JIS COLLEGE OF ENGINEERING
DEPARTMENT OF MECHANICAL ENGINEERING
STRENGTH OF MATERIALS LAB
SUBJECT CODE: ME391

Experiment No.: 01

Title: Rockwell Hardness Test

Objective: To determine the Hardness of the given Specimen using Rockwell Hardness Test.

Materials and equipments required:

1. Rockwell Hardness Testing Machine.
2. Black Diamond Cone Indenter/ 1/16" Steel ball.
3. Hard Steel Specimen.

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.In this test indenter is forced into the surface of a test piece in two perations, 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 or 1/16" Steel ball.

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

Precautions:

1. Thickness of the specimen should not be less than 8 times the depth of indentation to avoid the deformation to be extended to the opposite surface of a specimen.

2. Indentation should not be made nearer to the edge of a specimen to avoid unnecessary concentration of stresses. In such case distance from the edge to the center of indentation should be greater than 2.5 times diameter of indentation.

3. Rapid rate of applying load should be avoided. Load applied on the ball may rise a little because of its sudden action. Also rapidly applied load will restrict plastic flow of a material, which produces effect on size of indentation.

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:

1. Take average of five values of indentation of each specimen. Obtain the hardness number from the dial of a machine.
2. Compare Brinell and Rockwell hardness tests obtained.

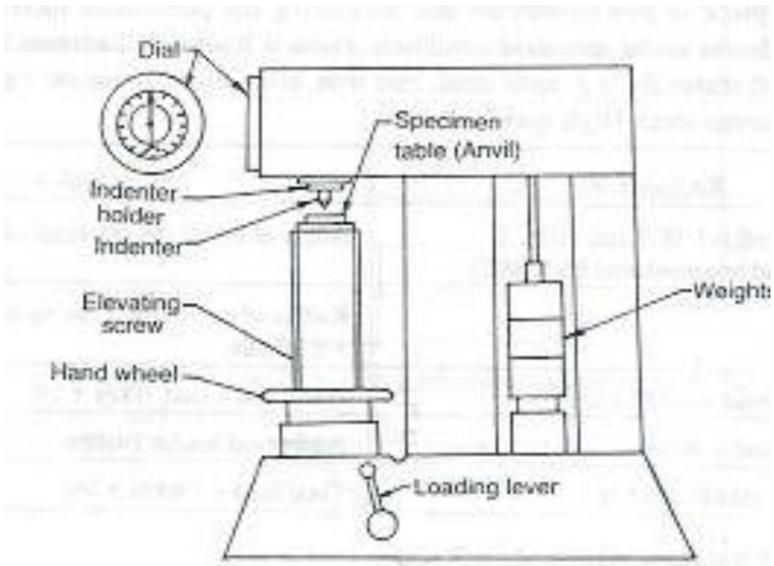

Fig. 1 Schematic diagram of Rockwell hardness test equipment

Observation Table:

Material	Type of Indenter	Rockwell Hardness Number		Average Rockwell Hardness Number
		1		
		2		
		3		
		4		
		5		

Result:

Rockwell Hardness(mean) of given specimen is …………………………..

Experiment No.: 02

Title: Brinell hardness test.

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

Materials and equipments required:

1. Brinell hardness Tester (Fig.2)
2. Brinell Microscope.
2. Specimen
3. Ball indenter (Dia = 5 mm.)

Precautions:

1. Thickness of the specimen should not be less than 8 times the depth of Indentation to avoid the deformation to be extended to the opposite surface of a specimen.

2. Indentation should not be made nearer to the edge of a specimen to avoid unnecessary concentration of stresses. In such case distance from the edge to the center of indentation should be greater than 2.5 times diameter of indentation.

3. Rapid rate of applying load should be avoided. Load applied on the ball may rise a little because of its sudden action. Also rapidly applied load will restrict plastic flow of a material, which produces effect on size of indentation.

4. Surface of the specimen is well polished, free from oxide scale and any foreign material.

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.

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_i) of indentation is measured after the removal of the load (F).

