LABORATORY MANUAL

MATERIAL TESTING LAB

SUBJECT CODE: BME-352

B.TECH. (ME) SEMESTER -III

Academic Session: 2023-24, ODD Semester

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List of Experiments mapped with COs

S. No	Aim of the Experiment	COs
1.	Strength test of a given mild steel specimen on UTM with full details and stress versus strain plot on the machine.	CO1
2.	Other tests such as shear, bend tests on UTM.	CO4
3.	Impact test on impact testing machine like Charpy, Izod or both.	CO1
4.	Hardness test of given specimen using Rockwell and Vickers/Brinell testing machines (this test should be conducted on MS Specimen – prior and after the various heat-treatment processes like Annealing / Normalizing / Hardening etc.; with this, 2 experiments can be designed: one for Annealing or Normalizing and another for Hardening / Tempering).	CO2
5.	Fatigue test on fatigue testing machine.	CO3
6.	Creep test on creep testing machine.	CO3
7.	Study of NDT (non-destructive testing) methods like magnetic flaw detector, ultrasonic flaw detector, eddy current testing machine, dye penetrant tests	CO4
8.	Modelling of Graphene / any other materials structure using LAMMPs (LAMMPS Molecular Dynamics Simulator) or any other simulation software and studying the mechanical properties.	CO5
9.	Measurement of mechanical properties (tensile test, compression test, hardness test / flexural test) of specimen made by 3-D printing	CO2

EXPERIMENT 1-

AIM

Strength test of a given mild steel specimen on UTM with full details and stress versus strain plot on the machine.

EQUIPMENTS USED

1. Universal Testing Machine
2. Specimen
3. Extenso meter
4. Scale

THEORY

A solid bar when loaded in tension elongates as the applied load to it increases. Then mechanism so separation of atoms is in the direction of loading. The separation of atoms is due to the displacement of atoms from the normal equilibrium position. So long as the mechanism involved is only separation of atoms, by relatively small amounts the release of the applied load will allow the atoms to return to their original position. If the axially loaded barreturns to its original shape and size, then the deformation is said to be elastic deformation.

PROCEDURE

1. A test to express the mechanical properties and to get the behavior of materials is the tensile test. The machine used here is Universal Testing Machine (U T M).
2. In the test, the metal piece is first prepared by turning into one of the standard shapes (either Round or Flat).

3. The ends of the test piece are gripped in the tensile testing machine and a gradually increasing load is applied until failure is approached.

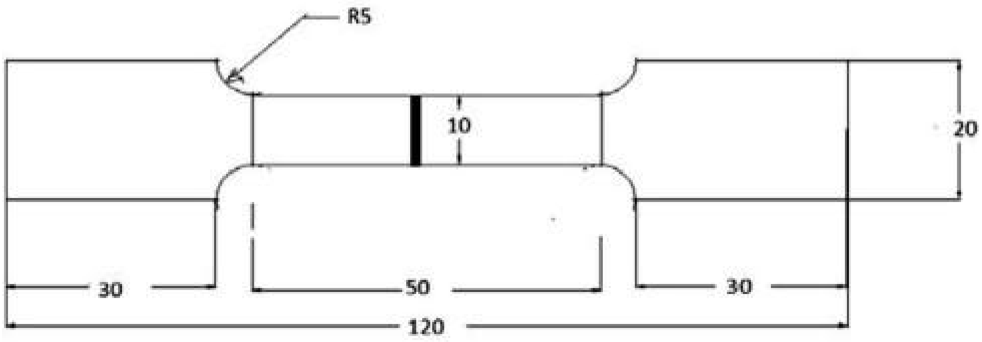
4. The amount of elongation in the test piece caused by load is measured by extensometer.

5. As the load increases, elongation increases.

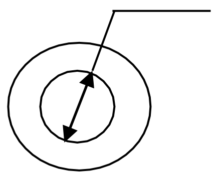
6. The stress is calculated from the load and the original dimensions of thepiece.

7. Finally, a graph is plotted with stress on abscissa and strain on ordinate toget the Stress-Strain curve.

SPECIMEN DIMENSIONS



Φ = 10



TABULATION :

