LAB MANUAL
OF
Introduction to Material Science & Engineering Lab

(PHP-301)

DEPARTMENT OF PHYSICS

LABARATORY CLASSES - INSTRUCTIONS TO STUDENTS

1. Students must check if the components, instruments and machinery are in working condition before setting up the experiment.
2. Power supply to the experimental set up/ equipment/ machine must be switched on only after the faculty checks and gives approval for doing the experiment. Students must start to the experiment. Students must start doing the experiments only after getting permissions from the faculty.

5. Any damage to any of the equipment/instrument/machine caused due to carelessness, the cost will be fully recovered from the individual (or) group of students.
6. Students may contact the lab in charge immediately for any unexpected incidents and emergency.
7. The apparatus used for the experiments must be cleaned and returned to the technicians, safely without any damage.
8. Make sure, while leaving the lab after the stipulated time, that all the power connections are switched off.

ANNEXURE

NAME: ____

ROLL NO.: ____________________ DEPARTMENT: ____________________

DATE OF EXPERIMENT: ____________ DATE OF SUBMISSION: ______________

CO-WORKER

NAME:	ROLL NO.:
1.____________________	____________________
2.____________________	____________________
3.____________________	____________________
4.____________________	____________________
5.____________________	____________________
6.____________________	____________________
7.____________________	____________________

TITLE: ____

OBJECTIVE: ____

____

MARKS OBTAINED: SIGNATURE OF THE TEACHER

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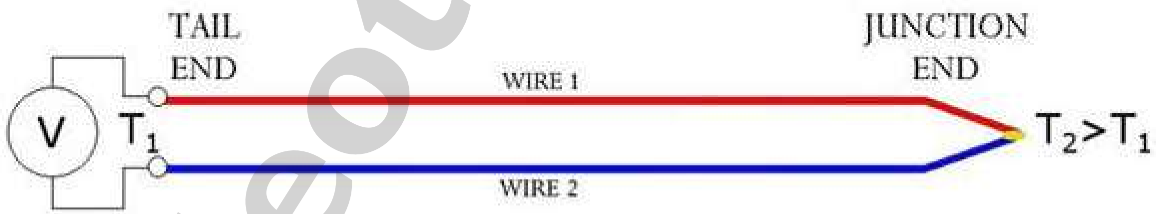
EXPERIMENT NO- 01

AIM: To determine the thermoelectric power of Thermocouple / Transducer

PRINCIPLE: A transducer is a device that converts one form of energy to another. Energy types include (but are not limited to) electrical, mechanical, electromagnetic, chemical, acoustic, or thermal energy. While the term transducer commonly implies the use of a sensor/detector, any device which converts energy can be considered a transducer. Transducers are widely used in measuring instruments

A thermocouple is a device made by two different wires joined at one end, called **junction end** or **measuring end**. The two wires are called **thermo elements** or legs of the thermocouple: the two thermo elements are distinguished as positive and negative ones. The other end of the thermocouple is called **tail end** or **reference end**. The junction end is immersed in the environment whose temperature T_2 has to be measured, which can be for instance the temperature of a furnace at about 500°C, while the tail end is held at a different temperature T_1, e.g. at ambient temperature. Because of the temperature difference between junction end and tail end a voltage difference can be measured between the two thermo elements at the tail end: so the thermocouple is a temperature-voltage transducer.



Schematic drawing of a thermocouple

Due to Seebeck effect an emf is induced in the transducer/thermocouple when there is a temperature difference exists between its two junctions. This emf is called Seebeck emf. From theory of Seebeck effect we know that this emf is directly proportional to the difference of temperature between the two junctions. So if ΔV is Seebeck emf and ΔT is the temperature difference between two junctions, then we have $\Delta V = \varepsilon \Delta T$ where ε is known as Seebeck coefficient or thermoelectric power of the transducer/thermocouple. Thus, thermoelectric power, of the transducer/thermocouple is a measurement of the magnitude of an induced thermoelectric voltage in response to a temperature difference across it. The thermoelectric power has units of volts per kelvin (V/K), although it is more often given in microvolts per kelvin (μV/K).

Therefore the thermoelectric power of the transducer/thermocouple is given as:

$\varepsilon = dV/dT$

APPARATUS:

- Transducer/thermocouple set up
- Oven
- Oven Controller

PROCEDURE: (Don't write the procedure in your Lab. Copy)

- Fix Transducer/thermocouple probe in the set up.

↓

- Switch on the heater. Once you set the gain, do not change it throughout your experiment. Rotate the temperature controlling knob by one division. The LED will be illuminated which indicates the oven is on and the temperature increases.

↓

- Note down the increasing temperatures and corresponding voltages (Amplifier Output) in the Table – 1 until a certain final temperature is attained and the LED gets off. If this temperature is not appreciably high, rotate temperature controlling knob by one more division. The LED will be illuminated again and the temperature of the oven increases further.

↓

- Again start to note down the increasing temperatures and corresponding voltages in the Table – 1.

↓

- Continue the above steps until you have an appreciable high temperature (say 130^0C)

↓

- Draw a graph of voltage vs. temperature

↓

- From graph calculate the value of thermoelectric power as shown in Table – 2.

TABULATIONS:

TABLE-1

Temperature vs. Voltage data

Ambient temperature =.. .... ^{0}C & Initial Amplifier Gain=.....

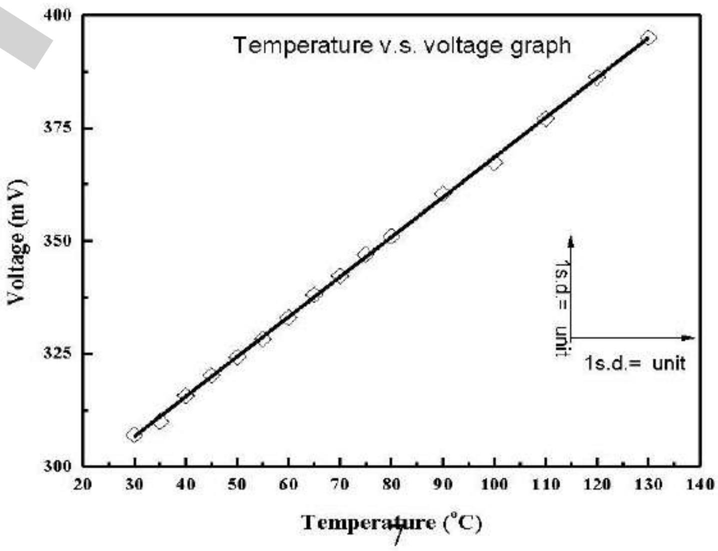
Sl no.	Temperature(^{0}C)	Amplifier Output (mv)
1	30	
2	35	
3	40	
4	45	
5	50	
.		
..		
....		
......		
....		
....	125	
....	130	

TABLE-2

Calculation Thermoelectric power from graph

Value of ΔV from graph (mV)	Value of ΔT from graph (K)	$\varepsilon = \frac{\Delta V}{\Delta T \times gain}$ **(mV/K)**

Graph: Draw a graph of voltage vs. temperature



ERROR CALCULATION:

Thermoelectric power of a material is conventionally defined as:

$$\varepsilon = \frac{\Delta V}{\Delta T}$$

For simplicity let us write it as $\varepsilon = V/T$

Taking ln both sides we get,

$$\ln\varepsilon = \ln V - \ln T$$

After diff. we get

$$\frac{\delta\varepsilon}{\varepsilon} = \frac{\delta V}{V} + \frac{\delta T}{T}$$

Other terms will vanish after diff. As they are constant

δV = error in measuring V=smallest division of the voltmeter.