Observation

1. Take average of five values of indentation of each specimen. Obtain the hardness number from equation.

2. Compare Brinell and Rockwell hardness tests obtained.

Procedure:

1. Load to be applied for hardness test should be selected according to the expected hardness of the material. Ball diameter is taken as 10 or 5 mm.

2. Apply the load for a minimum of 15 seconds to 30 seconds. [If ferrous metals are to be tested time applied will be 15 seconds and for softer metal 30 seconds].

3. Remove the load and measure the diameter of indentation nearest to 0.02 mm using Brinell microscope (projected image)

4. CalculateBrinell hardness number (HB). As per IS: 1500.

5. Brinell hardness number is

$$\mathbf{HB = 2F/ (3.14D*(D-(D^2 - D_i^2)^{1/2}))} \ldots\ldots\ldots\ldots \quad (1)$$

Where

F- Applied load, kg
D – Indenter diameter, mm
D_i – Indentation diameter, mm.

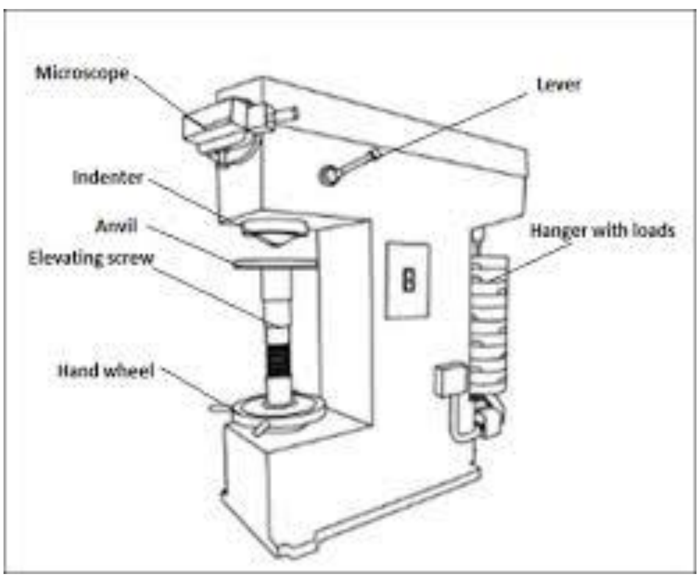

Fig. 2 Schematic diagram of Hardness test equipment

Observation Table:

Material	Diameter of Indenter, D	Applied Load, F	Diameter of Indentation, d		Average Diameter of Indentation	Average Brinell Hardness Number
	mm	kg_f		mm	mm	BHN
			1			
			2			
			3			
			4			
			5			

Result:

Brinell hardness (mean) of given specimen is …………………………..

Model Calculation: ………………

Applications

Because of the wide test force range the Brinell test can be used on almost any metallic material. The part size is only limited by the testing instrument's capacity.

Strengths

1. One scale covers the entire hardness range, although comparable results can only be obtained if the ball size and test force relationship is the same.

2. A wide range of test forces and ball sizes to suit every application.

3. “Nondestructive”, sample can normally be reused.

Weaknesses

1. The main drawback of the Brinell test is the need to optically measure the indent size. This requires that the test point be finished well enough to make an accurate measurement.

2. Slow, Testing can take 30 seconds not counting the sample preparation time.

Experiment No.: 03

Title: Izod Impact test

Aim: To determine the Impact toughness (strain energy) through Izod test

Theory:

In a 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 W (hammer) from a height h. Release of the weight from the height h swings the weight through the arc of a circle, which strikes the specimen to fracture at the notch (fig. 3) Kinetic energy of the hammer at the time of impact is $mv^2/2$, which is equal to the relative potential energy of the hammer before its release. (mgh),where m is the mass of the hammer and $v = \sqrt{2gh}$ is its tangential velocity at impact, g is gravitational acceleration (9.806 m/s^2) and h is the height through which hammer falls. Impact velocity will be 5.126 m/s or slightly less. 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. If the scale is calibrated in energy units, marks on the scale should be drawn keeping in view angle of fall () and angle of rise (. Height h_1 and h_2 equals,

h_1= R (1- cosθ) and h_2= (1- cosθ).

