MECHANICS OF MATERIALS AND SOLIDS
LAB MANUAL

DEPARTMENT OF CIVIL ENGINEERING

CENTRAL UNIVERSITY OF JHARKHAND

LIST OF EXPERIMENTS

EXPERIMENT No. 01

TENSION TEST

AIM: Determine tensile Strength of a given specimen using UTM.

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

(i) Limit of proportionality
(ii) Elastic limit
(iii) Yield strength
(iv) Ultimate strength
(v) Young's modulus of elasticity
(vi) Percentage elongation
(vii) Percentage reduction in area.

APPARATUS:

(i) Universal Testing Machine (UTM)
(ii) Mild steel specimens
(iii) Graph paper
(iv) Scale
(v) Vernier Caliper

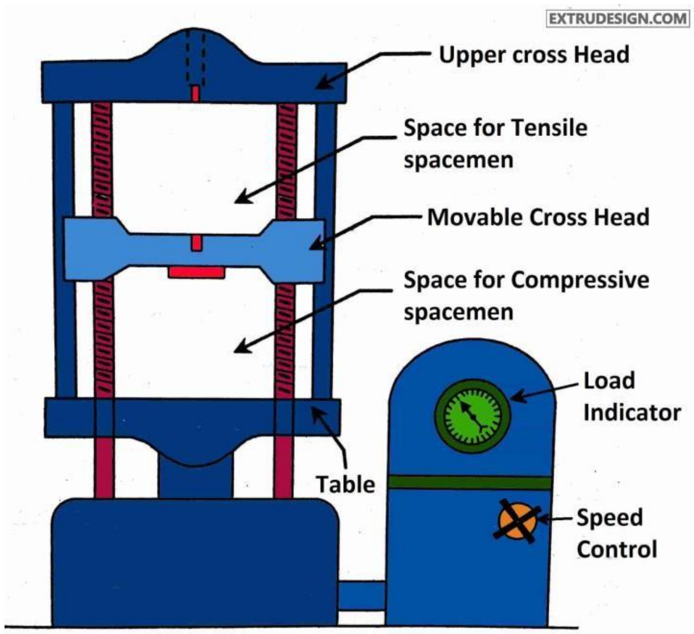
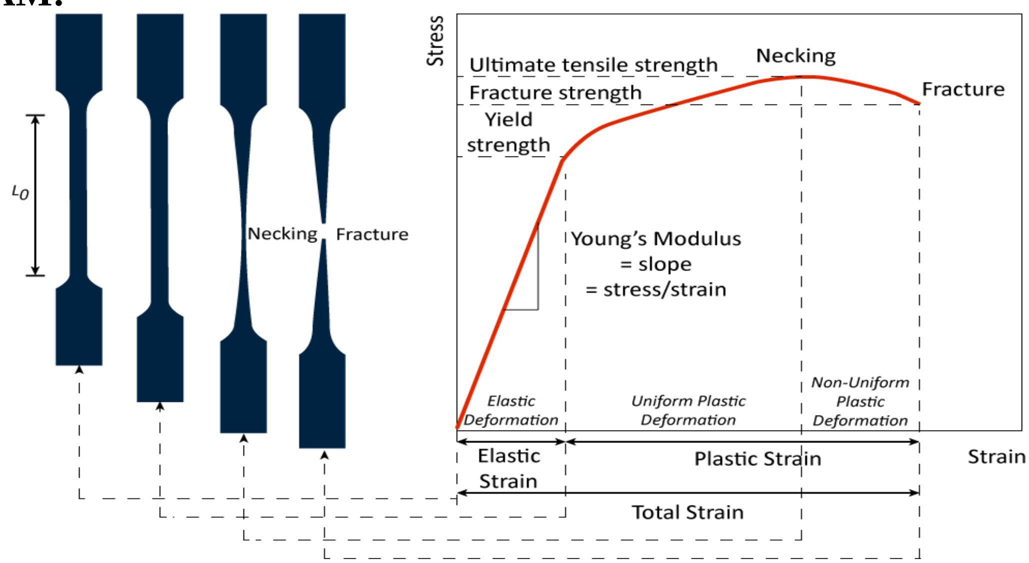


DIAGRAM:



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.

