German – Jordanian University (GJU)

Material Science Laboratory

IE 2210

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Experiment 10

Tensile Testing of Plastics

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Total Mark	**/100**

Objective:

1. To investigate the tensile behavior of polymers.
2. To determine the following properties:
    a. The relationship between tensile stress and strain.
    b. Modulus of elasticity.
    c. The tensile strength.
    d. Percentage of elongation.

Introduction:

Strength can be defined as the ability of a material to resist applied forces without yielding or fracturing.

The strength of materials can be determined using some kind of tests called Tensile Test, in which a tensile load (force) is applied to a specimen of the material and its extension is measured with respect to this load, i.e. Tensile test is used to measure the force required to break a specimen and the extent to which the specimen stretches or elongates to that breaking point.

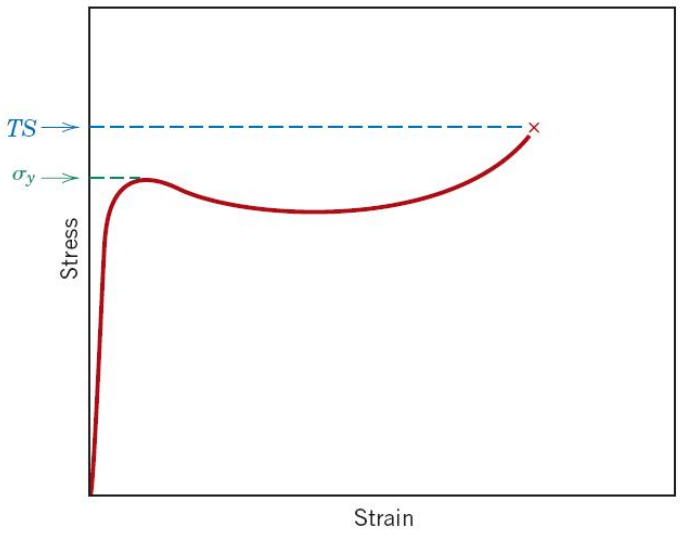
Applying this test, the Stress-Strain Diagram is produced, and we can investigate the tensile behavior of the material and its properties from this diagram.

Stress (σ): the force acting per unit area. $\sigma = \frac{(applied\ load)P\ \ [N]}{(cross\ section)A\ \ [mm^2]}$ [MPa]

Strain (ε): the measure of the elongation or contraction of a line segment in the body. $\boldsymbol{\varepsilon} = \frac{\Delta \boldsymbol{L}}{\boldsymbol{Lo}}$

In this experiment we are studying the tensile behavior of some polymers (Plastics) under specific conditions (such as temperature, initial geometry and speed of testing .etc.)

The testing speed: is the rate of separation of the grips of the testing machine during the test (expressed in [mm/min]).



The tensile behavior of polymers depends on many factors rather than the composition and structure; it depends also on the temperature T and the strain rate (testing speed).

Increasing the temperature results in decreasing of modulus of elasticity (E) and Tensile strength TS but increasing in Ductility (%EL).

The effect of strain rate is completely the opposite of T; while the strain rate of testing increases the ductility of the material decreases and it seems stronger.

Method:

1. **Test Atmosphere:**

    a. Conduct the test in the same atmosphere used for conditioning the test specimen. (the conditions we used in this experiment were:
    T = 23 ^{o}C (+/- 2)
    Humidity = 50% (+/- 5)

2. **Dimensions of test specimen[1]:**

    e. Define the gauge marks on the test specimen; these shall be approximately equidistance from the midpoint.
    f. Measure the width (b) and the thickness (h) at the center of each end of each specimen and within 5 mm of each end of the gauge length (4 readings for each).
    g. Calculate the arithmetic means for the width and thickness of each specimen, which shall be used for calculation purposes.

3. **Clamping:** place the test specimen in the grips.

4. **Prestresses:** the specimen shall not be stressed substantially prior to test.

5. **Adjustment of the Camera:** after balancing the prestresses, set and adjust the camera to be centered to the gauge length of the test specimen.

6. **Testing speed:** set the speed of testing in accordance with the appropriate for the material concerned.