With the increase or decrease in values, gap between marks on scale showing energy also increase or decrease. This can be seen from the attached scale with any impact machine.

Energy used in fracturing the specimen can be obtained approximately as $Wh_1 - Wh_2$

This energy value called impact toughness or impact value, which will be measured, per unit area at the notch.

Izod introduced Izod test in 1903. Test is as per the IS: 1598

Specimen and equipment:

1. Impact testing machine (Fig.3)

2. Specimen and v notch is shown in the Fig. 4

Size of the specimen is 10mm X 10mm X 75mm

Mounting of the specimen:

Specimen is clamped to act as vertical cantilever with the notch on tension side.

Direction of blow of hammer is shown in Fig. 3. Direction of blow is shown in figure.

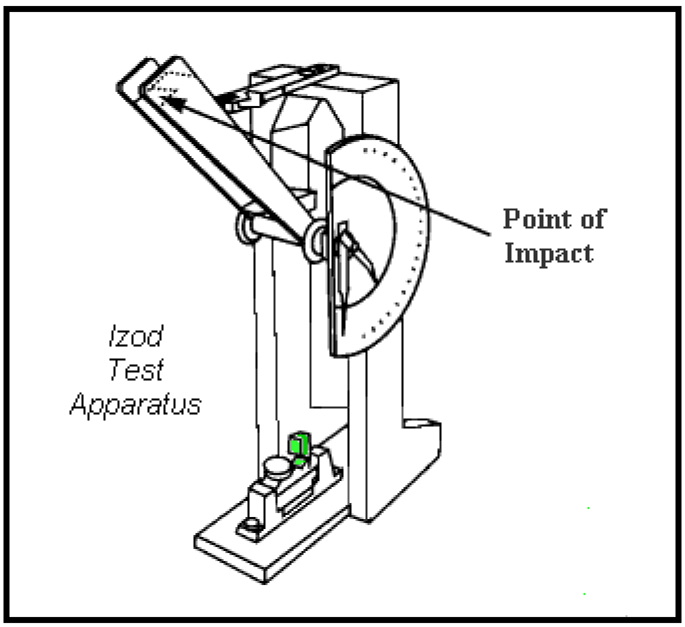

Fig. 3 Schematic diagram of Izod Impact Testing Machine

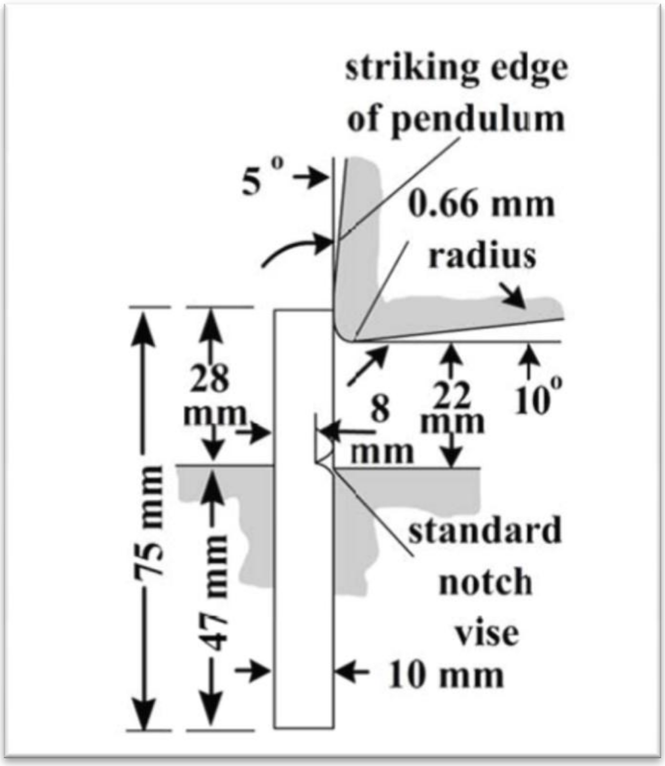

Fig. 4 Schematic diagram of Dimension and Job Position of Izod Specimen

Procedure:

1. Measure the dimensions of a specimen. Also, measure the dimensions of the notch.
2. Raise the hammer and note down initial reading from the dial, which will be energy to be used to fracture the specimen.
3. Place the specimen for test and see that it is placed center with respect to hammer. Check the position of notch.
4. Release the hammer and note the final reading. Difference between the initial and final reading will give the actual energy required to fracture the Specimen.
5. Repeat the test for specimens of other materials.
6. Compute the energy of rupture of each specimen.