About of UTM The tensile test is conducted on UTM. It is hydraulically operates a pump, oil in oil sump, load dial indicator and central buttons. The left has upper, middle and lower cross heads i.e; specimen grips (or jaws). Idle cross head can be moved up and down for adjustment. The pipes connecting the lift and right parts are oil pipes through which the pumped oil under pressure flows on left parts to more the cross-heads.

SPECIFICATIONS:

1. Load capacity
2. Least count
3. Overall dimension.
4. Power supply

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.

OBSEVATION:

(a) Initial diameter of specimen d1 =

(b) Initial gauge length of specimen L1 =

(c) Initial cross-section area of specimen A1 =

(d) Load of yield point F_t =

(e) Ultimate load after specimen breaking F =

(f) Final length after specimen breaking L_2 =

(g) Diameter of specimen at breaking place d2 =Cross section area at breaking place A2 =

OBESERVATION TABLE:

S.No	Load (N)	Original Gauge Length	Extension (mm)	Stress (N/mm2)	Strain

PRECAUTIONS:

1. The specimen should be prepared in proper dimensions.

2. The specimen should be properly to get between the jaws.

3. Take reading carefully.

4. After breaking specimen stop to m/c.

RESULT:

(i) Average Breaking Stress =

(ii) Ultimate Stress =

(iii) Average % Elongation =

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EXPERIMENT No. 2

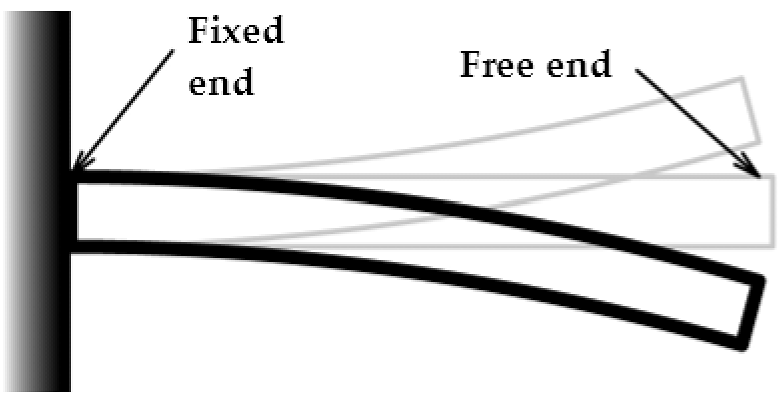
DEFLECTION TEST ON CANTILEVER BEAM

AIM: Determine the deflection and bending stress of cantilever beam.

APPARATUS:

Beam apparatus, Bending fixture, vernier caliper, meter rod, test piece & dial gauge.

DIAGRAM:



THEORY:

A Cantilever is a Beam one end of which is clamped and other end is free. A beam with a length Land is fixed at one end and the other end is free. Let the moment of inertia of the Beam is 'I' aboutits neutral axis and the Young's Modulus be 'E'.

Moment of inertia about the neutral axis

$$I = bh^3/12$$

Deflection at the end where point load is acting = δ

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

$$\delta = WL^3/3EI$$

PROCEDURE:

1. Clamp the Beam horizontally on the clamping support at one end.

2. Measure the length of cantilever L (distance from clamp end to loading point)

3. Fix the dial gauge under the beam at the loading point to Read down-ward Moment and seto zero.

4. Hang the loading Pan at the free end of the cantilever.

5. Load the cantilever with different loads (W) and note the dial gauge readings (δ)

6. Change the length of cantilever for two more different lengths repeat the Experiment.

7. Change the position of cantilever and repeat he experiment for the other value of I forrectangular cross-section.

TABLE:

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

CALCULATIONS:

1. I= $bh^3/12$

2. δ= $Wl^3/3EI$

PRECAUTIONS:

1. The length of the cantilever should be measured properly.

2. The dial gauge spindle knob should always touch the beam at the bottom of loading point.

3. Loading hanger should be placed at known distance of cantilever length.

4. Al the errors should be eliminated while taking readings.

5. Elastic limit of the Beam should not exceed.

6. Beam should be positioned horizontally.

RESULT: The Bending strength of given specimen ___

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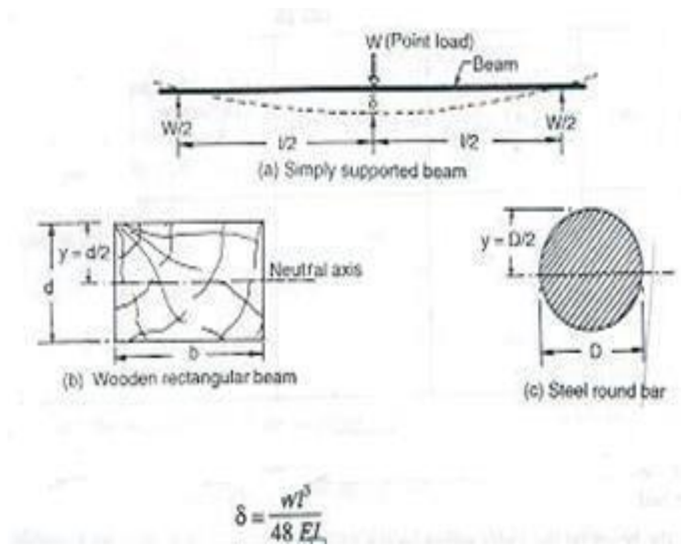
EXPERIMENT No. 3

DEFLECTION TEST ON SIMPLY SUPPORTED BEAM

AIM: Determine the deflection and bending stress of simply supported subjected to concentrated load at the center.

APPARATUS:

Beam apparatus, Bending fixture, vernier caliper, meter rod, test piece & dial gauge.



DIAGRAM

THEORY:

Bending test is performing on beam by using the three point loading system. The bending fixture is supported on the platform of hydraulic cylinder of the UTM. The loading is held in the middle cross head. At a particular load the deflection at the center of the beam is determined by using a dial gauge. The deflection at the beam center is given by:

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

PROCEDURE:

1. Measure the length, width and thickness of test piece, by vernier caliper.
2. Place the bending fixture on the lower cross head of the testing machine.
3. Place the test piece on the rollers of the bending fixture.

4. By loading the dial gauge in a stand, make its spindle knob the test piece.Start the m/c and note down the load and dial gauge readings.

5. Plot the graph between load and deflection.

OBSERVATIONS:

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

TABLE:

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

CALCULATIONS:

1. $I = \frac{b\,t^3}{12}$

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

PRECAUTIONS:

1. The length of the simply supported should be measured properly.
2. The dial gauge spindle knob should always touch the beam at the bottom of loading point.
3. Loading hanger should be placed at known distance
4. Al the errors should be eliminated while taking readings.
5. Beam should be positioned horizontally.

RESULT:

The Bending strength of given specimen ____

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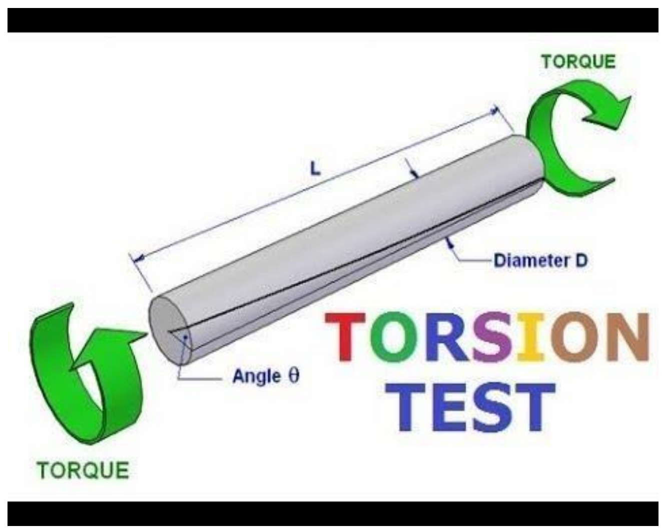
EXPERIMENT No. 4
TORSION TEST

AIM: To conduct torsion test on mild steel specimen to find modulus of rigidity or tofind angle of twist of the materials.

