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Application News

No.i253

Material Testing System

Tensile Test of Plastic Materials

Introduction

The physical characteristics of plastic materials are an essential part of product design and quality control. Various materials tests are performed because of this, of which the most basic test is tensile testing that is cited in many product specifications. The tensile properties of plastic materials assessed by tensile testing include strength, elastic modulus, and breaking strain. Tensile testing of plastics was once performed according to the standard test methods described in ISO 527-1 (JIS K 7161), but ISO 527-1 was revised substantially in 2012 (and JIS K 7161 in 2014). This revision resulted in a number of important changes, of which the main changes are summarized below.

First, the preferred gauge length for type 1A geometry specimens was changed to 75 mm. The previous gauge length of 50 mm is still allowed, but since it became possible to set a longer gauge length, a gauge length of 75 mm is preferred since using this length makes it easier to produce a break within the gauge length. Also, a gauge length of 75 mm is recommended due to the relationship between gauge length and extensometer accuracy that is mentioned below. ISO 527-1 (JIS K 7161) noted that tests must be performed within a standard error of 1 % to calculate elastic modulus accurately. Fig. 1 shows absolute values for the extensometer accuracy required when using a 75 mm and 50 mm gauge length. It shows the absolute accuracy of a 75 mm gauge length is ±1.5 µm, while the absolute accuracy of a 50 mm gauge length is ±1.0 µm. In other words, performing the same test with a 75 mm gauge length increases the permissible range of absolute accuracy. This widens the choice of extensometers and allows the TRViewX non-contact digital video extensometer (absolute accuracy of ±1.5 µm) to be used for standard testing.

The revision also added a method for calculating strain at yield point. The previous Method A calculated strain with equation (1). The newly added Method B calculates strain with equation (2).

$$\varepsilon_t = \frac{L_t}{L} \quad (1)$$

$$\varepsilon_t = \varepsilon_y + \frac{\Delta L_t}{L} \quad (2)$$

ε_t : Nominal strain
L : Initial distance between grips [mm]
L_t : Increase in distance between grips [mm]
ε_y : Yield strain
ΔL_t : Increase in distance between grips beyond the yield point [mm]

Method B is preferred for materials that exhibit yielding and necking. Fig. 2 shows an illustrated image of a strain calculation performed using Method B. Shimadzu's TRAPEZIUM X software supports both Method A and Method B.

In this article, PP (polypropylene), PVC (polyvinyl chloride) and PC (polycarbonate) specimens are tested in accordance with current standards.

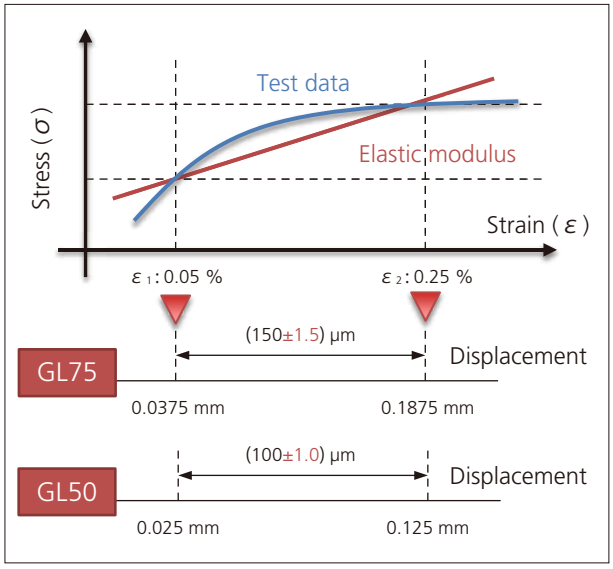

Fig. 1 Comparison of Absolute Accuracy between 75 mm and 50 mm Gauge Lengths

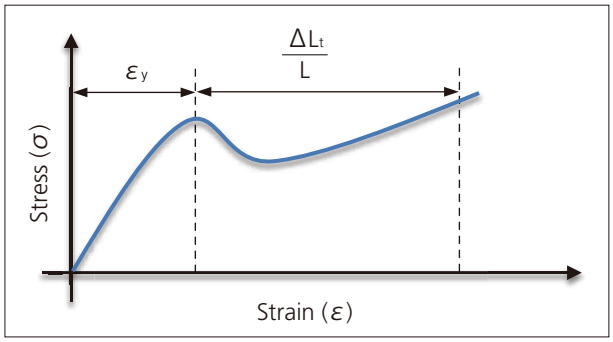

Fig. 2 Strain Calculated by Method B

Measurement System

Measurements were made using an AGS-X table-top precision universal testing instrument, a contact extensometer, and a non-contact digital video extensometer. A gauge length of 75 mm was used with both extensometers. Table 1 shows a list of the equipment used.