Observation Table:

Sl. No	Izod Valve	Average Izod Value
1.		
2.		
3.		

Result:

Strain energy of given specimen is **……………N/mm^2** in Izod impact test.

Experiment No.: 04

Title: Charpy Impact test

Aim: To determine the Impact toughness (strain energy) through Charpy test.

Theory:

In a 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 W (hammer) from a height h. Release of the weight from the height h swings the weight through the arc of a circle, which strikes the specimen to fracture at the notch (fig. 3) Kinetic energy of the hammer at the time of impact is $mv^2/2$, which is equal to the relative potential energy of the hammer before its release. (mgh),where m is the mass of the hammer and $v = \sqrt{2gh}$ is its tangential velocity at impact, g is gravitational acceleration (9.806 m/s^2) and h is the height through which hammer falls. Impact velocity will be 5.126 m/s or slightly less. 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. If the scale is calibrated in energy units, marks on the scale should be drawn keeping in view angle of fall () and angle of rise (. Height h_1 and h_2 equals,

h_1= R (1- cosθ) and h_2= (1- cosθ).

With the increase or decrease in values, gap between marks on scale showing energy also increase or decrease. This can be seen from the attached scale with any impact machine.

Energy used in fracturing the specimen can be obtained approximately as $Wh_1 - Wh_2$

This energy value called impact toughness or impact value, which will be measured, per unit area at the notch.

Charpy introduced Charpy test in 1909. Test is as per the IS: 1499.

Specimen and equipment:

1. Impact testing machine. (Fig.5)
2. U notch is cut across the middle of one face as shown in (fig.6).

Mounting of the specimen:

Specimen is clamped to act as horizontal simply supported beam with the notch is opposite side of pendulum impact

Direction of blow of hammer is shown in fig. (5). Direction of blow is shown in figure.