APPARATUS:

1. A torsion test machine along with angle of twist measuring attachment.
2. Standard specimen of mild steel or cast iron.
3. Steel rule.
4. Vernnier caliper or a micrometer.

DIAGRAM:



THEORY:

For transmitting power through a rotating shaft it is necessary to apply a turning force. The force isapplied tangentially and in the plane of transverse cross section. The torque or twisting moment may be calculated by multiplying two opposite turning moments. It is said to be in pure torsion andit will exhibit the tendency of shearing off at every cross section which is perpendicular to the longitudinal axis.

Torsion equation:

$$\frac{T}{Ip} = \frac{C\theta}{L} = \frac{r}{R}$$

T= maximum twisting torque (N mm)

Ip= Polar moment of inertia (mm^4)

τ = shear stress N/mm^2

C = modulus of rigidity N/mm^2

Θ = angle of twist in radians

L = length of shaft under torsion (mm)

PROCEDURE:

1. Select the suitable grips to suit the size of the specimen and clamp it in the machine byAdjusting sliding jaw.
2. Measure the diameter at about the three places and take average value.
3. Choose the appropriate loading range depending upon specimen.
4. Set the maximum load pointer to zero
5. Carry out straining by rotating the hand wheel or by switching on the motor.
6. Load the members in suitable increments, observe and record strain reading.
7. Continue till failure of the specimen.
8. Calculate the modulus of rigidity C by using the torsion equation.
9. Plot the torque –twist graph (T vs θ)

OBSERVATIONS:

Gauge length L =

Polar moment of inertia I_p =

Modulus of rigidity C $= TL/I_p\theta$

TABLE:

S.No	Twisting MomentKgf-m	Twisting Moment N-mm	Angle of Twist (Degrees)	Twist (Radians)	Modulus ofrigidity (C)	Average C $\frac{N}{mm^2}$

RESULT:

The modulus of rigidity of the given test specimen material.

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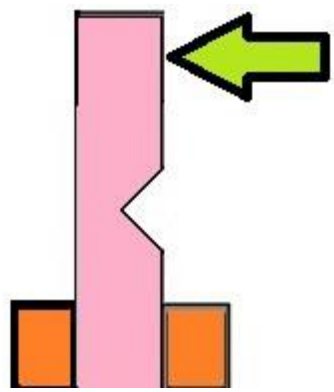
EXPERIMENT No. 5

IZOD IMPACT TEST

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

APARATUS: Impact testing machine, MS Specimen

DIAGRAM:



PROCEDURE:

1. For conducting charpy test, a proper striker is to be fitted firmly to the bottom of the hammer with the help of the clamming piece.

2. The latching take for charpy test is to be firmly fitted to the bearing housing at the side of the columns.

3. The frictional loss of the machine can be determined by free fall test, raise the hammer by hands and latch in release the hammer by operating lever the pointer willthen indicate the energy loss due to friction. From this reading confirm that the friction loss not exceeding 0.5% of the initial potential energy. Otherwise frictional loss has to be added to the final reading.

4. The specimen for izod test is firmly fitted in the specimen support with the help of clamping screw and élan key. Care should be taken that the notch on the specimen shouldface to pendulum striker.

5. After ascertaining that there is no person in the range of swinging pendulum, release them pendulum to smash the specimen.

6. Carefully operate the pendulum brake when returning after one swing to stop the oscillations.

7. Read-off position of reading pointer on dial and note indicated value.

8. Remove the broken specimen by loosening the clamping screw.

The notch impact strength depends largely on the shape of the specimen and the notch. the values determined with other specimens therefore may not be compared with each other.

