. Gold. Gold is the most malleable metal.

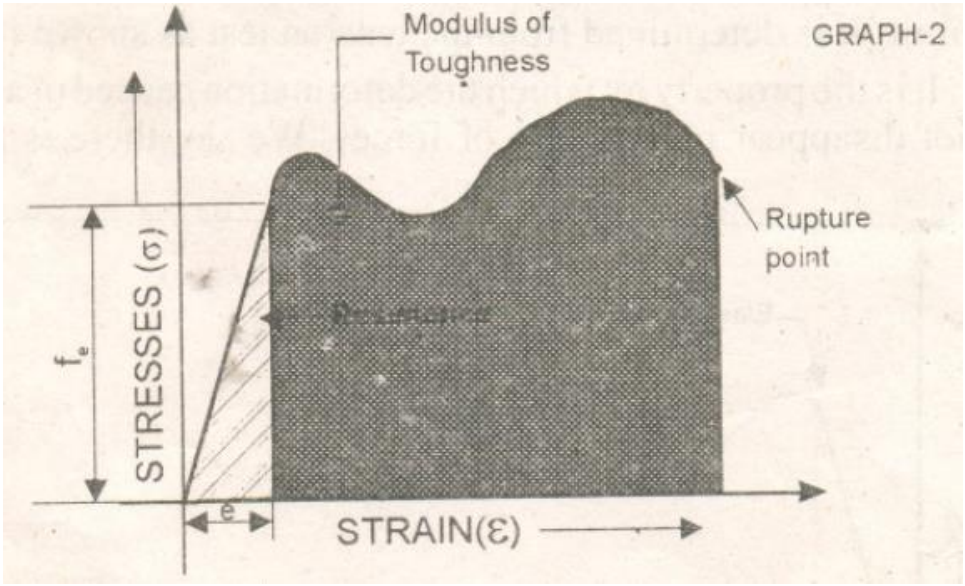
11) Rigidity: Sometimes, some materials are rigid against shear deformation. i e. they resist the deformations caused due to shear. Such property of the materials is termed as rigidity.

12) Toughness: The property of a material to-resist fracture under suddenly applied loads is termed as Toughness. To some extent, toughness is related to impact resistance.

13) Modulus of Toughness: It is the work-done on the body in loading up to rupture point per unit volume or it is the area enclosed between stress-strain diagram up to rupture point (see. Graph 2)

14) Resilience: It is the work done on the body in loading it up to elastic limit per unit volume or it is the strain energy stored at elastic limit per unit volume. It is given by the area of the stress- strain diagram upto elastic limit (ref Graph 2). It is also termed as "Modulus of Resilience".

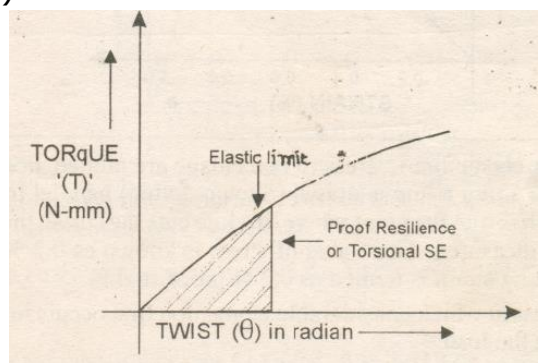
Modulus of resilience = shaded area in graph 2.



$$= \frac{1}{2} Fe.e = \frac{1}{2} Fe \frac{Fe}{E} \qquad E = \frac{Stress}{strain} = \frac{Fe}{e}$$

$$= \frac{fc^2}{2E} \qquad \text{or} \qquad e = \frac{fc}{E}$$

15) Proof resilience or Torsional strain energy: It is the torsional S.E stored at elastic limit per unit volume It is given by the area of the torque-twist diagram up to elastic limit. (Approximately, the triangular area as shown in the figure).



It is equal to = ½ TΘ where T is the torque in N. m upto elastic limit and Θ is the angle of twist in radians.