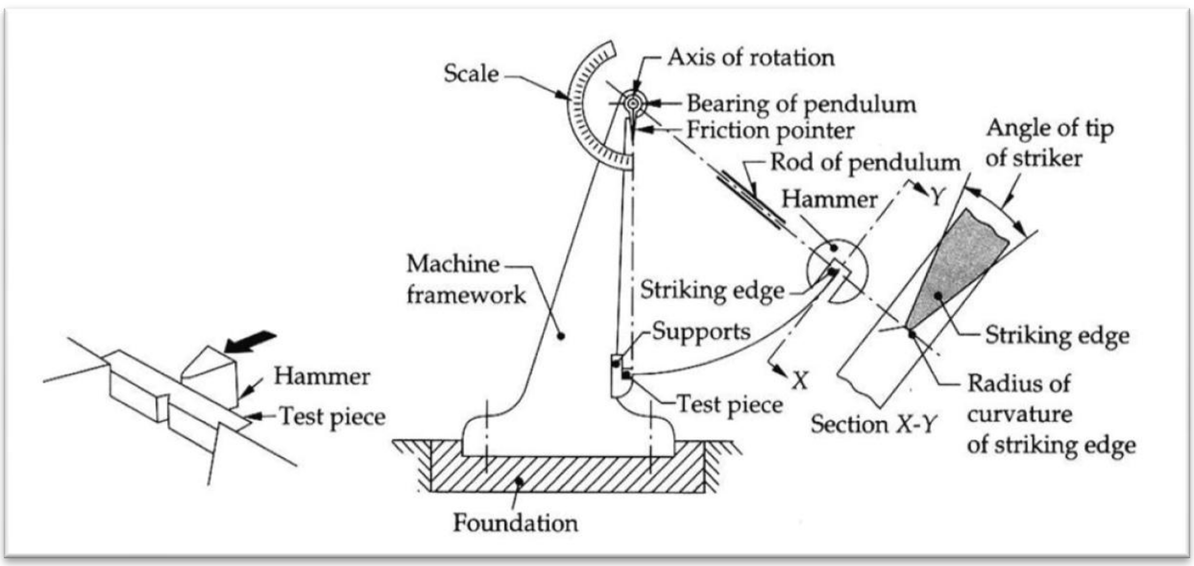

Fig. 5 Schematic diagram of Charpy Impact Testing Machine

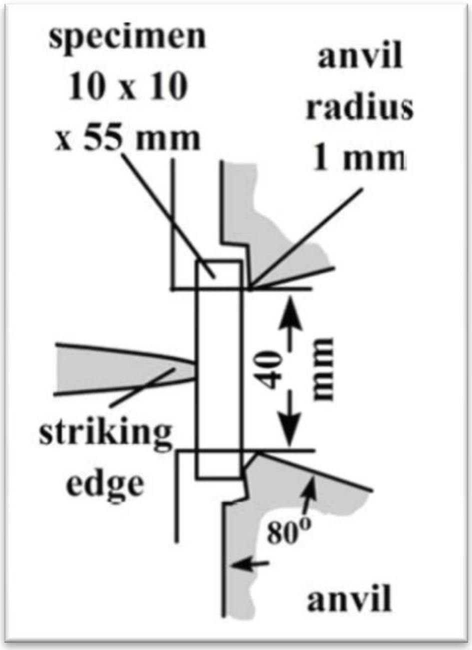

Fig. 6 Schematic diagram of Dimension and Job Position of Charpy specimen

Procedure:

1. Measure the dimensions of a specimen. Also, measure the dimensions of the notch.

2. Raise the hammer and note down initial reading from the dial, which will be energy to be used to fracture the specimen.

3. Place the specimen for test and see that it is placed center with respect to hammer. Check the position of notch.

4. Release the hammer and note the final reading. Difference between the initial and final reading will give the actual energy required to fracture the Specimen.

5. Repeat the test for specimens of other materials.

6. Compute the energy of rupture of each specimen.

Observation Table:

Sl. No	Charpy value	Average Charpy Value
1.		
2.		
3.		

Result:

Strain energy of given specimen is **……………N/mm^2** Charpy impact test.

	JIS COLLEGE OF ENGINEERING DEPARTMENT OF MECHANICAL ENGINEERING STRENGTH OF MATERIALS LAB **SUBJECT CODE: ME391**

Experiment No.: 05

Title: **Tension test**

Aim: To determine the tensile strength of a given specimen.