TABLE:

S.NO	**Area of cross section specimen (A)**	**Impact Energy (K)**	**I (Impact strength)**

	Charpy Impact Testing	Izod Impact Testing
Materials Tested	Metals	Plastics & Metals
Types of Notches	U-notch and V-notch	V-notch only
Position of the Specimen	Horizontally, notch facing away from the pendulum	Vertically, notch facing toward the pendulum
Striking Point	Middle of the sample	Upper Tip of the sample
Common Specimen Dimensions	55 x 10 x 10 mm	64 x 12.7 x 3.2 mm (plastic) or 127 x 11.43 mm round bar (metal)
Common Specifications	ASTM E23, ISO 148, or EN 10045-1	ASTM D256, ASTM E23, and ISO 180

PRECAUTIONS:

1. Measure the dimensions of the specimen carefully.
2. Locate the specimen in such a way that the hammer. Strikes it at the middle.
3. Note down readings carefully.

RESULT:

The Impact strength of the given specimen

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EXPERIMENT No. 6

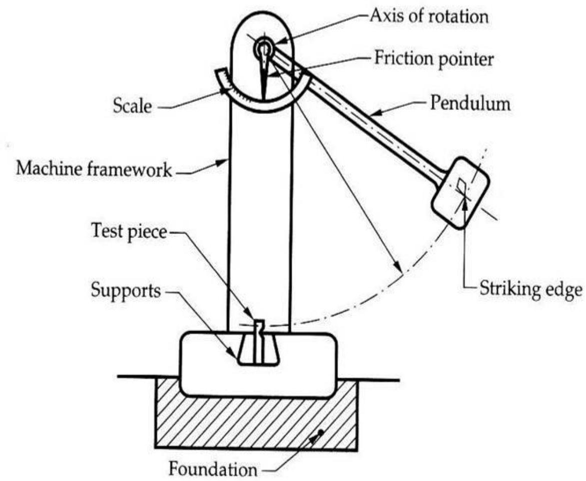
CHARPY IMPACT TEST ON METAL SPECIMEN

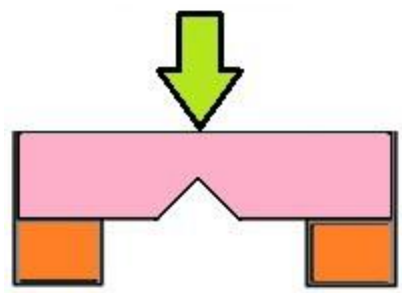
AIM: To perform the Charpy impact test on materials.

APPARATUS: Izod Impact test machine, test specimen, Vernier calipers, and steel rule.

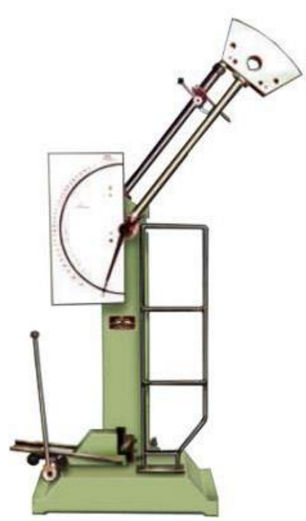
IMPACT STRENGTH: The resistance of a material to fracture under sudden loadApplication.

MATERIALS: Mild steel (Square test pieces)





(b) Charpy Test



THEORY:

An impact test signifies toughness of material that is ability of material to absorb energyduring plastic deformation. The type of test specimen used for this test is a Square Cross-section. The specimen may have single, two or three notches.

The testing machine should have the following specifications.

1. The angle 0 between top face of grips and face holding the specimen vertical=90^0 The angle of tip of hammer =$75^0 \pm 1^0$
2. The angle between normal to the specimen and underside face of the hammer atstriking point= $10^0 \pm 1^0$
3. Speed of hammer at impact=3.99 m/sec
4. Striking energy=168N-m or Joules
5. Angle of drop 0of pendulum =90
6. Effective weight of pendulum=21.79kg
7. Minimum value of scale graduation=2 Joules.
8. Permissible total friction loss of corresponding energy=0.50%
9. Distance from the axis of rotation of distance between the base of specimen notch and the point of specimen hit by the hammer=22mm±0.5mm

The longitudinal axes of the test piece shall lie in the plane of swingof the center of gravity of the hammer. The notch shall be positioned so that it is in the plane of the hammer .the notch shall be positioned its plane of symmetry coincides withthe top face of the grips .for setting the specimen the notch impact strength I iscalculated according to the following relation.

