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Application News

No. i274

Dynamic Ultra Micro Hardness Tester

Hardness Test of Plastic Materials (ISO/TS 19278:2019)

In recent years, plastic materials have been used in diverse products in a wide range of fields, including not only automotive parts such as bumpers, but also daily commodities, packaging, sports products, and medical materials. An important feature of plastic is the fact that products with a wide range of hardness properties can be produced, from soft materials to hard products such as machine parts. Hardness testing is effective in both quality control and research and development because the mechanical properties and physical properties of plastic materials can be measured in a simple and easy manner.

On the other hand, the following issues arise in Rockwell hardness tests of plastics. Due to the large force, correct measurements are not possible with small specimens and thin-film specimens, and when the thickness is less than 6 mm, different scales are used depending on the material, and simple comparison by numerical values of hardness is not possible.

To address these issues, ISO/TS 19278 was issued in 2019 as a technique for measurement of the indentation hardness of plastics. Because specimens are measured at a low force, hardness testing of even small specimens and thin-film specimens is possible, and hardness is evaluated by the same scale irrespective of the type of material. This article introduces hardness testing conforming to the above-mentioned standard (ISO/TS 19278:2019) by the Shimadzu DUH™-210 Dynamic Ultra Micro Hardness Tester for plastics using representative plastic materials.

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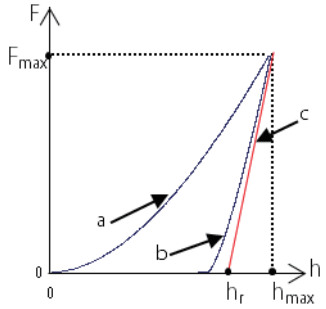
Introduction of Standard

Under the ISO/TS 19278:2019 standard, a hardness tester conforming to ISO 14577-1 (Metallic Materials – Instrumented indentation test for hardness and materials parameters – Part 1: Test method) is necessary. This is a hardness tester that can measure the force and indentation depth in real time, and can evaluate the surface properties of the specimen. Indentation hardness is calculated from the results of one load/unload process using this instrument. In the graph of the force and indentation depth at this time, as shown in Fig. 1, the contact depth is calculated from the maximum depth and the tangent at the start of unloading, and the value obtained by dividing the force F_{max} by the projected area A_p calculated from this contact depth is defined as indentation hardness H_{IT}. Table 1 shows the main test conditions of ISO/TS 19278.

Table 1 Main Test Conditions of ISO/TS 19278

Maximum force	500 mN
Loading time	30 s
Unloading time	30 s
Holding time at maximum force	40 s
No. of test cycles	Min. 5



$H_{IT} = F_{max} / A_p$

$A_p = 23.96 \times h_c^2$

$h_c = h_{max} - 3/4 \times (h_{max} - h_r)$

where, H_{IT} : Indentation hardness
A_p : Projected area of contact between indenter and specimen
h_c : Contact depth
F_{max} : Maximum force
h_{max} : Maximum indentation depth
a : Application of the force
b : Removal of the force
c : Tangent curve to b at F_{max}

Fig. 1 Definition of Indentation Hardness H_{IT}

Samples and Test Conditions

Table 2 shows the specimen information used in the measurements. PP, HDPE, ABS/PMMA, and PS were selected as representative plastics. Table 3 shows the test conditions, and Fig. 2 shows the appearance of the DUH-210 Dynamic Ultra Micro Hardness Tester for plastics.