Specimen and equipments

1. Universal testing machine (Fig.7(a) & 7(b))
2. Specimen as shown in the (Fig.8)

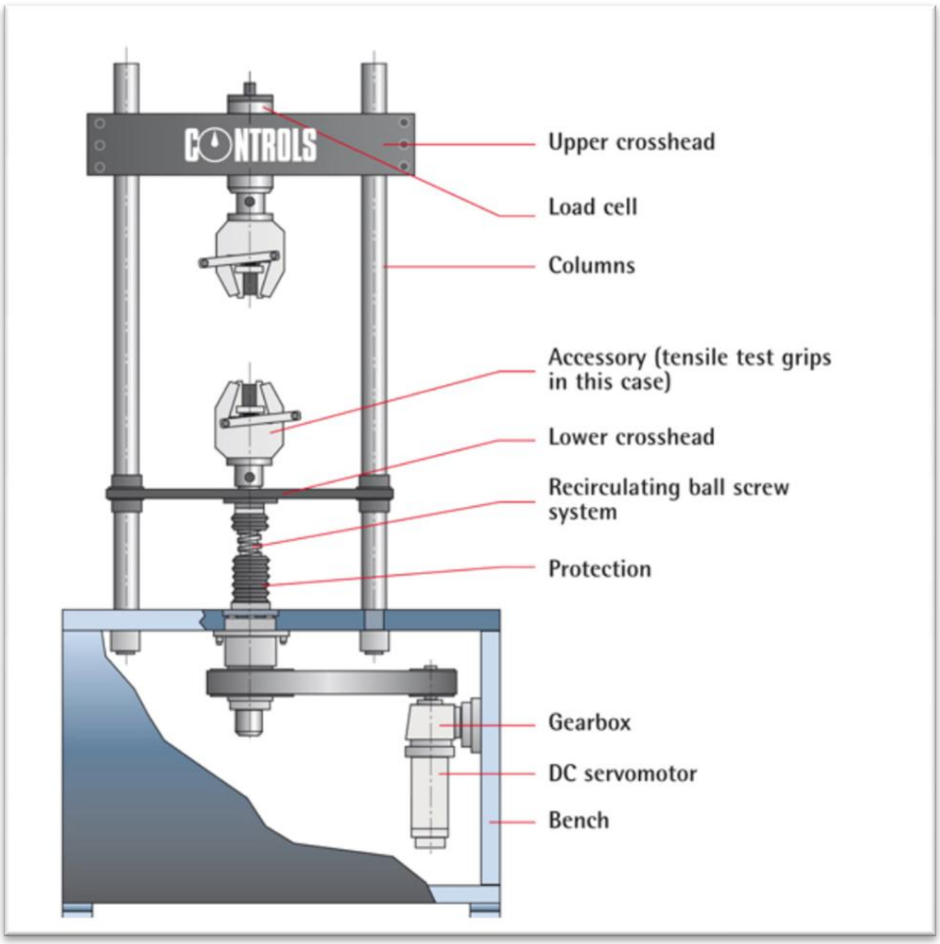

Fig. 7(a) Schematic diagram of Universal testing machine

Fig. 7(b) Universal Testing Machine

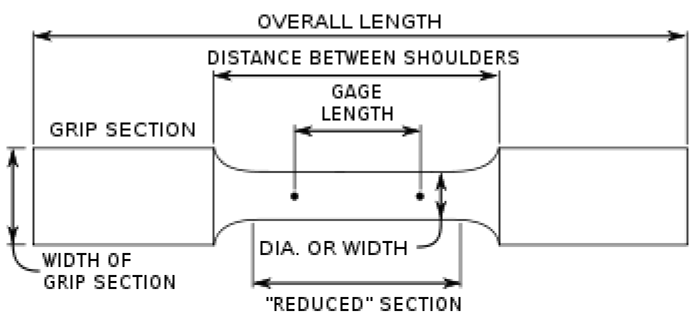

Fig. 8 Schematic diagram of Job Specimen

Theory:

The tensile test is most applied one, of all mechanical tests. In this test ends of a test piece are fixed into grips connected to a straining device and to a load measuring device (fig.7a & 7b). 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 position 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 (fig.9), which is recoverable immediately after unloading, is termed as elastic and rest of the curve,

which represents the manner in which solid undergoes plastic deformation is termed plastic. the stress below which the deformation is essentially entirely elastic is known as the yield strength of material. In some materials (like mild steel) the onset of plastic deformation is denoted by a sudden drop in load indicating both an upper and 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 trough a maximum and then begins to decrease. As this stage the' Ultimate strength ', which is defined as the ratio of the specimen to original cross –sectional area, reaches a maximum value. Further loading will eventually cause 'neck' formation and rupture. Usually a tension test is conducted at room temperature and the tensile load is applied slowly. During this test either round or flat specimens (fig.8) may be used. The round specimens may have smooth, shouldered or threaded ends. The load on the specimen is applied mechanically or hydraulically depending on the type of testing machine.