Where I= impact strength in joules/m^2

PROCEDURE:

1. For conducting charpy test, a proper striker is to be fitted firmly to the bottom of thehammer with the help of the clamming piece.
2. The latching take for charpy test is to be firmly fitted to the bearing housing at theside of the columns.
3. The frictional loss of the machine can be determined by free fall test, raise thehammer by hands and latch in release the hammer by operating lever the pointer will then indicate the energy loss due to friction. From this reading confirm that the friction loss not exceeding 0.5% of the initial potential energy. Otherwise frictional loss has to be added to the final reading.
4. The specimen for izod test is firmly fitted in the specimen support with the help of clamping screw and élan key. Care should be taken that the notch on the specimen shouldface to pendulum striker.
5. After ascertaining that there is no person in the range of swinging pendulum, release them pendulum to smash the specimen.
6. Carefully operate the pendulum brake when returning after one swing to stop the oscillations.
7. Read-off position of reading pointer on dial and note indicated value.
8. Remove the broken specimen by loosening the clamping screw.
9. The notch impact strength depends largely on the shape of the specimen and the notch. The values determined with other specimens therefore may not be compared witheach other.

TABLE:

S.NO	Area of cross section specimen (A)	Impact Energy (K)	I (Impact strength)

PRECAUTIONS:

1. Measure the dimensions of the specimen carefully.
2. Locate the specimen (Charpy test) in such a way that the hammer. Strikes it at the middle.
3. Note down readings carefully.

RESULT: The Impact strength of material by Charpy test

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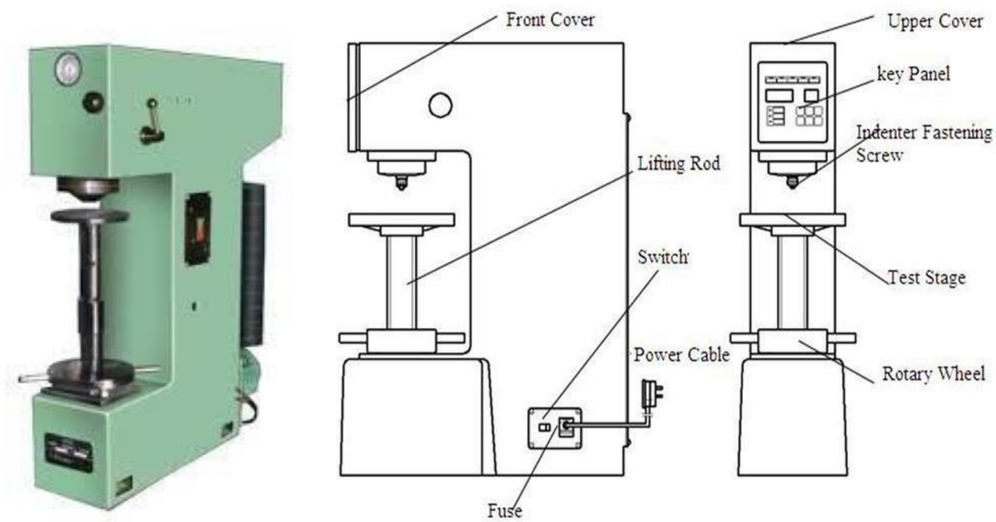
EXPERIMENT No. 07

BRINELL HARDNESS TEST

AIM: To determine the hardness of the given specimen using Brinell hardness test.

APPARATUS: Brinell hardness testing machine, Aluminum specimen, Ball indenter.

DIAGRAM:



THEORY:

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

Its specifications as follows:

1. Ability to determine hardness up to 500BHN.
2. Diameter of ball (as indenter) used D= 2.5mm, 5mm, 10mm.
3. Maximum application load= 3000kgf

.4. Method of load application= Lever type

5. Capability of testing the lower hardness range= 1BHNonapplicationof0.5D2load.

PROCEDURE:

1. Insert ball of diameter 'D' in the ball holder of machine.
2. Make the specimen surface clean by oil, grease, dust etc.
3. Make contact between the specimen surface and ball using jack adjusting wheel.
4. Push the required button for loading.
5. Pull the load release level and wait for 15 seconds.
6. Remove the specimen from the support table and locate the Indentation.
7. View the indentation through microscope and measure the diameter 'd' of the indentation usingmicrometer fixed on the microscope.
8. Repeat the procedure and take three readings.