δt = error in measuring T=smallest division of the thermometer.

(Because probability of making error is in one side)

Hence, the percentage error is

$$\frac{\delta\varepsilon}{\varepsilon} \times 100\%$$

DISCUSSION:

You have to write all the difficulties you faced during the experiment and their remedies. Also you have to mention some way out that one should adopt during the practical to have a better result.

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EXPERIMENT NO- 02

AIM: Determination Dielectric Constant & Curie Temperature of Ferroelectric Ceramics

Principle: Dielectric or electrical insulating materials are understood as the materials in which electrostatic fields can persist for a long time. These materials offer very high resistance to passage of electric current under the action of applied direct current voltage and therefore sharply differ in their basic electrical properties from conductive materials. Layers of such substances are commonly inserted into capacitance to improve their performance, and the term dielectric refers specifically to this application

PEROVSKITE STRUCTURE

Perovskite is a family name of a group of materials and the mineral name of calcium titanate ($CaTiO_3$) having a structure of the type ABO_3. Many piezoelectric (including ferroelectric) ceramics such as Barium Titanate ($BaTiO_3$), Lead Titanate ($PbTiO_3$), Lead Zirconate Titanate (PZT), Lead Lanthanum Ziconate Titanate (PLZT), Lead Magnesium Niobate (PMN), Potassium Niobate ($KNbO_3$), etc. have a cube perovskite type structure (in the paraelectric state) with chemical formula ABO_3.

BARIUM TITANATE ($BaTiO_3$,)

Barium Titanate ($BaTiO_3$) has a ferroelectric tetragonal phase below its curie point of about 120°C and paraelectric cubic phase above Curie point. The temperature of the curie point appreciably depends on the impurities present in the sample and the synthesis process.

DIELECTRIC CONSTANT

The dielectric constant (ε) of a dielectric material can be defined as the ratio of the capacitance using that material as the dielectric in capacitor to the capacitance using a vacuum as dielectric.

Dielectric constant (ε) is given by $\varepsilon = \frac{C}{C_0}$ where $C_0 = \frac{\varepsilon_0 A}{t}$

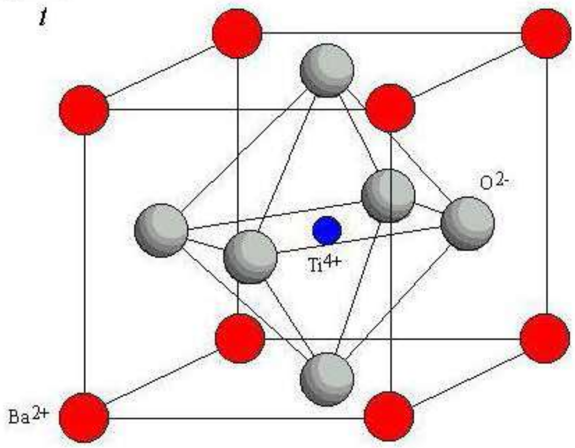
C = Capacitance using the material as the dielectric in the capacitor

C_0 = Capacitance using vacuum as the dielectric

ε_0 = Permittivity of free space (8.85×10^{-12} F/m).

A = Area of the plate /sample cross section area.

t = Separation between two plates of the capacitor having vacuum as dielectric



APPARATUS REQUIRED:

- Two probe arrangement
- Barium Titanate ($BaTiO_3$,) plate
- Oven
- Oven Controller
- Digital Capacitance Meter

PROCEDURE:

- Calculate C_0 with the supplied values of A, ε_0 and t.

↓

- Switch on the heater. Rotate the temperature controlling knob by one division. The LED will be illuminated which indicates the oven is on and the temperature increases.

↓

- Note down the increasing temperatures and corresponding capacitance (C) in the Table – 1 until a certain final temperature is attained and the LED gets off. If this temperature is not appreciably high, rotate temperature controlling knob by one more division. The LED will be illuminated again and the temperature of the oven increases further.

↓

- Again start to note down the increasing temperatures and corresponding capacitance in the Table – 1. Each time from the formula calculate the value of dielectric constant

↓

- Continue the above steps until you have an appreciable high temperature (say 180°C)

↓

- Draw a graph to show the variation of dielectric constant with temperature (Temperature is along x-axis and Dielectric along y-axis.) From the graph determine the Curie temperature where the dielectric constant is maximum

TABULATION:

Sample: Barium Titanate ($BaTiO_3$) Area (A): 57.15 mm^2 Thickness (t): 1.67 mm

Permittivity of Space (ε_0): 8.85×10^{-12} F/m or 8.85×10^{-3} pf/mm

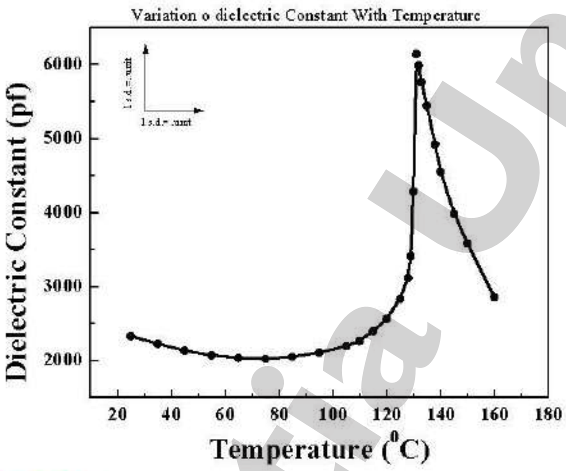
Dielectric Constant $\varepsilon = \frac{C}{C_0}$ where $C_0 = \frac{\varepsilon_0 A}{t} =$ .... pf

TABLE-1

Temperature (°C) - Capacitance, C (pf) data

Sl.No.	Temperature (°C)	Capacitance C (pf)	Dielectric Constant (ε) = C/C_0
1	25		
2	35		
..	...		
..	180		

Curie temperature (From Graph) = °C



ERROR CALCULATION:

We have the formula for the Dielectric constant as $\varepsilon = \frac{C}{C_0}$ where $C_0 = \frac{\varepsilon_0 A}{t} = ...pf$

So, $\varepsilon = \frac{Ct}{\varepsilon_0 A}$. Taking ln in both sides we get, $\ln\varepsilon = \ln C + \ln t - \ln\varepsilon_0 - \ln A$

Differentiating we get for maximum proportional error, $\frac{\delta\varepsilon}{\varepsilon} = \frac{\delta C}{C}$

(Rest of the term will be zero as t, ε_0, and A are constants and differentiation of these terms will vanish). δC= error in measuring C = smallest division of the capacitance meter. Hence, the percentage error is $\frac{\partial\varepsilon}{\varepsilon} \times 100\%$.