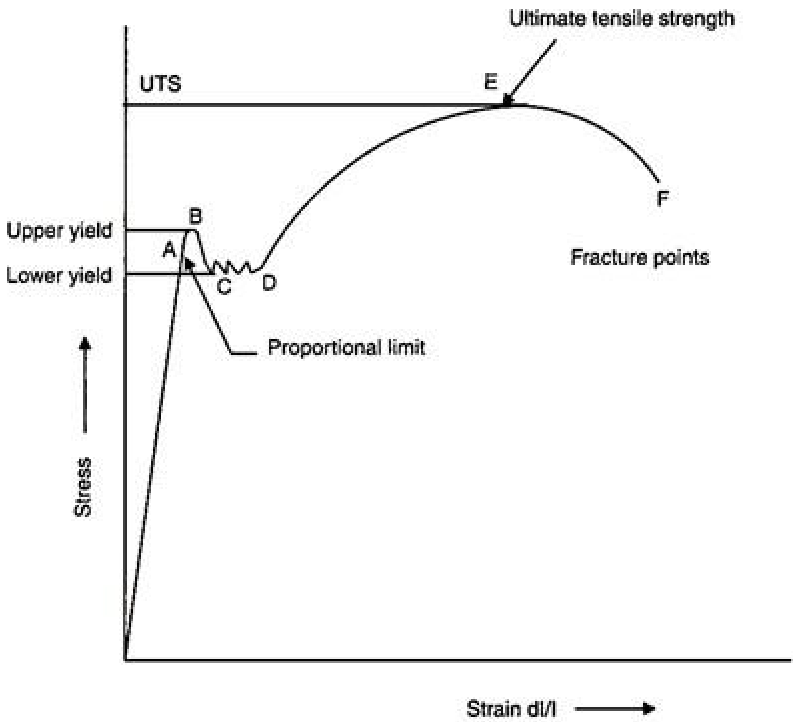
ELONGATION (mm)	LOAD (Kg)	STRESS (N/mm^2)	STRAIN

RESULTS

The tensile test was conducted on the given specimen and the following were found

1. Area of specimen =
2. Fracture stress =
3. Ultimate tensile stress =
4. Upper yield stress =
5. Lower yield stress =
6. Young's modulus =
7. Toughness of material =

MODEL GRAPH



A typical stress-strain curve for mild steel

QUESTIONS

1. Distinguish between Elasticity and Plasticity
2. Define Hooke's law.
3. Differentiate between Ductile and Brittle materials.
4. Whether the given material is Ductile or Brittle? Comment on your answer.
5. Compare the results with standard data book and comment.

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EXPERIMENT 2

AIM

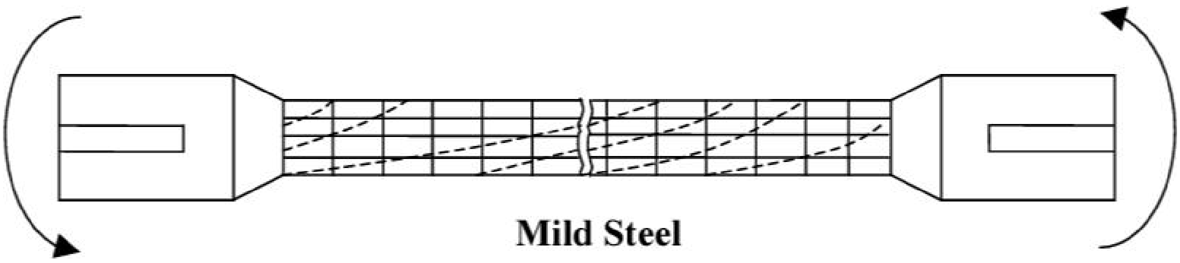
To determine the rigidity modulus and maximum shear stress for the given material.

EQUIPMENTS USED

1. Torsion testing machine
2. Specimen
3. Vernier caliper
4. Scale

THEORY

A structural member subjected to a twist about an axis is said to be loaded in torsion. A shaft, which has strength normally greater, is set for transmission of power and components of control system and for determining the properties of material. The shear stress is maximum at outer radius.



FORMULAE

$T / J = G\Theta / l = \tau / r$---------------------------------------(1)

Where,

G = Modulus of rigidity (GPa)

Θ = angle of twist in the rod (Radians) r = radius of specimen (mm)T =

torque applied (N-m)

l = length of the specimen (mm)

J = polar moment of inertia (mm^4)τ =

shear stress (N/ mm^2)

PROCEDURE

1. Initially the specimen to be tested is fixed in the machine and machine calibrated by adjusting the needle to read zero in the dial.
2. Now a mark is made near the operating wheel.
3. The specimen is twisted at a rate of angle 0.4° per rotation of the operatingwheel and the torque values are tabulated.
4. The polar moment of inertia is calculated using the formula,

$$J = \pi d^4 / 32$$

5. The shear stress and rigidity modulus are calculated using the formula (1).
6. A graph is drawn between angle of twist and shear stress.
7. The slope of the curve will give the rigidity modulus. The same is comparedwith theoretical value.

RESULT

The torsion testing was conducted on the following specimen.