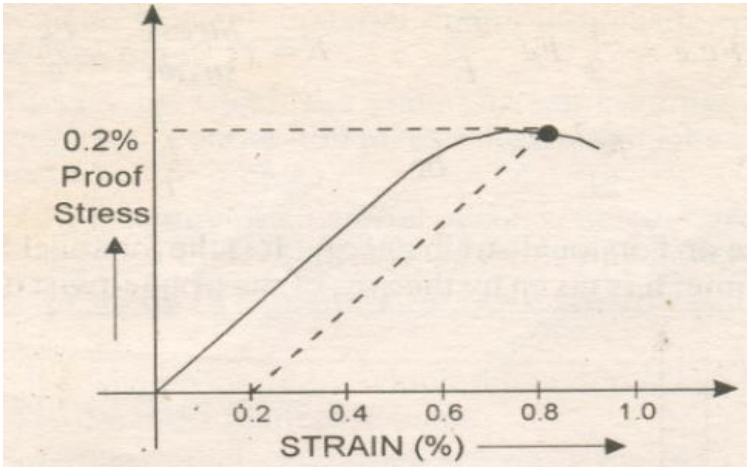
16) Stress: When a material is subjected to the

action of forces, it develops internal resistance; this Resistance *Per* unit area is called the stress.

Stress= $\frac{\text{Load}}{\text{Area}}$ N/mm^2

17) Strain: It is defined as ratio of change in length to original length.

Strain= $\frac{\text{Change in dimension}}{\text{Original dimension}}$ (Unit: Dimensionless.)



18) Proof Stress: It is the stress at which if the material is unloaded, there will be specified percentage of strain permanently left in it. When a stress-strain curve for a brittle material subjected to tension is drawn, it indicates from a graph that for such a material there is no definite yield point. Then to locate the approximate position of yield or elastic limit, stress in-percentage is plotted along y-axis and x-axis. From 0.2 % strain a line is drawn (Shown dotted) parallel to the straight line portion of graph. From the point where this line cuts the curve, the corresponding stress value is measured. This value of stress is known as 0.2 % proof stress and the corresponding strain is termed as .0.2 % proof strain.

19) Yield stress: Stress at which considerable elongation first occurs in the test piece without increase in the load. Unit: same as in stress.

20) Ultimate stress: (or Tensile Strength): The maximum load reached in a tension test divided by the original area of cross-section. This is also termed as maximum stress.

21) Direct stress: The resistance developed in a material due to the action of direct load or axial load passing through the centroidal axis of the section- is termed as direct stress.

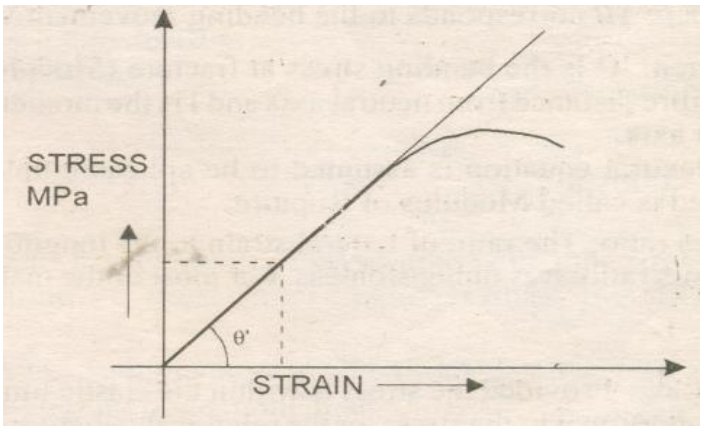
22) Shear stress: The stress caused by forces which act parallel to an area of cross section and tends to produce sliding of one portion past another is termed as shear stress.

23) Bending stress: It is the stress due to the applied external bending moment on the structure.

24) Principal stress: The maximum and minimum direct or the normal stress acting in a body without shear stresses are termed as principal stresses. This can be determined either analytically or graphically (by Mohr's graphical method).

25) Young's Modulus of Elasticity: It is defined as the ratio of linear stress to the linear strain or the Ratio of normal stress to the axial strain, within elastic limit. (From graph) The Young's Modulus is calculated by taking the corresponding value of stress and strain at elastic limit from the stress- strain graph. (Unit N/mm^2)

26) Tangent Modulus / Secant Modulus: It is the slope of the stress / strain diagram



at any specified point. This is used where the stress-strain diagram is not a straight line even in the initial stage. Slope of the tangent (tan Θ) = Stress/strain at any specified point. This is named as tangent modulus.

