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Aurangabad

Maharashtra Institute of Technology, Aurangabad

Department of Plastics and Polymer Engineering

LABORATORY MANUAL

Academic Year: 2018-19 **Part: I** **Course: Polymer Testing**

Course Coordinator: Dr. Prashant Gupta

Experiment: 1

AIM: - To determine the Tensile strength of given polymer sample.

SIGNIFICANCE: -Composites and Plastic are polymers with substances added to improve performance or reduce costs. Plastic may be pressed or cast or extruded into sheet, film, or fiber reinforced plate, glass, tubes, fiber, bottles and boxes. Thermohardening or thermosetting plastics can be brittle or hard and temperature resistant. Thermosets include polyester resins, epoxy resins, polyurethane, phenolic resins, non-meltable, non-deformable and polyurethane. Polymers and plastics can be tensile tested to measure product quality. Tensile tests measure the weight required to split or break a plastic test material and sample elongation or stretch to that breaking load. The resulting data help to identify product quality and quality control checks for materialsThe measurements taken during the test reveal the characteristics of a material while it is under a tensile load.

Principle: - Tensile test is a measurement of the ability of a material to withstand forces and tend to pull it apart and to determine at which extent the material stretches before breaking.

Tensile Stress: - The tensile load per unit area of original cross-section carried by the test specimen at any time interval. It is expressed in megapascals (MPa).

% Elongation: - Increase in the distance between reference line on the test specimen due to tensile load. It is expressed in percentage (%).

Yield Point: - The first point on load extension curve at which the rise in extension occurs without rise in the stress.

Elastic Modulus: -Often referred to as Young's modulus, or the modulus of elasticity, tensile modulus is the slope of a secant line between 0.05% and 0.25% strain on a stress-strain plot.

APPARATUS: -UTM, Micrometer, Vernier Calliper, Dumbell Sample.

PROCEDURE: -

1) Measure the width and thickness of the test specimen at several points within the gauge length of 50 mm.
2) It is then placed in the grips of the testing machine.
3) Care should be taken while tightening grip that specimen should be along with the axis of machine.
4) Tightening should be even and firm in both the grip to avoid slippage.
5) The load cell is selected as per the requirement.
6) The speed of testing is set per proper rate the machine is started as the machine elongates; the resistance to the specimen increased and is recorded by instrument.
7) The elongation of specimen continues until there is a loss of 50% load/break..
8) The tensile strength at yield and at break can be calculated as follows.

OBSERVATIONS: -

Length = _______ mm

Width = _______ mm

Thickness = _______ mm

FORMULAE: -

- Tensile strength at yield or break = load at yield point/ original cross-section

- % Elongation at break or peak= ((length at break) - initial length)/ initial length

- Tensile modulus=$E_t=(\sigma_2-\sigma_1)/(\varepsilon_2-\varepsilon_1)$
  where ε_1 is a strain of 0.0005,
  ε_2 is a strain of 0.0025,
  σ_1 is the stress at ε_1, and σ_2 is the stress at ε_2.

CALCULATIONS: -

Tensile strength of peak load = peak load/ thickness X width

% Elongation at peak load = (elongation at peak load/specimen thickness) X 100

RESULT –

The tensile strength at yield point of given sample is____________

ASSIGNMENT QUESTIONS

1. Write down the tensile strength (MPa) of the following materials: LLDPE, PP, ABS, PC, Nylon 6, PET, 20% Glass filled PP, 50% Glass filled Nylon 6, PEEK, Kevlar etc.
2. What is the importance of Young's Modulus of a polymer? Which instrument/attachment is used to measure the same. Draw a mounted image of the instrument with the tensile sample.
3. Explain and discuss with a neat diagram the elements of a typical stress-strain curve for Tensile Testing of plastics.

Experiment No: 2

AIM: - To determine the Compressive strength of given polymer sample.

SIGNIFICANCE: - Composites and Plastic are polymers with substances added to improve performance or reduce costs. Plastic may be pressed or cast or extruded into sheet, film, or fiber reinforced plate, glass, tubes, fiber, bottles and boxes. Thermohardening or thermosetting plastics can be brittle or hard and temperature resistant. Thermosets include polyester resins, epoxy resins, polyurethane, phenolic resins, non-meltable, non-deformable and polyurethane. Polymers and plastics can be tensile tested to measure product quality. The method is used to investigate the compressive behaviour of the test specimens and for determining the compressive strength, compressive modulus and other aspects of the compressive stress/strain relationship under the conditions defined.