DISCUSSION:

You have to write all the difficulties you faced during the experiment and their remedies. Also you have to mention some way out that one should adopt during the practical to have a better result.

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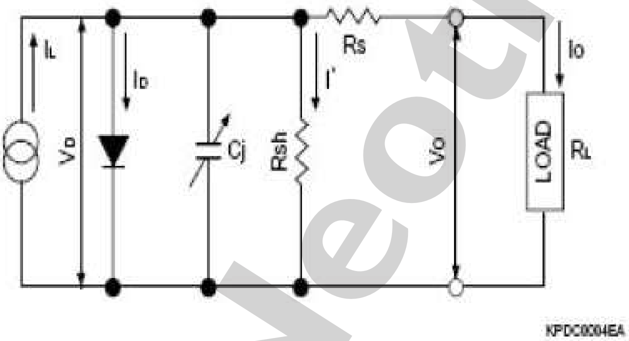
EXPERIMENT NO- 03

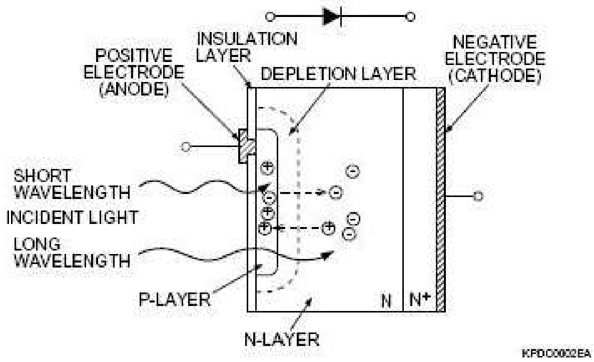
NAME OF EXPERIMENT: Study of Solar Cell

AIM: Study of power vs. Load, Areal characteristics, Spectral response, and Intensity response of the photovoltaic Solar cell.

PRINCIPLE: If a beam of light falls on p-n junction, then an electron from the valence band of the p-type semi conductor can move to the conduction band of the n-type semi conductor (photons of sufficiently high energy can cause this transition), and thus the two sides of the junction are oppositely charged. This is because the p-type semi conductor has a positively charged hole in its valence band, where as the n-type semi conductor has an additional electron in its conduction band, making it negatively charged. This leads to a potential difference which can be used to give current to an external circuit. Thus, solar energy can be converted into electrical energy using a p-n junction. This device is known as the solar cell. Photodiodes are p-n junctions specifically designed to optimize their inherent photosensitivity. Photodiodes can be used in two ways -- in a photovoltaic (here it becomes a current source when illuminated, example is solar cell), and in photoconductive mode. To use a photodiode in its photoconductive mode, the photodiode is reverse-biased; the photodiode will then allow a current to flow when it is illuminated.

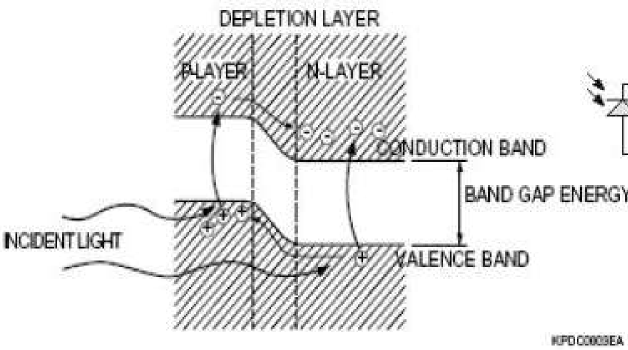


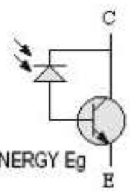
Photodiode equivalent circuit

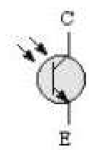


Photodiode cross section

- I_L : Current generated by the incident light (proportional to the amount of light)
- I_D : Diode current
- C_j : Junction capacitance
- R_{sh} : Shunt resistance
- R_s : Series resistance
- I' : Shunt resistance current
- V_D : Voltage across the diode
- I_o : Output current







- V_o : Output voltage

Power load characteristics: To derive maximum power from the panel, an appropriate load is to be connected across it. The value of the load (R_L) that allows the cell to give maximum output power is obtained by drawing a power load characteristics, it has been seen that a load other than R_L will produce less power. Because photodiodes generate a power due to the photovoltaic effect, they can operate without the need for an external power source. However, frequency response and linearity can be improved by using an external reverse voltage V_R. It should be borne in mind that the signal current flowing in a photodiode circuit is determined by the number of photovoltaically generated electron-hole pairs and that the application of a reverse voltage neither affect the signal current nor impair the photoelectric conversion linearity.

Areal characteristics: The power delivered is proportional to the surface area of the solar panel exposed to the light. It is governed by the relation,

$$P = KA$$

Where, P is the total power available; A is the area of the cell; and K is a constant.

Spectral characteristics: The response of a solar cell to light also depends on the wavelength of the incident light. In the sunlight, different colors have different intensities. The photocurrent produced by a given level of incident light varies with wavelength. This relation between photoelectric sensitivity and wavelength is referred to as spectral response characteristic has an interesting site on the technology behind photodiodes here. Note that phototransistors behave much like photodiodes, but with higher gain (i.e., a phototransistor allows more current to flow than would a photodiode in a photoconductive role).

Intensity variation characteristics: We will also study response of a solar cell with the intensity variation. The intensity of incident light will be varied by moving the light source nearer or further from the solar cell. Corresponding current and voltage will be noted.

APPARATUS: Solar cell, Solar cell kit, lamp house, optical bench, plastic choppers with an opening of different cross-sectional area, filters.

PROCEDURE:

- Switch on the solar cell kit. Arrange the source of light and the solar cell separated by a suitable distance.

↓

- Increase the load resistance gradually from zero value. Note down the load resistances and corresponding currents and voltages. Record them in Table – 1. Calculate the power for each load resistance.

↓

- Draw the graph power vs. load resistance. Determine the optimum load resistance for which the power is maximum. Keep fix the load resistance at this optimum value. Do not change it further.

↓

- Without changing the position of the solar cell and the source of light place the choppers with various cross sectional areas in front of the solar cell. Record the voltage and current for different cross sectional chopper areas in the Table – 2. Calculate the power for each cross sectional chopper area.

↓

- Draw the areal response curve by plotting the cross sectional chopper area along abscissa (x-axis) and power along vertices (y-axis).

↓

- Next without changing the position of the solar cell and the source of light place color filters in front of the solar cell. Note down the voltage and current for different color filters. Record the wavelength of the color filter, voltage, and current in the Table – 3. Calculate the power for each color filter.

↓

- Draw the frequency characteristic curve by plotting the wavelength along abscissa (x-axis) and power along vertices (y-axis).

↓

- Now move the source of light toward the solar cell. Because of changing the position of the light source the intensity of the light falling on the solar cell is changed. Record the voltage and current for different positions of the light source in the Table – 4. Calculate the power for each position.

↓

- Draw the intensity response curve by plotting the position of the light source along abscissa (x-axis) and power along vertices (y-axis).