7. **Recording of data:** record the force and the corresponding values of increase of the gauge length and the distance between grips during the test using the automatic recording system of the tester.

[1] In this experiment we have tested three specimens; 2 PVC (Poly Vinyl Chloride) specimens (with different testing rate) and 1 HDPE (High Density Polyethylene) specimen.

Results:

Applying the experiment method we got the following results:

1. Dimensions of test specimens:

Material	Thickness (mm)	Width (mm)	Gauge Length (mm)	Testing Speed
HDPE	3.06	6.12	25	100 mm/min
PVC_1	3.3325	3.175	50	5 mm/min
PVC_2	3.4	11.72	50	15 mm/min

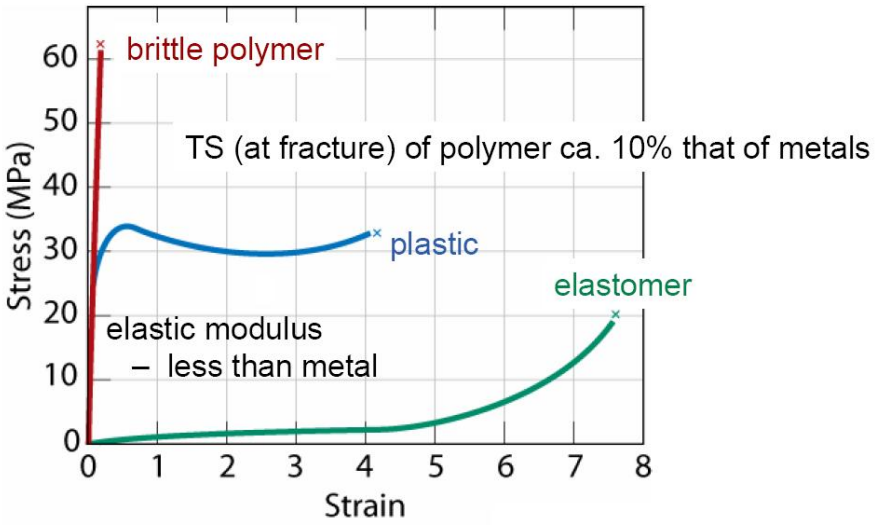
2. Stress-Strain[2] Diagrams:

The stress strain diagram for each specimen was drawn by the automatic recording system of the tester and you can see them in the next pages.

Material	Tensile Strength (MPa)	Yield Stress YP (MPa)	Ductility %EL
HDPE	25.6061	21.4127	640%
PVC_1	50.3081	1.4514	150%
PVC_2	50.7984	-	63%

Discussion and Conclusion:

- In this experiment we learned about the tensile testing of Polymers.
- This test is carried out to study the tensile behavior of polymers (under tensile load).
- There are many properties related to this test such as strength, Ductility toughness, stiffness and so on.
- Polymers differ widely in their tensile behaviors.



[2] The diagrams on Pages(7-9) are force-extension diagrams, that we can turn into Stress-Strain using the two equations of Stress and Strain (in the introduction part of this report).

- The main aim of tensile test is to measure the strength of materials in term of Tensile (Max) or Yield strength (stress).
- The main difference between metals and polymers tensile behavior is that polymers' depends on temperature and strain rate.
- Another important difference is in ductility; since polymers (in general) are much more ductile than metals.
- Metals have more strength than polymers.
- Here we have tested two types of polymers; HDPE and PVC, and we got the following results:
    - HDPE is more ductile than PVC.
    - HDPE has less tensile strength than PVC.
- Applying the tensile test on PVC specimens with different strain rate (5 and 15 mm/min), we got the following:
    - By increasing the strain rate, the strength of polymer increases (here the TS increased from 50.3081 MPa to 50.7984 MPa).
    - By increasing the strain rate, the ductility of the polymer decreases (here from %EL 150% to 63%).
      And these results meet the theoretical information mentioned in the introduction part of this report.
- The PVC specimen with high strain rate has no yield strength i.e. it directly deforms plastically without plastic deformation, because of the high testing speed.
- Tensile test is very important to check if the specimen meets the standards or not.