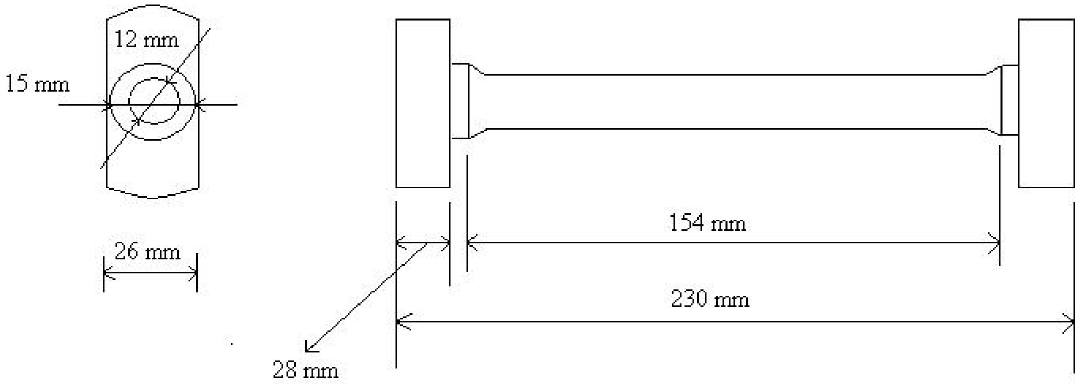
Maximum shear stress =

Rigidity modulus of material =

GRAPH

TABULATION

S. No	ANGLE OF TWIST (Deg)	TORQUE APPLIED(N-m)	ANGLE OF TWIST (Deg)	TORQUE APPLIED (N-m)



QUESTIONS

1. Derive the relation between Young's modulus and Rigidity modulus.
2. Mention the advantages in selecting tubular components over solid components for torque transmission.
3. A shaft of uniform solid circular section is subjected to a torque of 1500 N m. Determine the maximum shear stress in the shaft and its resulting angle of twist, if the shaft's diameter is 0.06 m, the shaft's length is 1.2 m, and therigidity modulus, $G = 77 \times 109$ N/m^2. What power can this shaft transmit if it is rotated at 400 rev/min?

EXPERIMENT 3

HARDNESS TEST

AIM

Hardness test of given specimen using Rockwell and Vickers/Brinell testing machines

EQUIPMENTS USED

1. Brinell harness testing machine
2. Vickers hardness testing machine
3. Materials
4. Microscope

THEORY

Hardness of a substance can be defined as the resistance to indentation. There is direct relation between the hardness and other mechanical properties. Hardness canbe measured in the following ways

1. Resistance to indentation is static or dynamic load.
2. Resistance to scratching.
3. Resistance to abrasion.
4. Resistance to cutting.

On the metallurgical sense, it has become a practice to understand hardness as the indentation hardness only. Other hardness may be used for routine check up. Unfortunately the different types of hardness are not related to each other. However the different indentation hardness values measured are to a certain extent inter- convertible.

FORMULA

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

Where,

BHN = Brinell hardness numberP = Load

applied in ‘kg’

D = Diameter of indenter in ‘mm’

d = Diameter of indentation in ‘mm’

Usually,

$P / D^2 = 30$ for Steel

= 10 for non-ferrous metals

= 2 for soft materials like Lead

VHN = 1.854 P / d³

Where,

VHN = Vickers hardness Number,

P = Load applied

d = Diagonal length of indentation

PROCEDURE

1. In Brinell hardness test, a hardened steel ball of 10 mm diameter is indented on a flat polished surface of the sample under a load, usually 500 to 3500 kg.

2. The load is maintained for 10 to 15 seconds and the diameter of the indentation made on the test piece is subsequently measured by means of microscope in the order of accuracy being 0.01 mm.

3. The Brinell hardness number is obtained from the equation,

BHN = load on ball / area of indentation

TABULATION Brinell Hardness – Steel ball D = 10 mm

Material	Load	Dia of indentation	BHN number
MILD STEEL			
DURALUMIN			
PURE ALUMINIUM			

TABULATION Vickers Hardness – Diamond Indenter

Material	**Load**	**Length of diagonal**	**VHN number**
H S S			
18% Cr - SS			
ALUMINIUM			

PROCEDURE

1. The Vickers hardness HV is the ratio of the test load 'P' to the surface area'F' of the permanent impression made by a four-sided diamond pyramid.
2. The angle of which is 136^0 between the sides facing each other.
3. The length of the diagonal 'd' should be measured with an accuracy of 2 microns.
4. If the length of the diagonal exceeds 0.5 mm an uncertainty of 5 microns is permissible.
5. It is calculated from the following formula.

$$HV = P / F = Px1.854 / d^2$$

RESULTS

The hardness test was conducted on the given material, the BHN and VHNvalues were found to be

The BHN for Mild steel	=
The BHN for Duralumin	=
The BHN for Aluminium	=
The VHN for HSS	=
The VHN for 18% Cr – SS	=
The VHN for pure Aluminium	=

QUESTIONS

1. Define hardness
2. Derive BHN = $\frac{2P}{\pi D(D-(\sqrt{D^2-d^2}))}$
3. Derive VHN = 1.854 / d^2
4. Is this hardness test is destructive? Why?
5. For higher hardness whether Brinell or Vickers is preferred?
6. Compare the significance of different types of hardness test.