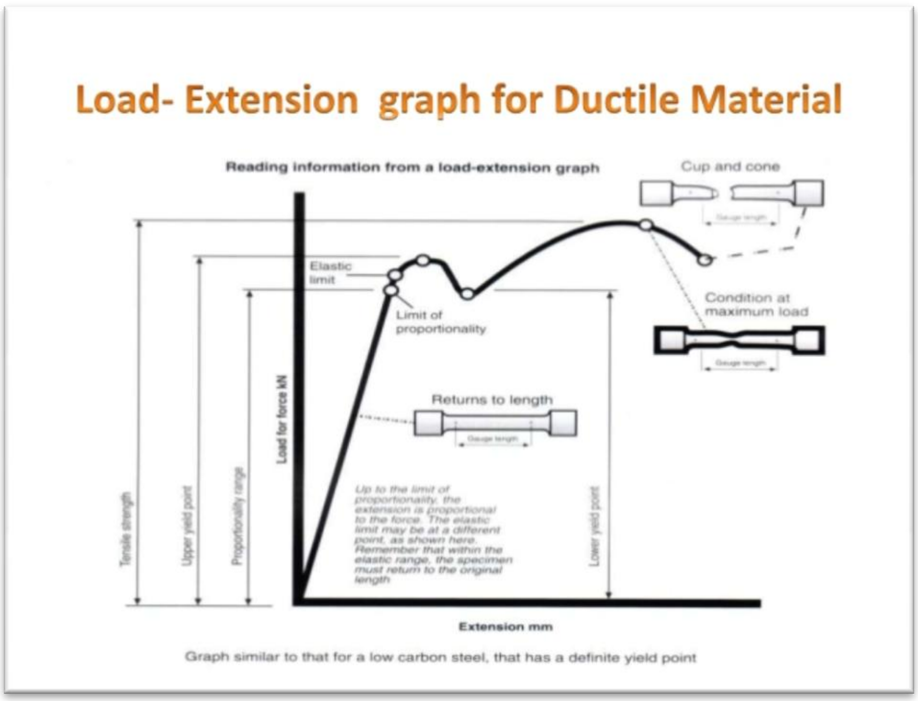

Fig. 9 Load Extension Graph

Procedure:

1. Measure the dimensions of a specimen

Diameter= d =   mm,

Total length of a specimen,

Cross sectional area = Ao= mm^2,

Mark gauge length (L_o) at three different portions on the specimen, covering effective length of a specimen.(this is required so that necked portion will remain between any two points of gage length on the specimen.)

2. Grip the specimen in the fixed head of a machine. (Portion of the specimen has to be gripped as shown in the fig.8.)

3. Fix the extensometer within the gauge length marked on the specimen. Adjust the dial of extensometer at zero.

4. Adjust the dial of a machine to zero, to read load applied.

5. Select suitable increments of loads to be applied so that corresponding elongation can be measured from dial gauge.

6. Keep speed of machine uniform. Record yield point, maximum load point, point of breaking of specimen.

7. Remove the specimen from machine and study the fracture observes type of fracture.

8. Measure dimensions of tested specimen. Fit the broken parts together and measure reduced diameter and final gage length.

Observations

Specimen prepared from M.S bar

1. Diameter = d_i = ____________mm
2. Gage length (l_i) = 5Xd= _____________mm
3. Original cross sectional area of the specimen = A_o= ___________mm^2
4. Final gage length obtained= Lf'= __________mm
5. Final diameter obtained =d_f = ____________mm^2

Observation Table:

Sl. No.	Max. Load, N	Breaking Load, N
1.		
2.		
3.		

1. Using Vernier caliper to measure diameter, gage length etc. for the specimen.

Results

1. Calculate stress and strain for every interval of applied load.

2. Draw stress strain curve as shown in the Fig.(9)

Compute the following;

a. Elasticity limit

Elastic limit = load at elastic point/ original cross sectional Area

Take F.O.S = 2, and Proof Stress = 0.1 percentage.

b. **Tensile strength**:

Tensile strength= maximum tensile load/ original cross sectional Area.

c. **Percentage elongation**:

The extension produced in a gage length, expressed as a percentage of its original value(L_i)

% Elongation=$[(L_f – L_i)/L_i]$ X 100

where L_f is final gage length after fracture.

e. Percentage reduction in area:

= $[(A_i-A_f)/ A_i]$ X100

Where A_f is final reduced cross sectional area.