The slope of the line joining the origin of co-ordinate axis to any point on curve (p) in a load deformation curve in a compression test is called secant Modulus.

27) Modulus of Rigidity: It is defined as the ratio of shearing stress to the shearing strain. Unit is N/mm^2

28) Modulus of Rupture: It is the value of bending stress computed from the formula corresponds to the bending movement which causes fracture of the specimen.

29) Poisson's ratio: The ratio of Lateral strain to the longitudinal strain is termed as the Poisson’s ratio. It is dimensionless. For most of the materials Poisson's ratio is 0.3

30) Hooke's Law: within the elastic limit, the stress is directly proportional to the strain up to elastic limit.

31) Stiffness: The term stiffness is an indication of deformation of the body under load (load per unit deformation). It is measured by the ratio of stress & strain. If the stress is directly proportional to the strain, the stiffness is constant.

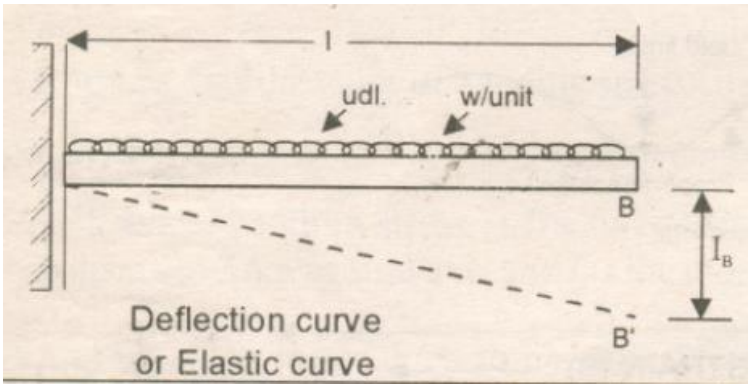
32) Stress Hardening: When a material is subjected to repeated cycle of stresses below fatigue limit it will exhibit higher static strength than when it is subsequently subjected to static tests. This is termed as stress hardening.

33) Strain Hardening: It is a phenomenon in which the mechanical properties of a material suddenly changes when the material changes from elastic to in-elastic range.

34) Elasticity constants: They are the properties of materials such as Young's Modulus, Rigidity modulus, Bulk Modulus and Poisson's Ratio.

35) Bulk modulus (K): It is the ratio of identical pressure acting in three mutually perpendicular directions to corresponding volumetric strain.

36) Deflection: A beam when loaded gets deflected. The axis of the loaded beam bends in a curve known as the elastic curve or deflection curve. The deflection at any point on the axis of the beam is the vertical distance between its position before the load and after loading.



37) Strength: It is the maximum resistance of a material to type of loading. E.g. Flexural strength, compression strength, impact strength etc.

38) What is the usual range of carbon content in cast iron, wrought iron and Mild steel?

What is its effect on yield and weight strengths?