TABULATION:

TABLE-1

Current voltage relationship:

No of obs.	Load resistance R_L (ohm)	Voltage (V)	Current I (mA)	Power P =VI (W)
1				
2				
..				
12				

Optimum resistance =…………ohm

TABLE-2

Areal characteristics:

No of obs.	Chopper area (mm^2)	Voltage (V)	Current I (A) (mA)	Power P=VI (W)
1				
2				
..				
5				

TABLE-3

Frequency characteristics:

Colour of the filter	Wave length in (Å)	Voltage (V)	Current I (A)	Power P=VI (W)
1				
2				
..				
5				

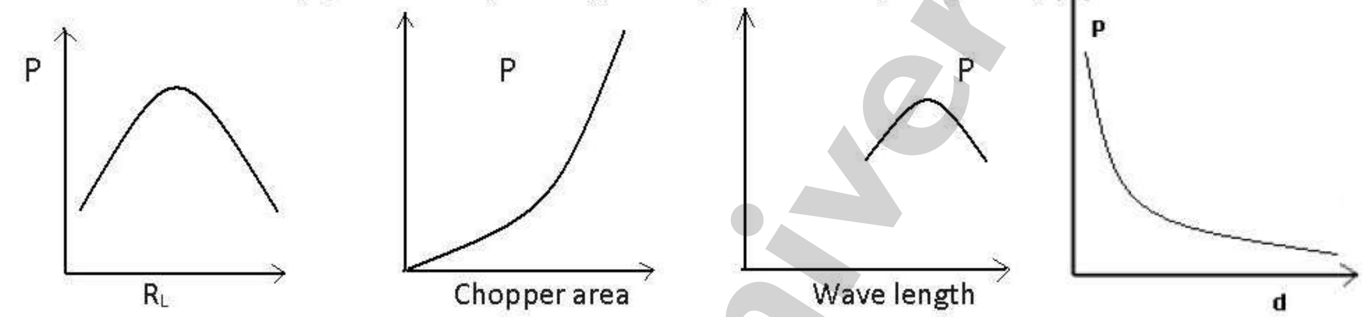
TABLE-4

Intensity Response:

Distance between solar cell and light source *d* (cm)	Voltage (V)	Current I (A)	Power P=VI (W)
1			
2			

..			
5			

Draw three graphs: (1) Load resistance vs. Power graph with R_L in *x*-axis and P in *y*-axis.
(2) Chopper area (in *x*-axis) vs. Power (P in *y*-axis) curve.
(3) Wave length (λ in *x*-axis) vs. Power (P in *y*-axis) curve.
(4) Distance (d along *x*-axis) vs. Power (P in *y*-axis) curve.



(1) (2) (3) (4)

DISCUSSION:

You have to write all the difficulties you faced during the experiment and their remedies. Also you have to mention some way out that one should adopt during the practical to have a better result.

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EXPERIMENT NO- 04

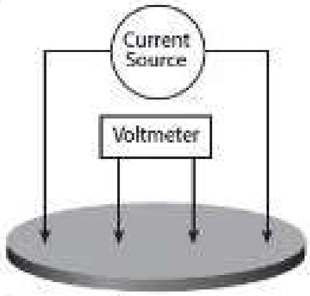
NAME OF EXPERIMENT: Study of Band-Gap of SEMICONDUCTOR

AIM: MEASUREMENT OF RESISTIVITY BY USING A DIRECT READING POTENTIOMETER AND TO FIND BAND-GAP OF A SEMICONDUCTOR SAMPLE

PRINCIPLE: The crystal or sample has four individually spring loaded probes coated with Zn at tips. The probes are co-liner and equally separated. The Zn coating and individual spring ensure good electrical contacts with the sample. The probes are mounted in a Teflon bush which ensures a good electrical insulation between the probes (not shown in figure).

The resistivity of a sample in a four-probe is given by:

$$\rho_0 = \frac{V}{I} 2\pi S$$



Where, V is Potential across voltage probe

I is Constant current through sample

S is distance between probes

ρ_0 is the of resistivity of a material

Since the current probes are not fixed at the edge of the sample and the sample has a finite width, a correction factor will appear in the above expression of the resistivity. If the two edges of the sample are at a distance of x_1 and x_2 from the current probes, then the correction function would be respectively $G_7(x_1/S)$ and $G_7(x_2/S)$. Where the function $G_7(X/S)$ can be approximated for smaller values of X/S as: $G_7(X/S) = 2\frac{S}{X}\ln 2$.

In addition, when we consider finite width of the sample, the total correction factor becomes

$F = G_7(w/S) \times G_7(x_1/S) \times G_7(x_2/S)$; Where w is width of the sample.

Therefore, $F = 2\frac{S}{w}\ln 2 \times 2\frac{S}{x_1}\ln 2 \times 2\frac{S}{x_2}\ln 2$

With the correction term we get the expression for resistivity as $\rho = \frac{V}{I} 2\pi S \frac{1}{F} = \frac{\rho_0}{F}$

We know that if ρ be resistivity and E_g be the band gap, then for a particular temperature T, resistivity of a material is given by $\rho = Ae^{E_g/2kT}$, Where k is Boltzmann constant.

So, $\ln \rho = \ln A + E_g / 2kT$

$$E_g = \frac{2k \ln \rho}{1/T} + A$$

The slop of the graph between $\ln \rho$ vs. $1/T$ is equal to $\frac{E_g}{2k}$. From that E_g can be calculated.

Thus, band gap = $E_g = 2k \times$ Slope.

APPARATUS REQUIRED:

- Four probe arrangement
- Semiconductor plate
- Oven
- Oven Controller
- Digital Current Voltage Meter

PROCEDURE:

- Set up the four probe arrangement on the semiconductor plate. Put whole arrangement inside the oven. Note down the room temperature from the thermometer. Calculate the correction factor, F, from the supplied values of S, x_1, x_2, and w.

↓

- Turn on the oven. Set the oven controller switch towards ×10 side. Note down the current by Set the Current/Voltage converter towards the Current side and fix a current passing through the sample by using a current controlling knob. Note down and record it in the Table – 1. Don't disturb the knob throughout the experiment. In this way you fix the current constant flowing through the sample. After that you set the Current/Voltage converter towards the Voltage side and don't change this set up until you finish the recording of the voltage.

↓

- Now since the oven is on, temperature increases and correspondingly the voltage decreases. In the Table – 1 record the temperature obtained from the thermometer and corresponding voltage displayed on the panel until you get appreciable high temperature (say about 150°C).

↓

- Draw a graph by plotting $1/T$ along abscissa (x-axis) and $\ln\rho$ along vertices (y-axis). Calculate the band gap from the slope of the graph as instructed in Table – 2.

TABULATION:

Name of the Sample:.......... Room temp=

S= .... mm. w= ..... mm. x_1= .... mm. x_2= ..... mm.