The method applies to the following range of materials:

- Rigid and semi-rigid thermoplastic moulding and extrusion materials, including compounds filled and reinforced by e.g. short fibres, small rods, plates or granules in addition to unfilled types; rigid and semi-rigid thermoplastic sheet;
- Rigid and semi-rigid thermoset moulding materials, including filled and reinforced compounds; rigid and semi-rigid thermoset sheet;
- Thermotropic liquid-crystal polymers.

Principle: -Compressive test is a measurement of the ability of a material to withstand forces that tend to reduce size and to determine at which extent the material stretches before breaking.

Compressive Stress: -Compressive load, per unit area of original cross-section, carried by the test specimen It is expressed in megapascals (MPa).

% Elongation: - Increase in the distance between reference line on the test specimen due to tensile load. It is expressed in percentage (%).

Yield Point: - The first point on load extension curve at which the rise in strain occurs without rise in the stress.

Compressive Modulus: -It is theratio of the stress difference ($\sigma_2 - \sigma_1$) to the corresponding strain difference values. Compressive modulus is the slope of a secant line between 0.05% and 0.25% strain on a stress-strain plot.

APPARATUS: -UTM, Micrometer, Vernier Calliper, Compression Sample.

PPROCEDURE: -

1. Measure the width and thickness of the test specimen at several points
2. It is then placed between the platens of the testing machine.
3. The load cell is selected as per the requirement.
4. The speed of compressivetesting is set per proper rate
5. The machine is started as the machine compresses; the resistance to the specimen increased and is recorded by instrument.
6. The strain of specimen continues until it breaks.
7. The compressive strength at yield and at break can be calculated as per the following formulae.

OBSERVATIONS: -

Length = _______ mm

Width = _______ mm

Thickness = _______ mm

FORMULAE: -

- Compressive strength at yield or break = load at yield point/ original cross- section
- % Elongation at break or peak= ((length at break) - initial length)/ initial length
- Compressive modulus= $E_t=(\sigma_2-\sigma_1)/(\varepsilon_2-\varepsilon_1)$
  where ε_1 is a strain of 0.0005,
  ε_2 is a strain of 0.0025,
  σ_1 is the stress at ε_1, and σ_2 is the stress at ε_2.

CALCULATIONS: -

Compressive strength of peak load = peak load/ thickness X width

% Elongation at peak load = (elongation at peak load/specimen thickness) X 100

RESULT: –

The compressive strength at yield point of given sample is____________

ASSIGNMENT QUESTIONS

1. What kind of jaw arrangement is used for compression testing of plastics. Explain with a neat diagram.
2. Discuss in brief some examples where compressive strength of plastics play a crucial role in the desired application.
3. Briefly discuss the process of compressive strength testing of a reinforced plastic composite cube measured 70*70*70 mm.

Experiment No: 3

AIM: - To determine the flexural strength of given polymer sample.

SIGNIFICANCE: - Composites and Plastic are polymers with substances added to improve performance or reduce costs. Plastic may be pressed or cast or extruded into sheet, film, or fiber reinforced plate, glass, tubes, fiber, bottles and boxes. Thermohardening or thermosetting plastics can be brittle or hard and temperature resistant. Thermosets include polyester resins, epoxy resins, polyurethane, phenolic resins, non-meltable, non-deformable and polyurethane. Polymers and plastics can be tensile tested to measure product quality. The method is used to investigate the compressive behaviour of the test specimens and for determining the compressive strength, compressive modulus and other aspects of the compressive stress/strain relationship under the conditions defined.

Principle: -The flexural test measures the force required to bend a beam under three point loading conditions. The data is often used to select materials for parts that will support loads without flexing. Flexural modulus is used as an indication of a material's stiffness when flexed. Since the physical properties of many materials (especially thermoplastics) can vary depending on ambient temperature, it is sometimes appropriate to test materials at temperatures that simulate the intended end use environment.