In M.S. carbon content is 0.3 %

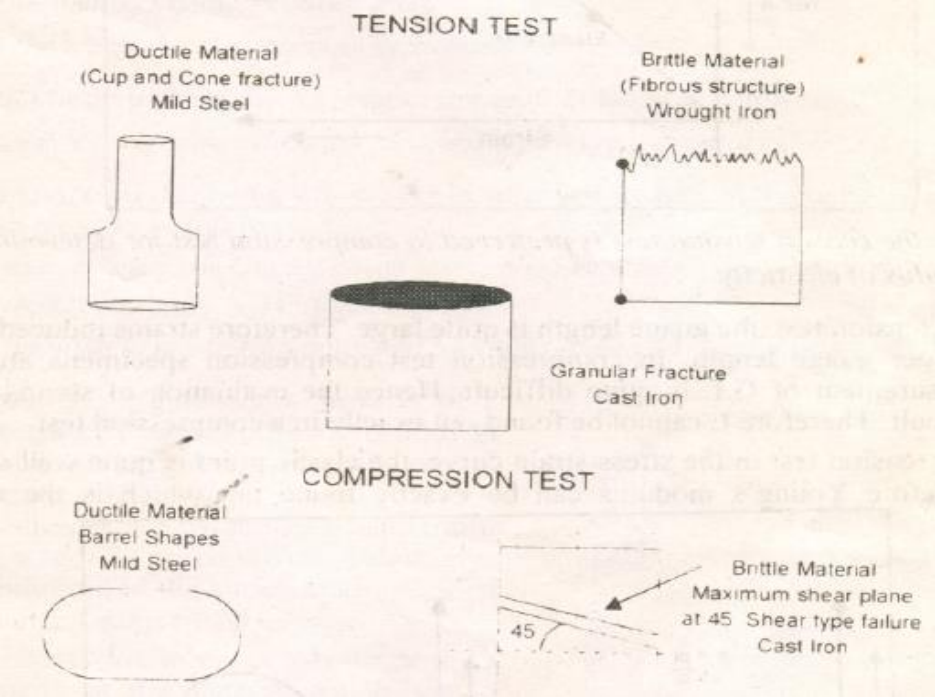
In C.I - 0.25 to 0.8 %

In W.I -0.2%

Effect of carbon content op yield and weight strengths:

As the carbon content increases, the material becomes brittle.

39) Sketch the typical failures in a tension & compression test on a ductile material and brittle material.



40) State the reason tension test is preferred to compression test for determining the modulus of elasticity.

1. In tension test, the gauge length is quite large. Therefore strains induced are over a larger gauge length. In compression test compression specimens are short. Measurement of G.L is quite difficult. Hence the evaluation of strains is also difficult. Therefore E cannot be found out exactly in a compression test.

2. In tension test in the stress-strain curve, the elastic point is quite well defined. Therefore Young's modulus can be exactly found out which is the ratio of stress-strain up to elastic limit. In compression test, the elastic limit is not well defined, as seen from graph of stress vs. strain *for* a material subjected to compression. Therefore evaluation of E is not accurate in a compression test as in a tension test.

41) What is Static loading and Dynamic loading as applied to hardness test?

Static loading: They are the normally applied loads. They are the standardized loads for the Particular type of specimen. The loads are applied gradually, the initial load being applied first And then the total load is finally being applied.

Dynamic loading: Application of suddenly applied loads on the surface of specimen to determine the hardness of metals is called dynamic loading.

42) *Very hard materials cannot be tested in Brinell Hardness testing machine. State the reason.*

For very hard materials like case hardened steel, spring steel, etc., the indentation made on the specimen in B.H. test is very small, because the standard ball diameter is small equal to 2.5mm and intensity of load applied is very small. As the B.H. number is a function of the spherical area of indentation and load, if the indentation area is small, it greatly affects the hardness value of the material. Hence, for very hard material B.H. test is not suitable.

43) *What is the purpose of applying the minor load in case of Rockwell Hardness test?*

We should have a datum load (or a reference load) before applying the major load on the surface of specimen so that a proper and clear indentation is made on the surface of specimen. The datum or the reference load that is applied on specimen is called the minor load which is normally 10 Kg in Rockwell Hardness test. After the application of minor load the total major load is applied on the specimen.

44) *What physical property is determined from impact test? What is its significance?*

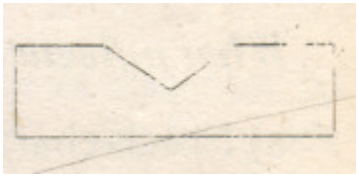
The physical property determined from impact test is the resistance of a material due to suddenly applied loads or prepared clutches. Ex. Helipad, i.e. a helicopter landing suddenly on the Landing pad causing sudden impact, impact of a drop hammer, etc.,

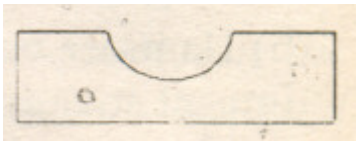
45) *What are the types of impact tests?*

Two types:

a)Izod impact test: Specimen is placed as a cantilever. The type of notch will be 'V' type. The notch is facing the direction of striker of hammer.

b) Charpy Impact test Specimen is placed as a simply supported beam. The type of notch is 'U' type. The notch will be facing on the opposite direction of striker of hammer.