Correction factor $F = 2\frac{S}{w}\ln 2 \times 2\frac{S}{x_1}\ln 2 \times 2\frac{S}{x_2}\ln 2 = ...$

Current through probe (I) = ... mA

TABLE-1

Table to take temperature vs voltage reading at a constant current

Serial No.	Temp. (°C)	Temp in K (T)	1/T in ($K^{-1}x10^{-3}$)	Voltage when temperature is Increasing (mV) (V)	Resistivity $\rho_0 = \frac{V}{I}2\pi S$ (ohm-c.m.)	Corrected Resistivity $\rho = \frac{\rho_0}{F}$ (ohm-c.m.)	lnρ
1							
2							
..							
15							

GRAPH: Draw a graph: 1/T along x-axis & $\ln\rho$ along y-axis

TABLE-2

DETERMINATION OF BAND GAP

k_B= Boltzmann's Constant=1.38×10^{-23} Jule/K

Value of $\Delta(1/T)\times 10^{-3}$ from graph (K^{-1}) (a)	Value of $\Delta\ln\rho$ from graph (b)	Value of slope =b/a	Band gap $E_g = 2k_B \times slope$ (eV)

8.0 Error calculation:

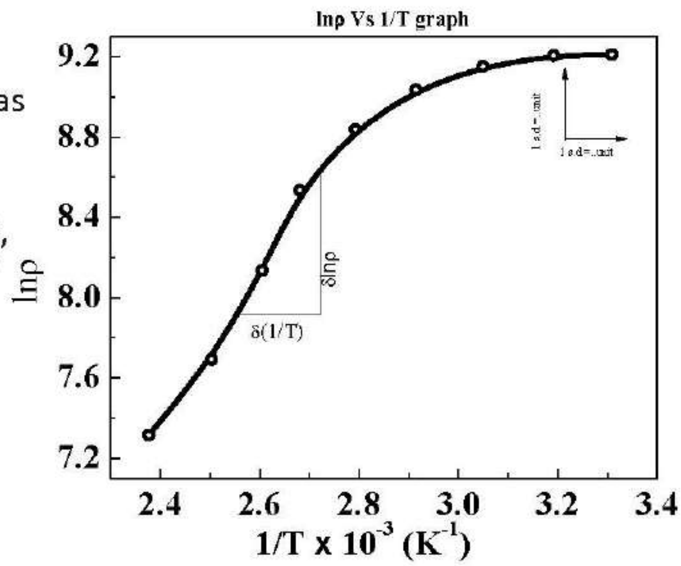
We have the experimental formula of band gap as

$$\rho = \frac{V}{I}2\pi S\frac{1}{F}$$

Taking ln of both sides of above equation we get,

$$\ln\rho = \ln V + \ln 2 + \ln\pi + \ln S + \ln l - \ln I - \ln F$$

After differentiating we get $\frac{\delta\rho}{\rho} = \frac{\delta V}{V} + \frac{\delta I}{I}$



Other terms become zero because they are constants

δV = error in measuring V = smallest division of the voltmeter.

δI = error in measuring I = smallest division of the ammeter

(Because probability of making error is in one side)

Hence, the percentage error is $\frac{\partial \varepsilon}{\varepsilon} \times 100\%$

DISCUSSION:

You have to write all the difficulties you faced during the experiment and their remedies. Also you have to mention some way out that one should adopt during the practical to have a better result.

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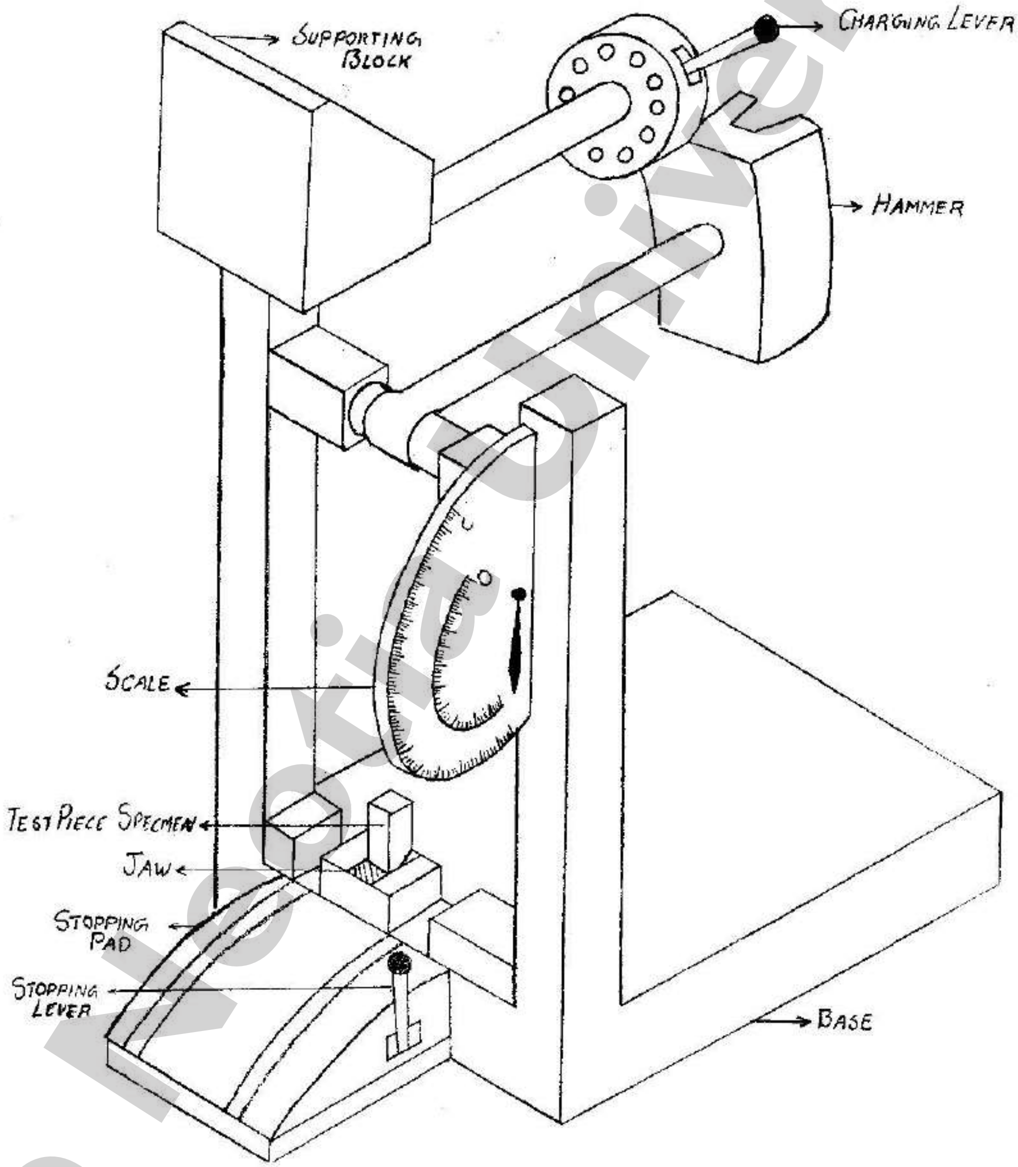
EXPERIMENT NO.05

AIM - To study the Impact Testing Machine and test the specimen of Izod.