EXPERIMENT 4

AIM

To determine the rigidity modulus of given spring material.

EQUIPMENTS USED

1. Spring
2. Weights
3. Screw Gauge
4. Scale
5. Vernier Caliper

THEORY

Springs may be made of carbon steel, silicon steel and manganese steel or somecompletely alloyed steel. It is essential to know the rigidity modulus, because springs are used most of the engineering parts.

FORMULAE

Deflection, $\alpha = 8nPD^3 / Gd^4$

Where,

n = Number of effective turns

D = Mean diameter of springs (outer dia – wire dia)

G = Torsional or Rigidity modulusd = Wire

diameter

P = Load

PROCEDURE

1. The given spring is fixed on the experimental setup initially.
2. The length of the spring is found without adding any load.
3. A load of 0.5 kg is added to the spring and the compressed length of the spring is noted.
4. The 0.5 kg loads are gradually increased up to 10 kg and corresponding lengths are noted..
5. Now the loads are removed in steps of 0.5 kg and the corresponding lengthsare also noted.
6. The number of effective turns of the spring is noted.
7. Mean diameter of the spring is calculated using a vernier caliper.
8. For a load 'P' kg with the deflection 'α', the rigidity modulus of the givenspring can be calculated using the formula,

$$\mathbf{G = 8nPD^3 / \alpha d^4}$$

9. A graph is drawn between deflection and load. From the slope, the stiffnessof the spring or spring constant is calculated as,

Spring constant = Slope X 9.81 N / m

RESULT

BULK MODULUS OF THE SPRING

1. From the graph...........................GPa
2. From tabulation........................ GPa

STIFFNESS

3. From the graph.................... N - m
4. From the tabulation............. N – m

TABLATION

S. NO	LOAD APPLIED	DEFLECTION LOAD UNLOAD	MEAN LENGTH	MEAN DEFLECTION	STIFFNESS LOAD DEFLECTION

GRAPH

LOAD Vs DEFLECTION

QUESTION

1. What are the uses of springs?
2. What are the materials used in the manufacture of springs?
3. For the same spring, if P = Kg., what will be the D / d ratio?
4. A spring for a balance to measure 0 to 1000 N over a scale of length 80 mmis to be designed. The spring is to be enclosed in a casing of 25 mm diameter. The approximate number of turns is 30. The modulus of rigidity is85 kN/mm^2. Calculate the outer diameter, mean diameter of the spring coil. Wire diameter of spring = 4 mm.

EXPERIMENT 5- FATIGUE TEST

AIM

Fatigue test on fatigue testing machine.

Completed reversed stress cycle.

EQUIPMENTS USED

1. Fatigue testing machine
2. Specimen
3. Vernier caliper

THEORY

Like human, metals also experience fatigue. To avoid human fatigue we take some rest or food whereas this is not possible for metals and alloys.

Fatigue is generally defined as the breakage of the material when it is subjectedto cyclic loads. The fatigue is time dependent phenomenon. The fatigue characters are generally represented as stress – no. of cycles diagram.

SIGNIFICANCE OF FATIGUE FAILURE

The stress required for fatigue failure is less compared to the stress required forother failures. All vibrating parts experiencing consistent reversal of load undergo failure. It occurs without any warning. Fatigue failure is a brittle one.