Flexural Stress: -When a homogeneous elastic material is tested in flexure as a simple beam supported at two points and loaded at the midpoint, the maximum stress in the outer surface of the test specimen occurs at the midpoint. Flexural stress is calculated for any point on the load-deflection curve

% Elongation: -Nominal fractional change in thelength of an element of the outer surface of the test specimenat midspan, where the maximum strain occurs

Tangent Modulus of Elasticity: -The tangent modulusof elasticity, often called the "modulus of elasticity," is theratio, within the elastic limit, of stress to corresponding strain.It is calculated by drawing a tangent to the steepest initialstraight-line portion of the load-deflection curve.

APPARATUS: -UTM, Micrometer, Vernier Calliper, Flexural Sample.

PPROCEDURE: -

1. Measure the width and thickness of the test specimen at several points
2. It is then placed on the loading supports of the testing machine.
3. The load cell is selected as per the requirement.
4. The speed of flexural testing is set at 2 mm/min.
5. The machine is started as the machine flexures; the resistance to the specimen is increased and is recorded by instrument.
6. The strain of specimen continues until it breaks/displacement upto maximum depth to avoid contact of loading nose with base platen.
7. The sample breaks/bends and further calculations are done as per follows:

OBSERVATIONS: -

Length = _______ mm

Width = _______ mm

Thickness = _______ mm

FORMULAE: -

- Flexural Stress = 3PL/2bd2

  Where P = load at a given point on the load-deflection curve,
  L = support span, mm,
  b = width of beam tested, mm, and

d = depth of beam tested, mm.

- Flexural Strain = 6Dd/L2

  Where D = maximum deflection of the center of beam, mm
  L = support span, mm, and
  d = depth, mm
- Flexural modulus= $L^3m/4bd^3$

  b = width of beam tested, mm,
  d = depth of beam tested, mm, and
  m = slope of the tangent to the initial straight-line portion of the load-deflection curve, N/mmof deflection.

CALCULATIONS: -

Flexuralstrength at peak load = peak load/ thickness X width

% Elongation at peak load = (elongation at peak load/specimen thickness) X 100

RESULT: –

The flexural strength at yield point of given sample is____________

ASSIGNMENT QUESTIONS

4. What kind of fixtures are used for flexural testing of plastics. Explain with a neat diagram.
5. Why is conditioning necessary for a flexural strength specimen. What are the conditions at which the process is carried out.
6. Briefly discuss the process of flexural strength testing that was carried out in the laboratory.

Experiment No: 4

Aim: - To find out the impact strength for the given sample.

Apparatus: - Notch cutter, Izod impact tester, sample.

Theory: -

The impact properties of the polymeric material are directly related to the overall toughness of the material. Toughness is defined as the ability of the polymer to absorb applied energy. Impact resistance is the ability of material to resist breaking under a shock loading or the ability to resist the fracture under stress applied at high speed. Most polymers when subjected to impact loading, seen to fracture in a characteristic fashion. The crack is initiated on a polymer surface due to the impact loading. The energy required to initiate such a crack is called the crack initiation energy. If the load exceeds the crack initiation energy, the crack continues to propagate. A complete failure occurs, when a load has exceeded the crack propagation energy. Thus both crack initiation and crack propagation contribute to the measured impact energy. There are basically four types of failures encountered due to the impact load.

The object of the Izod-Charpy impact test is to measure the relative susceptibility of a standard test specimen to the pendulum type impact load. The results are expressed in terms of kinetic energy consumed by the pendulum in order to break the specimen.

Procedure: -

1. Carry out the blank testing, calibrate the instruments.
2. Sample is notched using notch cutter.
3. Clamp the specimen such that the notch is facing toward the pendulum

4. Release the pendulum, the pendulum strikes the specimen and breaks it and the energy absorbed by the sample in Joules is recorded, on the dial gauge.
5. After selecting appropriate dial scale and corresponding unit conversion, calculate Izod impacts strength from given formula.

Observations & calculations: -

1. Length = _______ mm
2. Width = _______ mm
3. Thickness = _______ mm

Energy absorb by sample 1 = __________

Energy absorb by sample 2=__________

Formula: -

Impact strength = Energy absorbed / thickness of sample

RESULT: -

Izod impact strength of given polymer sample is________.

Experiment No: 5

Aim: - Determination of hardness of given polymer sample by shore hardness tester.

Apparatusand chemicals: - Hardness tester and specimens.