DIAGRAM-



IMPACT TESTING MACHINE

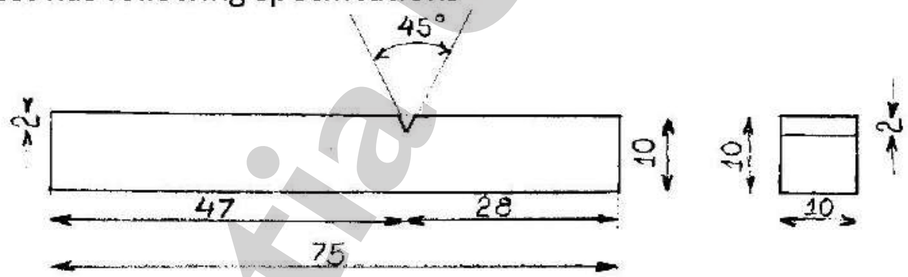
MACHINE & MATERIALS REQUIRED-

1) Impact Testing Machine.
2) A test piece specimen (Squire Cross section, Rectangular Mild Steel Bar having, V, notch)

WORKING PROCEDURE-

IMPACT TEST-The impact test is to determine the behavior of materials when subjected to high rates of (sudden) loading, usually in bending, tension or torsion. It measures the energy absorbed in breaking the specimen by a single bow or impact. Impact testing is done on the specimen test piece piece of a determine specification and a provided notch. A notch is a slot or groove of specified characteristics intentionally cut in a test piece so a to concentrate the stress, thus localizing the rupture.

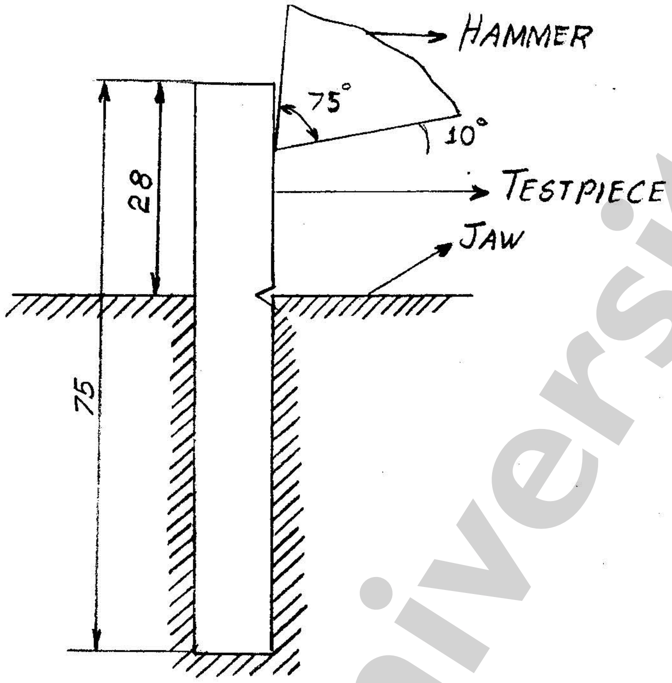
IZOD IMPACT TEST- A pendulum type, single blow impact test in which the specimen, usually notched (v- notch) is fixed at one end and broken by a falling pendulum. The energy absorbed as measured by the subsequent rise of the pendulum is a measure of impact strength or notch toughness. The impact strength is measured as N-M or joule (j). The test piece for Izod test has following specifications-



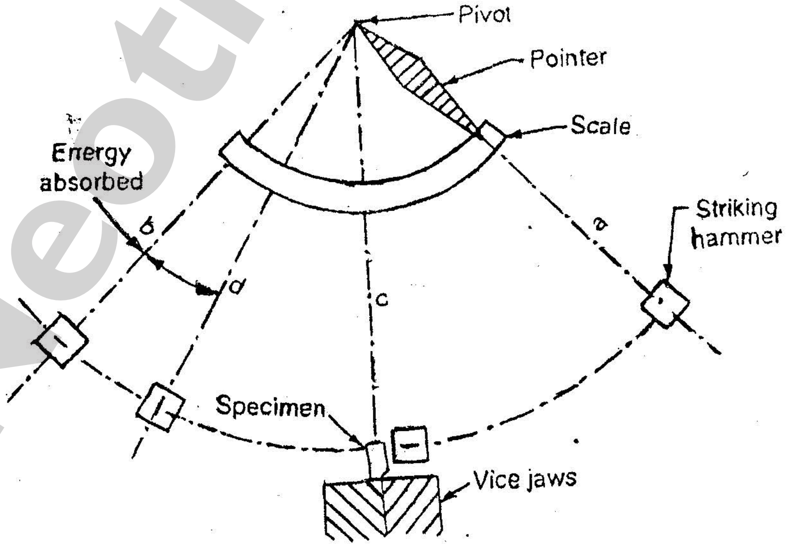
(All dimensions in mm)

METHOD-

1) The machine is first used without the specimen to observe the initial reading or initial energy. By pressing the charging lever, we blow down the hammer and the pointer of the scale will stick to some value. This is the initial energy, which stick to some value. This is the initial energy, which is to be noted and subtracted afterwards from the final value.
2) Now the test piece is fixed vertically between he jaws of the testing machine as shown in the
figure below-



3) The hammer should be kept at 90^0 from the vertical force of the jaws. The hammer is then blowed down by the charging lever and it passes away swinging by breaking the test piece at the v-notch.
4) The energy absorbed in breaking the test piece is noted in the observation table from the reading shown by the pointer on the scale.
5) By the use of the stopping lever, the swinging action of the hammer can be Stopped.



OBERVATION TABLE-

Material	Type of Impact test	Angle	Initial Energy (In j)	Energy absorbed in breaking the test piece (in j)
Mild steel test piece	Izod	90^0	0 J	
			0 J	

RESULT-Izod Impact Test shown that the materials which require higher energy for braking can withstand easily when subjected to high rates of (sudden) loading.