Table 2 Specimen Information

Sample name	PP, HDPE, ABS/PMMA, and PS
Sample geometry	Rectangular solid, 20 mm × 10 mm × 3 mm

Table 3 Test Conditions

Instrument	Plastic hardness analyzer (Dynamic Ultra Micro Hardness Tester for plastics DUH-210)
Room temperature (°C)	23 ± 2
Humidity (%)	50 ± 10
Upper pressure indenter	Berkovich indenter (diamond)
Test mode	Load/unload test
Test force (mN)	500
Loading/unloading time (s)	30
Holding time (s)	40
No. of test cycles	5

Fig. 2 Appearance of Plastic Hardness Analyzer (Dynamic Ultra Micro Hardness Tester for Plastics DUH™-210)

Test Results

Table 4 shows the hardness test results (average values), Fig. 3 shows the hardness test results (average values) and error ranges, and Fig. 4 shows the force-depth curves. With these sample materials, indentation ranged from 11.2 μm to 23.5 μm at a load of approximately 500 mN, and results showing hardness values of 45.7 to 227.8 were obtained. As the order of hardness, the results showed that the softest material was HDPE and the hardest was PS, as shown below.

PS > ABS/PMMA > PP > HDPE

Table 4 Hardness Test Results (Average Values)

Sample	Force [mN]	Depth [μm]	Indentation hardness H_{IT} [N/mm^2]	Standard deviation
PP	502.3	16.4	103.1	1.59
HDPE	502.2	23.5	045.7	0.87
ABS/PMMA	502.1	12.1	193.8	8.74
PS	502.2	11.2	227.8	6.15

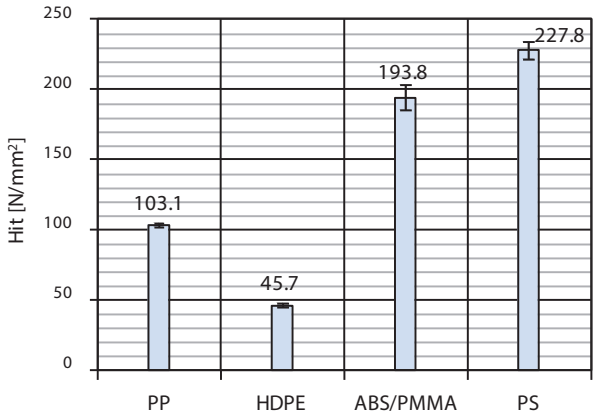


Fig. 3 Hardness Test Results (Average Values) and Error Ranges

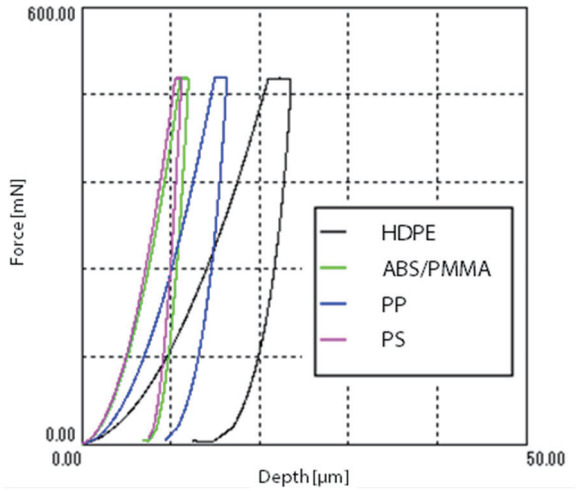


Fig. 4 Force-Depth Curves

Conclusion

This article introduced a standard for hardness testing as a technique for simple and easy measurement of the mechanical properties and physical properties of plastic materials. This standard was established in 2019 through deliberations with the related countries based on a Japanese proposal, and is suitable for hardness evaluations of plastics from the following viewpoints.

- Work related to changes in conditions is not necessary.
- Possible to measure micro specimens smaller than those with conventional techniques.
- Possible to measure specimens with thickness < 6 mm without overlaying.

Based on the above-mentioned features, wide use is possible, from evaluation of resins for quality control purposes to selection of resin materials in product development and evaluation of developed materials.

The plastic hardness analyzer (Dynamic Ultra Micro Hardness Tester for plastics DUH-210) used in this experiment enables simple measurements conforming to ISO/TS 19278.

First Edition: Nov. 2019

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