46) *What is meant by Notch Sensitivity? Or what is the effect of notching on test specimens.*

In order to induce a fracture to occur in a ductile material under a single blow in a impact test, the specimen is generally notched. The use of notch tends to reduce the ductility causing a brittle type of fracture or the tendency of a ductile material to act like a brittle material, when broken in the form of a notched specimen is called Notch Sensitivity.

Viva questions on MT lab

Tensile test:

1. Differentiate between Engineering Stress/Strain and True Stress/Strain.
2. What is meant by Plastic & Elastic Deformation?
3. Define Upper Yield Point; Lower Yield Point; Ultimate Strength; Fracture Strength.
4. What is meant by Gauge Length?
5. What are the various types of fractures?
6. Differentiate between Brittleness and ductility?
7. Define the term Malleability?
8. What is Strain hardening?
9. How the microstructural defect like slip effects the deformation?

Compressive strength test:

1. Differentiate between Compressive strength and tensile strength.
2. Describe the fracture mechanism of a material under compressive loading.
3. Theoretically compressive strength should be same as the tensile strength of a material, but practically it is not. Why?
4. What is anisotropy? How does it effect the mechanical properties?

Modulus of rigidity:

1. What is meant by modulus of rigidity?
2. Define torsion strength.
3. What are the factors which may affect the angle of twist?
4. What will be the effect on strength if a solid circular shaft is replaced by a hallow shaft of same dimension.
5. What is meant by strain energy? Give its expression in torsion for solid and hollow circular shaft.
6. What is Poisson's Ratio?

Impact test:

1. What is meant by toughness?
2. What is the purpose of V-notch in impact testing and what is its dimension?
3. What is resilience?
4. How does tempering changes the toughness of a material?
5. Define Notch Impact Strength & Modulus of Rupture.
6. Differentiate between Izod & Charpy impact testing techniques?

Young's modulus:

1. What is Young's Modulus?
2. What is meant by Moment of Inertia?
3. How to find out the least count of vernier caliper.
4. What is the effect of temperature on Young's Modulus?
5. How will you define a 'beam'?
6. What is the difference between a simple supported beam & cantilever beam?
7. What is the formula used to calculate the Moment of Inertia of a Square section beam; Rectangular section beam and a circular beam about the axis.
8. What is meant by Polar Moment of Inertia & how is it calculated?
9. Derive the relationship between Young's Modulus, Modulus of Rigidity & Bulk Modulus.
10. Describe different types of loads on beam with the help of sketches

Heat Treatment:

1. What is meant by heat treatment?
2. What are the different types of heat treatment?
3. Enumerate the need for heat treatment of steel?
4. List different types of hardness testing methods?
5. What is meant by BHN?
6. Differentiate between hardenability and hardness?
7. What are the different types of indenters used in hardness testing?
8. What are the factors which effect the hardness of steels?
9. Why is the minor load applied before applying the major load?
10. Derive the formula to calculate BHN.

Microstructures:

1. Why the microstructures of metals are different from each other?
2. What are the effects of microstructure of steel and CI on their mechanical properties?
3. In which way is the microstructure of copper different from the microstructure of brass?
4. Define Pearlite, Austenite, Ferrite, Cementite, Martensite, Bainite, and Ledeburite.
5. What is the purpose of alloying? Describe few alloys of Copper and Aluminium.
6. How are steels classified based on their alloying (carbon) content?

7. What is Cast Iron? What are its types?
8. What are stainless steels? Give its composition.
9. Discuss in brief, the steel manufacturing process.
10. Discuss the properties and manufacturing process of the following: Composites; Ceramics; Plastics and Glass.
11. What are the specifications of grinding and polishing machines?
12. What is lapping? Which degree of accuracy can be achieved in metals by polishing?
13. Why is grinding performed before polishing?
14. What is the need of polishing on four grades of emery paper?
15. Why is the specimen rotated by 90°, while changing from one grade of emery paper to another?
16. Why is dry polishing done before wet polishing?
17. What is the purpose of wet polishing after dry polishing?
18. Why is alumina powder used in wet polishing?
19. What is the purpose of etching?
20. Which etchant is used for etching MS; aluminium; copper?
21. What is the principle of working of metallurgical microscope?