FORMULA

$$M = \sigma b h^2 / 6$$

Where,

M = Bending momentσ = Stress

applied

b = lowest breadth of the specimenh = thickness of

the specimen

Number of cycles = Time of fracture x Motor rpm

PROCEDURE

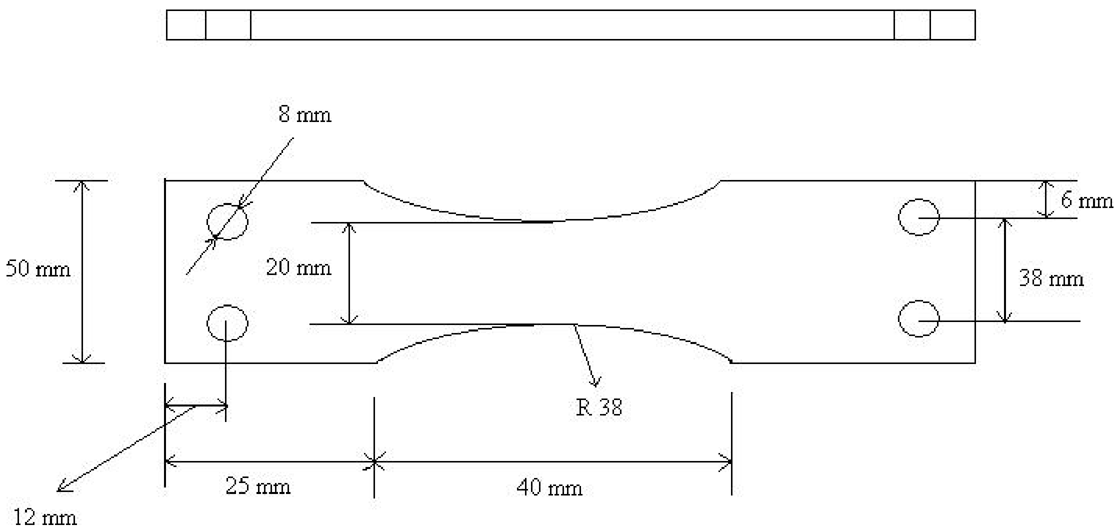
1. A fatigue testing machine attempts to simulate stress developed in parts by vibration of cyclic loads as in service.
2. The specimen is rotated at any given position and it attenuates between two positions.
3. Then the dial gauge is adjusted to zero.
4. The tip is adjusted for the dial gauge to read the reading corresponding tothe bending moment.
5. Then the motor is started on to fatigue, the specimen attains fracture aftersome time.
6. The time taken for fracture is noted. The number of cycles is thencalculated.

RESULTS

For the given specimen the number of cycles for the fatigue fractureis revolutions.

QUESTIONS

1. Define fatigue.
2. What is meant by endurance limit?
3. Write shirt notes on effect of composition, size, surface condition, etc on fatigue test.
4. Describe briefly about Orawans' s theory for fatigue failure.


8 mm
6 mm
50 mm
20 mm
38 mm
R 38
25 mm
40 mm
12 mm

EXPERIMENT 6- IMPACT TEST

AIM Impact test on impact testing machine like Charpy, Izod or both.

EQUIPMENTS USED

1. Impact testing machine
2. Specimen

THEORY

Some materials such as Cast Iron shows a very high tensile strength however, ifit is hammered it breaks. The material may be strong in static loading and may fail quickly in dynamic loading. The knowledge of dynamic effect is much needed in practical applications. A simple tensile test does not reveal the nature of metals and hence it is necessary to test the metals under shock or sudden loads.

The principle employed in the test is that almost all materials absorb some energy before it breaks. If it is brittle, it breaks readily i.e., it absorbs less energy. If it is tough, it needs more energy to fail.

PROCEDURE

1. The specimen is supported in a block, which fits in place of gripping dies.
2. A centering gauge for setting the specimen in correct position is located in the test.
3. The supports are 40mm apart, as required for 10mm specimen.
4. The specimen is square section of 10x10 mm and 50mm long, with 45^{o}, 2mm V-notch across the center of one side and is supported horizontally at both the ends.
5. The pendulum is released from the top to strike the specimen.
6. The toughness is directly measured from the reading of the pointer.

Corrections and Calibration

In the illustration,

W = Weight of the pendulum

R = Length of the pendulum (distance from its center of gravity to thepoint of support).

A = angle of fall B = angle of riseH

= height of fallh = height of rise

Initial energy (the energy in the pendulum

before it breaks the specimen) = WH

= WR(1-CosA)

Final energy (the energy remaining in the pendulumafter it broken the

specimen) = Wh

= WR(1-CosB)

Energy of rupture of specimen = W(H-h)

= WR(CosB – CosA)

A correction to the angle of rise is necessary. The bearing friction is calculated by swinging the pendulum in the air (without any specimen) and noting the pointer readings for a certain number of swings. The decrease in the pointer reading per swingis estimated. This is added to the angle 'B'. The pendulum not only breaks thespecimen but also throws out the fragment. The energy expended in this process should also be taken into account. This should be subtracted from the value of the energy indicated as absorbed by the material in fracture.

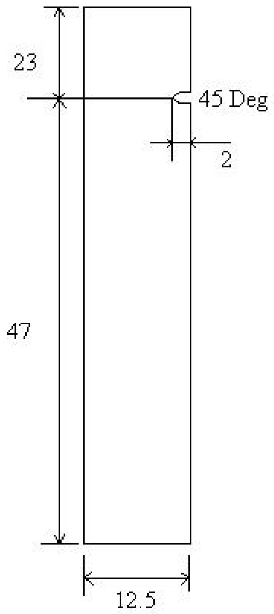
If the weight of the fragment be 'w' and 's' the distance of the specimen from the rotational axis of the pendulum, the energy expended moving the broken fragments will be, e = w.s. (1-Cos B).