OBSERVATIN:

Test piece material =

Diameter of the ball D =

Load section =

F/D^2 Test load =

Load application time =

Least count of Brinell Microscope =

S.NO	Ball Diameter D in mm	Load applied F in kgf		Diameter of indentation	$\frac{P}{D^2}$	

BHN= $\frac{\boldsymbol{Load\ Applied\ (kgf)}}{\boldsymbol{sperical\ surface\ area\ of\ indentation}}$

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

PRECAUTION:

1. Make sure that beam and load placed a proper position.
2. The cross- section of the beam should be large.
3. Note down the readings more carefully..

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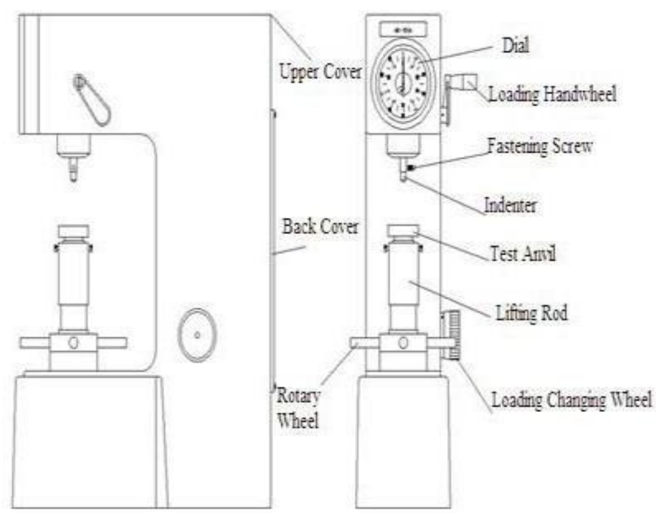
EXPERIMENT No. 08
ROCKWELL HARDNESS TESTER

AIM: To determine the hardness of the given Specimen using Rockwell hardness test.

APPARATUS: Rockwell hardness testing machine,

MATERIAL: soft and hard mild steel specimens, brass, Aluminum etc., Black diamond cone indenter.

DIAGRAM:



THEORY:

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. The test is subject of IS: 1586. The hardness of a material is resistance to penetration under a localized pressure or resistance to abrasion. Hardness tests provide an accurate, rapid and economical way of determining the resistance of materials to deformation.

There are three general types of hardness measurements depending upon the manner in which the test is conducted:

a. Scratch hardness measurement,

b. Rebound hardness measurement

c. Indention hardness measurement.

In scratch hardness method the material are rated on their ability to scratch one another and it is usually used by mineralogists only. In rebound hardness measurement, a standard body is usually dropped on to the material surface and the hardness is measured in terms of the height of its rebound .The general means of judging the hardness is measuring the resistance of a material to indentation. The indenters usually a ball cone or pyramid of a material much harder than that being used. Hardened steel, sintered tungsten carbide or diamond indenters are generally used in

PROCEDURE:

1. Examine hardness testing machine (fig.1)
2. Place the specimen on platform of a machine. Using the elevating screw raise the platform and bring the specimen just in contact with the ball. Apply an initial load until the small pointer shows red mark.
3. Release the operating valve to apply additional load. Immediately after the additional load applied, bring back operating valve to its position.
4. Read the position of the pointer on the C scale, which gives the hardness number.
5. Repeat the procedure five times on the specimen selecting different points for indentation.

OBSERVATION TABLE:

S.NO	**Specimens**	**Reading (HRC/)**			**Mean**	
		1	2	3		
1	Mild Steel				HRB =	
2	High Carbon steel				HRC =	
3	Brass				HRB =	

4	Aluminum				HRB =	

PRECAUTIONS:

1. The specimen should be clean properly
2. Take reading more carefully and
3. The test should not be made on specimens so thin that the impression shows through the metal,nor should impression be made too close to the edge of a specimen.

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