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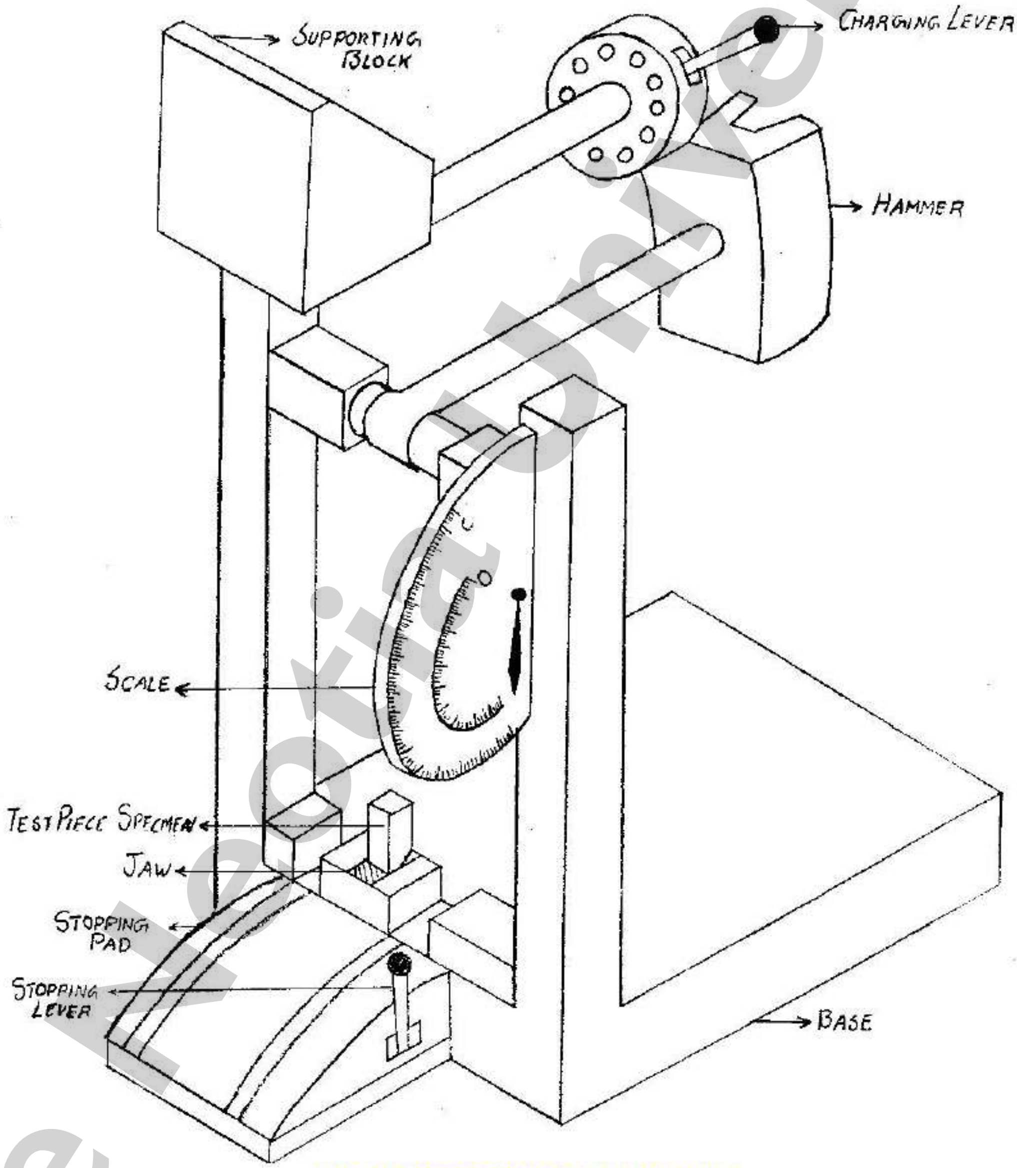
EXPERIMENT NO.06

AIM -To determines the impact energy by Charpy impact test using Impact Testing Machine.

DIAGRAM-



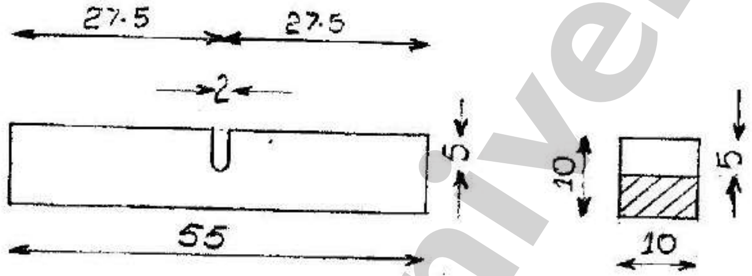
IMPACT TESTING MACHINE

MACHINE & MATERIALS REQUIRED-

1) Impact Testing Machine.
2) A test piece specimen. (Squire cross section, rectangular mild steel bar having, U, notch.)

WORKING PROCEDURE-

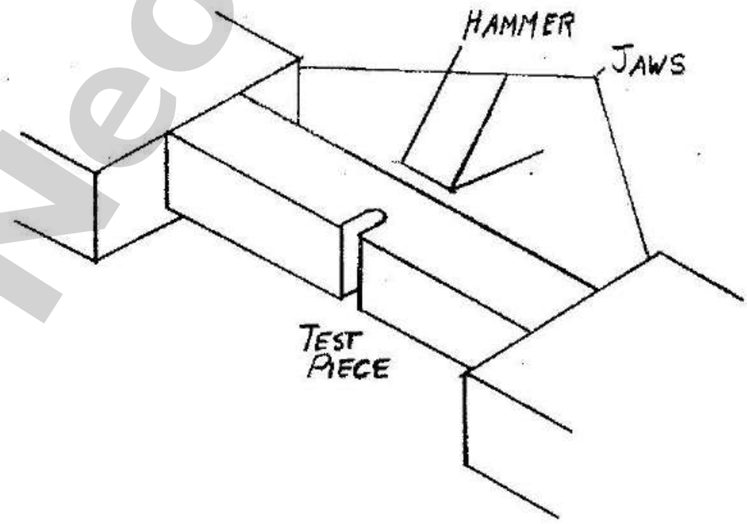
CHARPY IMPACT TEST-A pendulum type ingle blow impact test, in which the specimen (usually U- notched) is supported at both ends, as a simple beam and broken by a falling pendulum on the face opposite to and immediately behind the notch. The energy absorbed as determine by the subsequent rise of the pendulum, is a measure of impact strength or notch toughness and is expressed as N-m/m3. The test piece specimen for the charpy impact test has following specifications-



(All dimensions in mm)

METHOD-

1) The machine is first used the specimen to observe the initial reading or initial energy. By pressing the charging lever, we blow down the hammer and the pointer of the scale will stick to some value. This is the initial energy, which stick to some value. This is the initial energy, which is to be noted and subtracted afterwards from the final value.
2) Now the test piece specimen is fixed horizontally between the jaws and the hammer is blowed from behind the notch as shown in the figure-



3) During Charpy impact test the hammer should be kept at 140^0 to the vertical face of the jaws that is the hammer should strike the specimen cut on angle of 140^0, which is the angle for release of the hammer.
4) By pressing the charging lever, the hammer is released at passes away swinging the, braking the test piece specimen.

5) The energy used for breaking the specimen can be noted from the scale to the observation table.

OBSERVATION TABLE-

Material	Type of impact test	Angle	Initial energy (In J)	Energy absorbed in breaking the test piece (In J)
Mild steel bar	Charpy	140^0		

RESULT-Charpy impact test shows that the materials, which requires higher for braking can withstand easily when subjected to high rates of loading.

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EXPERIMENT NO- 07

AIM - To study the Fatigue Testing Machine and to discuss the procedure to find out endurance limit of given material.