RESULT

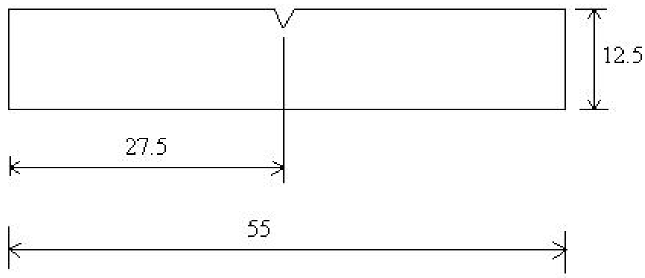
The toughness of given material is..Joule

QUESTIONS

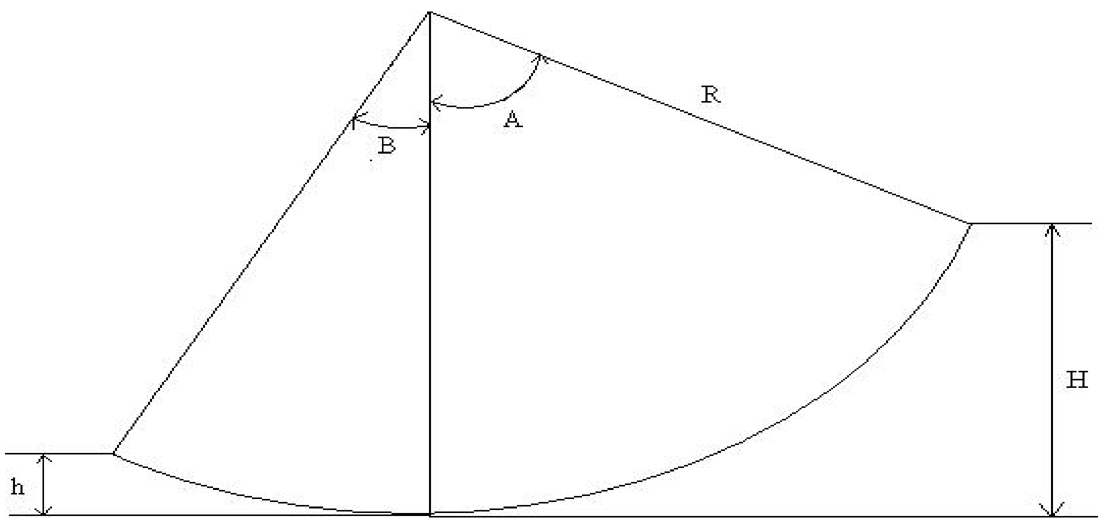
1. Explain Ductile to Brittle Transition Temperature(DBTT)
2. Write briefly on effect of test variables on absorbed energy.



IZOD TEST



CHARPY TEST



EXPERIMENT 7 - DEFLECTION OF BEAMS

AIM

To complete the various (both theoretical and practical values) of the deflection ifbeams of different materials.

APPARATUS REQUIRED

1. Vernier caliper
2. Weights
3. Measuring gauge (for measuring deflection of beam)
4. Different rods of different materials (such as Aluminium, Mild steel andStainless steel).

FORMULA USED

1. Theoretical deflection

$\delta = WL^3 / (48\ EI)$ (m)

Where,

δ = Deflection of beam (cm)

W =Weight of dead load + weight of 79 cm of the rods + added weight (kg)(Weight of dead load = 79 cm)

L = Length of the rod between the knife edges (in ‘m’)E = Young’s modulus of the material (N/m^2)

I = Moment of inertia of the rod (m^4)

If the rod is of rectangular cross section,I= $b\ d^3 / 12$ (m^4)

Where,

b = Breadth of the rod (m)d = Width of the rod (m)

If the rod is of circular cross section, $I = \pi D^4 / 64$ (m^4)

D = diameter of the wire (m)

2. Practical deflection

δ = Reading shown in the gauge (m)

THEORY

The axis of the beam deflects from its position under action of applied forces. Accurate values for this beam deflection are sought in many practical cases. Elements of machines must be sufficiently rigid to prevent misalignment and to maintain dimensional accuracy under load.

PROCEDURE

1. The given rod is fixed in between the two knife edges of the apparatus.
2. The dial head is set in zero condition.
3. Now the load is applied to the rod at its centre.
4. Reading for the load is measured from the gauge head. The measured readinggives the practical deflection of the beam directly.
5. Now the reading is taken for increasing loads of 0.5 kg to 2.5 kg.
6. The values are tabulated and the dimension of the rod is measured.
7. In the similar way the practical deflection is measured for different materialswith various cross sections.
8. The theoretical deflection is measured using the relation. $\delta = WL^3 / (48\ EI)$ (m)
9. The error % in the value is calculated using

$$\text{Error \%} = \frac{(Practical\ Value - Theoretical\ value) * 100}{Theoretical\ Value}$$

W = Dead load = 79 gm

'E' for Stainless steel and Mild steel = 2 × 10^5 N/mm^2'E' for

Aluminium = 0.675 × 10^5 N/mm^2

RESULT COMMENT

Thus the deflection of the beam of different materials are found and compared. Thus practical deflection value of the beam is comparatively less than that of the theoretical value because the device used to measure the deflection is not exactly kept in the middle, so we get some error in practical deflection value. Some errors may be in the measuring device due to the above reasons the errors may occurred.