Theory: -

Hardness is defined as resistance of body to penetrate of resistance of a plastic material to indentation. In has no. unit that is from 0-100, 0 is related to minimum, while 100 for maximum there are two standard methods for measurement of hardness.

a) SHORE A: -

b) SHORE D: -

Procedure: -

1) Clean the specimen to be tested.
2) Place the soften material on the bar of the shore hardness material such that indenter position approximately at the centre of the specimen and indenter just touches the sample.
3) Press the button provided and note the reading.
4) Similarly, the shore D hardness carried out.

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Observation Tables: -

SR NO.	TEST	SAMPLE NAME	HARDNESS
1	SHORE A		
2			
3			
4			
5			

SR NO.	TEST	SAMPLE NAME	HARDNESS
1	SHORE D		
2			
3			
4			
5			

Results: -

1) Hardness of rubber material is =
2) Hardness of plastic material is =

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Experiment No: 6

Aim: - To determine the heat deflection temperature of the given polymer sample.

Apparatus: - HDT tester, Dial Gauge, Weight & Thermometer.

Theory: -

HDT is defined as the temperature at which a standard test bar (5*0.5*0.25) deflects by 0.01" under stated condition of temperature and pressure. The test is also referred to as Heat Distortion Temperature (**HDT**). The test is commonly employed for the quality control and for screening and ranking the material for short time. It is the single point measurement and does not indicate long term heat resistance of plastics.

Procedure: -

1. A specimen is positioned in the apparatus along with the temp and deflection measuring device and the entire assembly is submerged into oil bath.

2. After 5 min. applying the load the pointer is adjusted to zero and oil is heated at the rate of $2^{O}C$ /min

3. The temp of oil at which the bar has deflected 0.01 inch or 0.25mm is recorded as the heat deflection temp at this specific fibre stress.

Result: -

Heat Deflection Temperature of the given polymer is ________ ^{O}C

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Experiment No: 7

Aim: - To determine the Vicat Softening Point (VSP) of given polymer sample.

Apparatus: - VSP Tester, Dial Gauge, Weight and Thermometer.

Theory: -

The Vicat softening temperature is a temperature at which a flat ended needle of $1mm^2$ circular cross-sectional will penetrate the thermoplastic specimen to the depth of 1mm under specified load using a selected rate of temp rise.

Procedure: -

A specimen is positioned on the specimen support and lower the needle rest on surface of specimen, the entire assembly is submerged in to the oil bath kept at room temperature.

1. The load is applied after the 5 min of applying the load the pointer is adjust to zero and oil is heated at the rate of 50^{O} c or 120 ^{O}C/hrs.
2. The temperature at which the needle penetrates by 1mm is recorded as the VSP.

Result: -

The Vicat Softening Point (VSP) of given sample is ________^{O}C

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Experiment No: 8

Aim: - To determine the specific gravity of given polymer sample.

Apparatus: - Specific gravity tester, beaker.

Theory: -

Specific gravity is defined as the ratio of the weight of the given volume of a material to that of an equal volume of water at a stated temperature. Specific gravity values represent the main advantage of plastic over other materials, namely, light weight. All plastics are sold today on a cost per pound basis and not on a cost per unit volume basis. Such a practice increases the significance of the specific gravity considerably in both purchasing and production control.

Procedure: -

1) Check the pointer of the tester; it should be freely moving on perfectly balanced instrument.
2) Adjust the right side weight turning it clock / anticlockwise so that the pointer should show reading 0/1 on the dial scale.
3) Fix up the rubber sample of around 5.7gms in the needle.
4) The rubber sample fixed on the needle should be in the air while the two weighs on the pointer should be adjusted to show set on the dial scale.
5) Do not touch the weights.
6) Now, fill the beaker with water and immerse the sample the water.
7) Set the sample is immersed in the water without bubbles.
8) Check the reading on the dial, i.e. the specific gravity of the sample.

Result: - Specific gravity of given sample is ________.

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Course Coordinator: Dr. Prashant Gupta

Experiment No: 9

Aim: Determination of MFI of given polymer sample.