Model Calculation: ………………

Experiment No.: 06

Title: Torsion Test

Aim: To find the Modulus of Rigidity of a given specimen.

Specimen and equipments:

1. A Torsion Testing Apparatus.
2. Standard Specimen of Mild Steel or Cast Iron.
3. Twist meter for measuring Angles of Twist
4. A steel rule and Calipers and Micrometer.

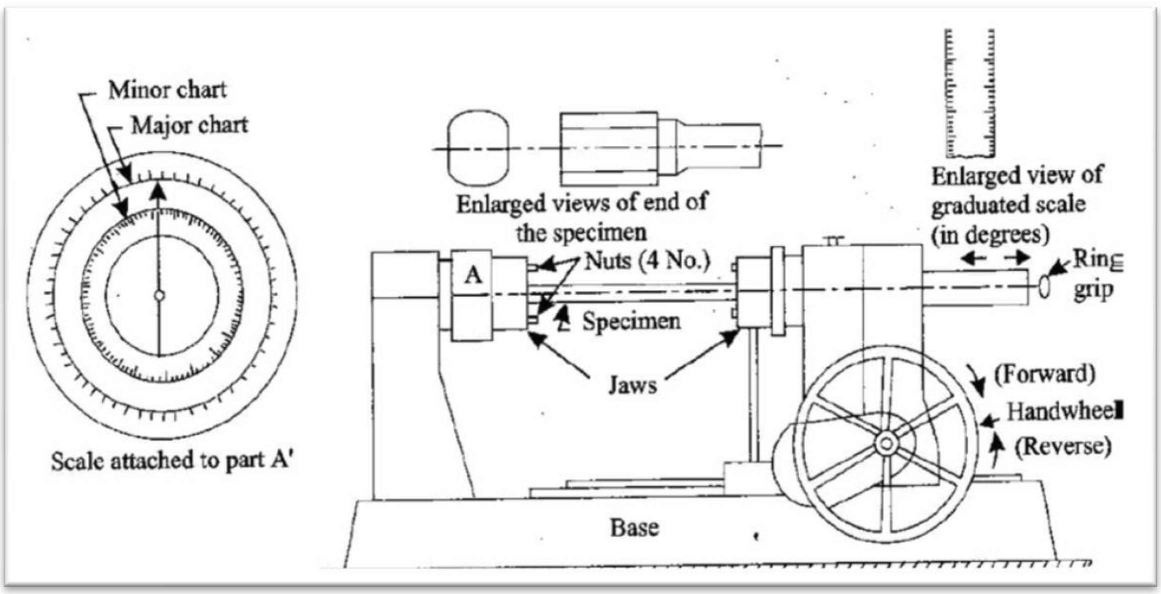

Fig.10 Schematic diagram of Torsion testing machine

Theory:

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

$$\frac{T}{I_p} = \frac{C\theta}{l} \quad \text{or} \quad C = \frac{Tl}{I\ \theta}$$

Where T=Torque Applied, N

I_p= Polar Moment of Inertia, mm^4

C= Modulus of Rigidity,

Ɵ= Angle of twist (radians), N/mm^2 and

l = gauge length, mm.

In the torque equipment refers Fig.10. One end of the specimen is held by a fixed support and the other end to a pulley. The pulley provides the necessary torque to twist the rod by a rotating motor which is connected via gear arrangement to a dial indicator. The twist meter attached to the rod gives the angle of twist.

Procedure:

1. Prepare the testing machine by fixing the two twist meters at some constant lengths from fixed support.
2. Measure the diameter of the pulley and the diameter of the rod.
3. Add weights in the hanger stepwise to get a notable angle of twist for T_1 and T_2
4. using the above formula calculate C

Observation Table:

Sl. no	Torque	Angle of Twist (radian)	Modulus of rigidity(C)	Average Modulus of rigidity(C)
1.				
2.				
3.				

Model Calculation: …………..

Result

Modulus of rigidity of the shaft is …………N/mm^2.