RESULT

Thus the theoretical and practical values of the deflection of beams arecompared and
percentage error is calculated.

1. **STAINLESS STEEL**

Maximum error =Minimum error =

2. **MILD STEEL (RECTANGULAR CROSS SECTION)**

Maximum error =Minimum error =

3. **MILD STEEL (CIRCULAR CROSS SECTION)**

Maximum error =Minimum error =

4. **ALUMINIUM**

Maximum error =Minimum error =

MEAN DEFLECTION

1.STAINLESSS STEEL

Theoretical deflection =Practical deflection =

2.MILD STEEL (RECTANGULAR CROSS SECTION)

Theoretical deflection =Practical deflection =

3.MILD STEEL (CIRCULAR CROSS SECTION)

Theoretical deflection =Practical deflection =

4.ALUMINIUM

Theoretical deflection =Practical deflection =

S.No.	Material	Dimensionof the Material	Weight	Deflection Shown In Gauge (mm)	$\Delta = WL^3/(48 EI)$	Error %
1.	Stainless Steel	Φ = 10mm				
2.	Mild Steel (Circular Cross Section)	Φ = 10 mm				
3.	Mild Steel (Rectangular Cross Section)	10 ×10 mm				
4.	Aluminium	Φ = 12.4 mm				

QUESTIONS

1. Why theoretical deflection values are not coincided practical deflection values?
2. Mention the significant of the experiment?

EXPERIMENT 8 – NON DESTRUCTIVE TESTING

AIM

Study of NDT (non-destructive testing) methods like magnetic flaw detector, ultrasonic flaw detector, eddy current testing machine, dye penetrant tests.

NON DESTRUCTIVE TESTING

Non-destructive testing refers to the use of testing techniques that do not alter any of the properties of the tested product. These properties could be its strength, integrity, appearance, corrosion resistance, conductivity, wear resistance, toughness and so on. Non-destructive testing is also known as non-destructive evaluation, non-destructive analysis, non-destructive examination and non-destructive inspection.

When the product passes an NDT test, it can still be used. There's no detrimental effect on the specimen because of the test.

This advantage makes non-destructive testing a very useful method for products that are freshly manufactured as well as for those that are already in service.

When the scope of work is simple, using a single NDT process may be sufficient. But in a lot of cases, a combination of techniques and test methods are used for concrete information about the product characteristics.

NON DESTRUCTIVE TESTING METHODS:-

1. Visual Testing
2. Ultrasonic Testing
3. Liquid Penetrant Testing
4. Radiographic Testing
5. Magnetic Particle Testing

Visual Testing

Visual testing remains the most popular NDT method across all industries. It involves taking a thorough look at the specimen and finding defects that are visible to the naked eye.

It is a quick and feasible method of tracking product quality at every stage of the manufacturing process as well as for those products that are in service.

With visual inspections, we can detect corrosion, cracks, welding defects, deformation, etc. All we need are simple instruments such as rulers, gauges or a camera.

When inspectors are not able to reach hard-to-access places or dangerous environments, drones can often be the solution.

Many industries are in fact using AI and machine learning to improve visual inspection results. For instance, such technology is becoming common in the maintenance of conveyor belts, rollers and pulleys in conveyor systems.

Advantages of visual testing:

- Safe
- Portable
- Effective
- Inexpensive
- Easy to train
- Minimal or no downtime
- Minimum or no part preparation needed

Disadvantages of visual testing

- Only works with surface defects
- Possible misinterpretation of flaws
- Cannot detect minute defects without additional optical instruments

Ultrasonic Testing

Ultrasonic testing remains the most popular nondestructive testing method after visual testing.

In this method, a high-frequency sound wave generated by a transmitter travels through the object under test. The frequency of this wave is usually between 1 and 10 MHz.

The wave distorts when encountering a change in the density of the material. This change in the transmitted wave is captured by a receiver.

The equipment then measures and analyses the received wave to understand the nature and depth of the defect. The equipment can also calculate the thickness of the specimen by dividing the wave speed in the material by the time taken for travel.

There are many types of ultrasonic testing available each with its own nuances and field of application. These are pulse-echo testing, immersion testing, guided wave testing and phased array ultrasonic testing to name a few.

We can identify defects such as cracks, abrasions, thinning, pitting and corrosion using ultrasonic inspection.