Theory:

The melt index, more appropriately known as melt flow rate (MFR) or melt flow index (MFI), test measures the rate of extrusion of a thermoplastic material through an orifice of specific length and diameter under prescribed conditions of temperature and load. A high-molecular-weight material is more resistant to flow than a low-molecular-weight material. However, the data obtained from this test does not necessarily correlate with the processibility of the polymer. This is because plastics materials are seldom manufactured without incorporating additives which affect the processing characteristics of a material, such as stability and flowability. The effect of these additives is not readily observed via the melt flow index test.

Apparatus:

a. Melt Flow Index Tester
b. Stopwatch
c. Weighing Balance

Procedure:

1. Switch on the main power supply of machine and the temperature controller which indicate the current temperature.
2. Set the desired temperature for the material by pressing the set bottom of the controller using the up and down arrow keys.
3. After getting the temperature, lock the retainer plate of orifice and piston on the barrel, after 15 min. remove the piston and keep the same safely on its position.

4. Take 3-4 gm of material and put in a barrel through hopper provided.
5. Remove the hopper and press the material tightly by the material charge provided.
6. Remove the material charge and place piston on the material
7. For ringing alarm set the timer by pressing set key, then the timer will start by giving alarm for the set timer.
8. After carrying out the step 6, heat the material for 5min. and put a desired weight on a piston. Note down the time and take 4-5 sample reading.
9. MFI is calculated in **gm/10min.**
10. After the test is observed, unlock the retainer plate, remove the orifice planer. By using cloth, clean the barrel and provide cleaner that is Xylene.
11. After performing test for sample, orifice and barrel should clean properly before next sample testing.

Observation:

Name of Sample	Weight of sample extruded in 1 min.	Weight of sample extruded in 10 min.
1. 2. 3.		

Result:

MFI of given polymer sample is gm/10min

Applications:

This test is primarily used as a means of measuring the uniformity of the flow rate of the material. The reported melt index values help to distinguish between the different grades of a polymer.

Assignment Questions:

1) What is the correlation between MFI and processing behaviour of material? Explain with example.
2) Enlist the different polymer materials with their MFI.
3) How the flow behaviours of polymer depend on their structure?
4) What precautions should take at the time of handling the MFI tester?

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Experiment: 10

Aim: To determine the surface resistance of a given polymer product

Theory

Surface Resistivity:

Surface resistance of a material is defined as the ratio of the direct voltage applied to the electrodes to that portion of the current between them that isprimarily in a thin layer of moisture or other semiconducting material thatmay be deposited on the surface. Simply stated, surface resistance is theresistance to leakage along the surface of an insulator. The surface resistanceof a material depends upon the quality and cleanliness of the surface of theproduct. A product with oil or dirt particles on it gives lower surface resistance values.

$$\rho S = KsR$$

Where

S = surface resistivity (per square)

R = measured resistance in ohms (V/I)

Ks = P/g

Where:

P = the effective perimeter of the guarded electrode (mm)

g = distance between the guarded electrode and the ring electrode(mm).

For circular electrodes:

$P = \pi D0$

$D0 = D1 + g$

Apparatus:

a) Voltmeter,
b) Current meter,
c) Screen,
d) Round material ring and High voltage electrodes

Measurement of Surface Resistivity, ρs

1. The following is a recommended procedure to be followed when measuring surface resistance/resistivity:
2. Determine the type of material being measured.
3. Make certain the contact electrodes are clean. The electrodes may be cleaned with Isopropyl alcohol.
4. Place the Probe firmly on the surface to be measured. If the material to be tested is soft or very flat, additional pressure should not be required.
5. Select the appropriate test voltage and resistance range.
6. Observe the meter reading for 15 seconds. If it is unstable or the test material is appears to be uneven, apply pressure to the Probe. If the meter reading decreases, continue to apply additional pressure until the reading stabilizes.
7. If the meter reading remains stabilized for several 10seconds, record the reading.

Observation:

Sr.No.	Sample	Surface resistivity
1		
2		
3		

Sample Calculation:

Surface resistivity $\rho S = KsR$

Result:

The surface resistivity of sample is…………

Applications:

A fundamental property of insulators is resistivity. Theresistivity may be used to determine the dielectric breakdown, dissipation factor, moisture content, mechanical continuity and other important properties of a material.

Assignment Questions:

1. Explain in detail the importance of surface and volume resistivity test.
2. What precautions should take at the time of performing the above experiments?
3. Describe the methods of sample preparation and standardization.
4. What factors are affected to electrical properties of polymer?