Table 1 Experimental Equipment

Testing Machine	: AGS-X
Load Cell	: 5 kN
Gripping Device	: Pneumatic parallel gripping device
Gripping Teeth	: Single-cut file teeth
Software	: TRAPEZIUM X (Single)
Displacement Gauge	: SG75-10, TRViewX 240S

Measured Results

An initial test speed of 1 mm/min was switched to 50 mm/min at 1 mm displacement. The contact extensometer was removed at 1 mm displacement. Fig. 3 shows testing with the SG75-10 and Fig. 4 shows testing with the TRViewX. The respective test results are shown in Table 2 and Table 3, and the stress-strain curve obtained using the SG75-10 is shown in Fig. 5. The results shown in Table 2 and Table 3 confirm that tests were performed successfully since there is almost no difference between them.

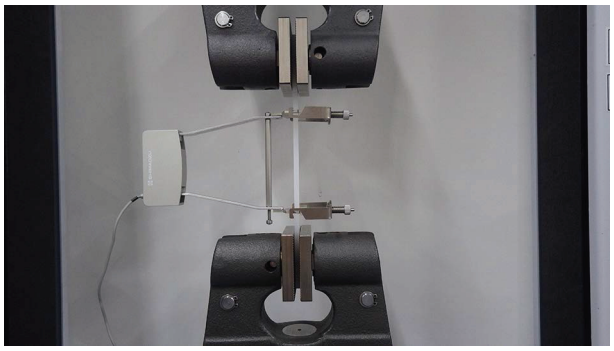

Fig. 3 Testing with SG75-10

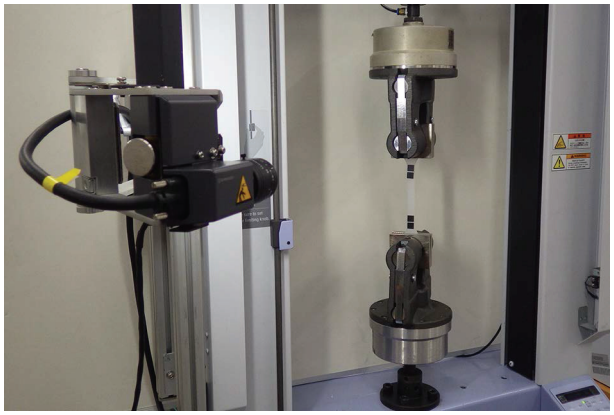

Fig. 4 Testing with TRViewX

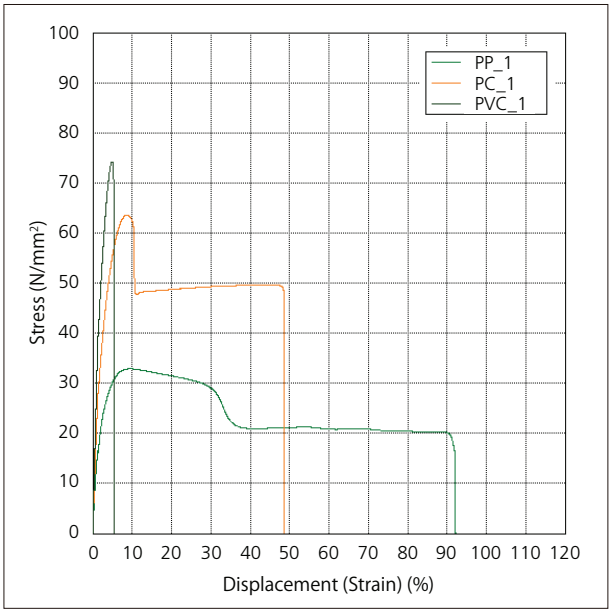

Fig. 5 Test Results Using SG75-10

Table 2 Test Results Using SG75-10

Specimen	Strength [MPa]	Elastic Modulus [GPa]
PP	32.5	1.66
PC	63.3	2.30
PVC	73.4	3.23

Table 3 Test Results Using TRViewX

Specimen	Strength [MPa]	Elastic Modulus [GPa]
PP	32.5	1.63
PC	63.7	2.26
PVC	73.4	3.12

Conclusion

The testing standard for tensile testing of plastic materials has undergone an important revision. Introduction of a 75 mm gauge length brings benefits that include an increased choice of extensometers for elastic modulus measurement and an easier break within the gauge length. Introducing Method B for calculating strain allows a more accurate determination of strain, in materials that exhibit yielding and necking in particular. Testing according to the current ISO 527-1: 2012 (JIS K 7161-1: 2014) standard can be performed successfully using the equipment described in this article.

First Edition: Aug. 2016

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