Advantages of ultrasonic testing:

- Quick
- Clean
- Reliable
- Portable
- Safe and easy to use
- Highly accurate and sensitive
- Ability to gauge dense materials
- Detection of surface and subsurface defects
- Identifications of minor defects not visible to the naked eye

Disadvantages of ultrasonic testing:

- Requires training
- Needs a smooth surface
- Difficult to use with thin materials
- Part geometry may create complications
- Wave propagation speed in tested material must be known for accurate results
- Couplants are required for smooth wave transfer from the transmitter to the specimen

Liquid Penetrant Testing:-

Liquid penetrant testing is another popular non-destructive testing method used to identify surface-level defects.

In this method, a low-viscosity liquid (penetrant) enters the surface defects such as cracks, fissures and voids. The excess liquid is then wiped off and the specimen is left alone for some time (penetrant dwell time).

The inspector then applies a developer that allows the penetrant to move towards the surface. The specimen is again left alone for a prescribed amount of time (developer dwell time).

Now, the inspector performs the surface inspection. If the dye is visible, it can be inspected with the naked eye. In the case of fluorescent dyes, black light is needed for inspection.

We can detect surface discontinuities such as cracks, porosity, seams, laps and leaks using this method.

Advantages of liquid penetrant tests:

- Works with many materials. Material properties such as magnetism, conductivity and metallic/non-metallic do not matter
- Can spot tiny defects such as hairline cracks
- Suitable for complex part geometries
- Low cost
- Can test large areas
- Portable
- Easy to use

Disadvantages of liquid penetrant tests:

- The depth of defects is not known
- Risk of exposure to toxic fumes
- Cannot identify subsurface defects
- Does not work with porous materials
- Time-consuming, generally needs more than 30 minutes
- Messy operation, pre- and post-cleaning are necessary
- Involves handling of chemicals and therefore not it’s not as safe as other methods. Chemical disposal may also become an issue

Radiographic Testing-

Radiographic testing uses radiation to spot internal defects in parts. X-rays work well with thinner materials whereas gamma rays are better for thicker materials.

The specimen is placed between the radiation source and a recording media. When the radiation falls on the part, the amount of radiation that exits the part in different locations is captured. A physical radiography film or a digital detector is used as the recording media.

The test allows us to obtain the shape and size of internal defects by changing the angle of radiation exposure.

We can use radiographic testing to pinpoint defects such as cracks, thinning, corrosion, voids, insufficient fusion, porosity, excess root penetration and laps.

Advantages of radiographic testing:

- Can test complex structures
- Documentation is permanent
- Works with a range of materials
- Needs minimum surface preparation
- Can record surface and subsurface defects
- Portability is possible for gamma ray testing
- Less misinterpretation of results compared to other methods

Disadvantages of radiographic testing:

- More expensive
- Needs two-sided access to specimen
- Not as effective for planar and surface defects
- High voltage and radiation can be harmful to personnel
- Skilled personnel needed for execution and accurate interpretation of results

Magnetic Particle Testing

Magnetic particle testing is also a fairly popular NDT technique because of its fast execution where no surface preparation is needed.

In magnetic particle testing, the part is placed between permanent magnets or electromagnets. The strength of the field is an important factor since a stronger field gives better results.

When the part under inspection is placed into the field, a magnetic current starts flowing through the specimen. If there's no defect, an uninterrupted magnetic flux field is obtained.

But if it comes across a defect, the magnetic field bends and a part of it leaks out. This leakage is also known as the flux leakage field.

In order to identify the defects via these leakage points, magnetic particles are used. These particles are applied to the test specimen and they are pulled into these leakage points because of the uneven magnetic flux density.

We may either use magnetic particles that can't be seen with the naked eye or fluorescent ones for better visibility.

The width of the magnetic particle strips is wider than the defect's width. As a result, it can reveal minute defects with an opening width of up to 0.001 mm and depth of 0.01 mm.

With this technique, we can detect defects such as cracks, pores, laps, inclusions, seams, laminations, shrinks, flakes, welding defects, machining tears and also service-related or fatigue cracks.

Advantages of magnetic particle testing:

- Easy to use
- Portable setup
- High sensitivity
- Immediate results
- Usually inexpensive
- Can work through thin surface coatings
- Parts with complex geometries are also suitable
- Visual indication of the shape and size of the defect
- Can detect surface defects well. Also works for subsurface defects to an extent

Disadvantages of magnetic particle testing:

- Can only test small areas at a time
- Does not work with non-magnetic materials
- Testing may burn the particle if the field is too strong
- Coatings thicker than 0.1 mm need removal for testing
- Demagnetization of test specimens is necessary but may be tricky
- Can only work for subsurface defects that have a depth of up to 3 mm

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