MACHINE & MATERIAL REQUIRED-

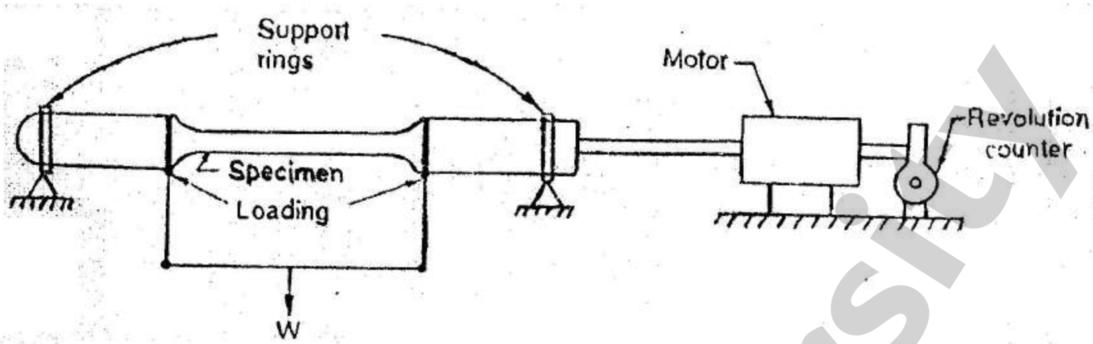
i) Test pieces.
ii) Rotary bending fatigue machine.
iii) Dial gauge.
iv) Fatigue testing machine

THEORY- Fatigue can be defined as the failure of a material under varying loads, well below the ultimate static load, after a finite number of cycle of loading and unloading. This is very frequent cause of failure of working parts of machines ,and load bearing parts of aircraft structures, rockets and missiles etc. subjected to repetitive loading.

A verity of fatigue apparatus is available in the market. Basically it should consist of some way to produce altering loads on the specimen, some counting arrangement for the number of loads cycles, and some load measuring device. Control devices like stopping the motor once the specimen brakes and keeping the load amplitude constant etc. may also be incorporated.

PROCEDURE-

i) Insert the test piece in the bearing housing of the machine and measure its diameter.
ii) By using a dial gauge and rotating the test piece check the eccentricity, which should not be generally more than .o3 mm.
iii) Apply suitable load by adjusting the jockey weight.
iv) Set the revolution counter to zero.
v) Start the motor of the machine and recorded the number of revolutions after which the specimen fails.
vi) Increase the load and test other specimen in a similar way.
vii) In each test calculate the stress applied.
viii) Plot a curve between stress and cycles.



ROTARY BENDING FATIGUE MACHINE

OBSERVATION-

Dia. of test piece, d (mm)	Load (Newton)	Number of cycles (N)	Stress (N/mm^2)

Endurance limit (10^6 cycle) = -------

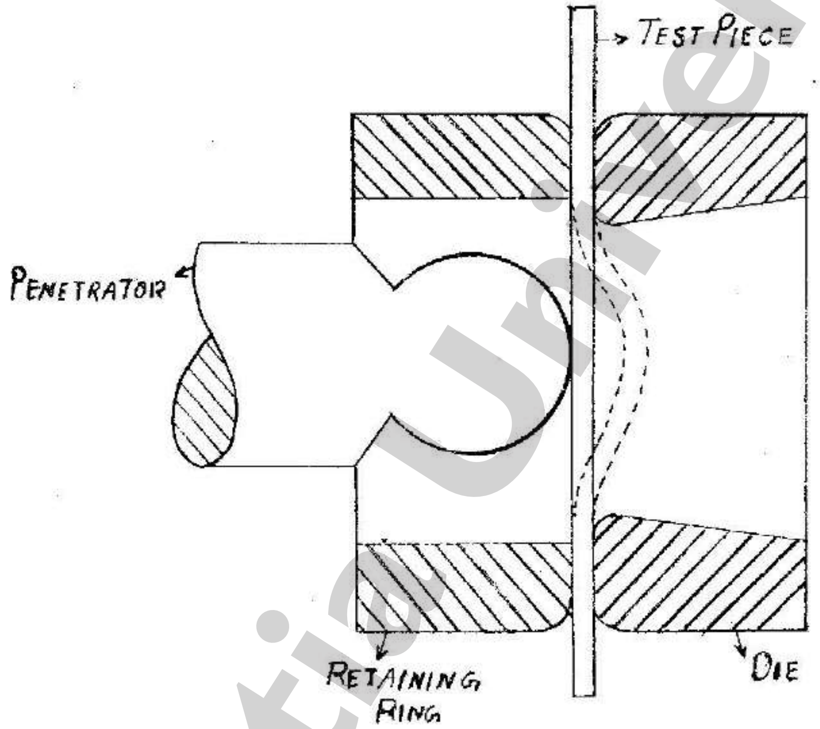
VIVA QUESTIONS –

1. What is the endurance limit?
2. What is fatigue & failure?
3. What are the different types of loading?
4. What is bending in beam?
5. What is Eccentricity?

EXPERIMENT NO. 08

AIM- To study the Cupping Test Machine and to determine Erichsen value of Mild Steel sheet.

DIAGRAM-



MACHINE & MATERIAL REQUIRED-

1) Erichsen cupping test machine
2) A bulb lamp.
3) Mirror.
4) A mild steel plate.
5) A piece of Drawing Sheet.
6) Vernier caliper.

WORKING PROCEDURE- In the Erichsen cupping test machine, the retaining ring is kept fixed with the machine block while the penetrator and the die can be moved to and fro with the help of hand wheels provided. The whole procedure is as follows-

1) The outer most point of the penetrator is aligned in a straight line with the retaining ring such that the zero of the circulars scale mounted on the penetrator coincides with the zero of the linear scale.
2) The circulars scale is divided into 20 points and each parts shows 0.25 Erichen number. That means that the circulars scale has (0.25x20) = 5 Eeichen numbers. The linear scale mounted on the retaining ring has divided into six parts and each part

denotes 5 Erichen numbers. Which means that one complete round of the circular scale moves one division over the linear scale and is equal to 5 Erichen numbers.

3) Now a mild steel plate is taken of about 120mm x120mm and then we find its thickness by a vernier caliper and note it in the observation table. The plate is then inserted between the retaining ring and the die and we precedes the die in forward direction with the help of hand wheel until the mild steel plate is firmly fixed between these two.
4) Now we glow up the lamp to see the inside view of the testing machine and the mirror is kept in such a position that we can easily view the whole process of metal rupture along with rotating the wheel manually.
5) The circular scale and the hand wheel are mounted on the penetrator. Now we start rotating the hand wheel of the penetrator along with viewing the inside process in the mirror. The penetrator start moving forward and began to push the metal plate with an increasing force. As we proceeds, we see that the penetrator makes a cup like structure on the metal plate. A white circle emerges along the outer side of the cup and there; we have to stop rotating the hand wheel. With the simple calculation on the circular scale we can note down the Erichen no. of the mild steel plate.
6) The some process (step 1to 5) is to be done while finding the Erichen no. of drawing sheet piece.

OBSERVATION TABLE-

Sl.No.	Material	Thickness (in mm)	Erichsen Number
01	Mild steel		
02	Drawing sheet		

PRECAUTIONS-

1) Cupping test is normal applicable to products having thickness of not less than 0.5mm and more than 2mm.
2) The speed of the penetrator should be kept between 5 to 20mm per minute.
3) The test pieces should be flat and pf such dimensions that the center of any indentation is not les than 45mm from any edge of the test piece and not less than 90mm from the center of the nearest indentation, where the dimensions of the product permit.

RESULT- The Erichsen cupping test shows that the metal with the grater Erichsen number is having more drawing properties and is more ductile.