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Application News

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Material Testing System

Influence of Sampling Speed on Strength Value

Although many metal and resin materials exhibit plastic deformation behavior, glass and ceramic materials display virtually no plastic deformation and thus are subject to brittle failure. When obtaining the material strength of brittle materials by high-speed and short-time measurement, the value of strength and the data scatter may vary depending on the sampling speed of the testing machine.

In this experiment, the effect of the sampling speed on measured strength values was confirmed by conducting strength tests of ceramic and resin samples and adjusting the sampling speed by data processing after the test.

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Tensile Test of Resin

A tensile test of an acrylic resin was conducted with a testing machine Autograph AGX™-10 kNV precision universal testing machine produced by Shimadzu Corporation. The test speed was set to the maximum value of 3000 mm/min and the sampling speed was set to 10,000 Hz. Further details of the test conditions and the specimen are reported in Table 1 and Table 2, respectively. A picture of the test is shown in Fig. 1. After the test, data corresponding to four sampling speeds (5,000 Hz, 1,000 Hz, 100 Hz, 20 Hz) have been obtained by data thinning processing.

Table 1 Test Conditions

Instrument	: AGX-V precision universal testing machine
Load cell	: 10 kN
Test jig	: 5 kN pneumatic flat grip
Grip teeth	: Single file teeth grip face
Initial distance between grips	: 115 mm
Software	: TRAPEZIUM™ X-V Single
Test speed	: 3,000 mm/min
Sampling speed (Hz)	: 10,000, 5,000, 1,000, 100, 20

Table 2 Specimen Details

Resin	: Acryl
Dimensions of narrow portion	: Width 10 mm × thickness 4 mm (ISO 527 dumb-bell-shaped type 1A)

Fig. 1 Tensile Test of the Resin Specimen

Fig. 2(a) shows the results measured at 10,000 Hz, and Fig. 2(b) to (e) show the results for each sampling speed after the data thinning post process. Due to the short measurement time of approximately 0.5s, a significant discrepancy in the force peak value between the data obtained at 20 Hz and 100 Hz was observed. Table 3 shows the tensile strength at each sampling speed, together with the strength decrease ratio against the strength at 10,000 Hz , which was set as the standard value.

The strength decrease from 10,000 Hz is on the order of 1 % at 100 Hz and 4 % at 20 Hz, due to the inaccurate detection of the peak value. Therefore, a minimum sampling speed of 1000 Hz is necessary to correctly evaluate the high speed tensile strength of acrylic resin.

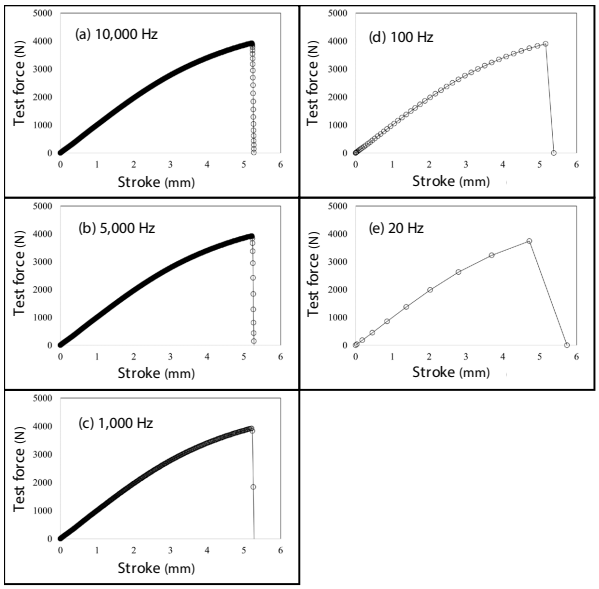

Fig. 2 Test Results

Table 3 Test Results Sorted by Sampling Speed (Average Value, Number of Tested Samples: 5)

Sampling speed (Hz)	Tensile strength (MPa)	Strength decrease ratio* (%)
10000	96.30	-
5000	96.30	0
1000	96.24	0.06
100	95.44	0.89
20	92.69	3.75

* Ratio of strength decrease to strength at 10,000 Hz as standard.

Compression Test of Ceramic

A compression test of an alumina sample was conducted with a testing machine Autograph AGX-100 kNV precision universal testing machine produced by Shimadzu Corporation. For protection of the compression plates, the test was conducted using metal spacers. The test speed was set to the maximum value of 1,500 mm/min and the sampling speed was set to 10,000 Hz. Further details of the test conditions and the specimen are reported in Table 4 and Table 5, respectively. A picture of the test is shown in Fig. 3. After the test, data corresponding to four sampling speeds (5,000 Hz, 1,000 Hz, 100 Hz, 20 Hz) have been obtained by data thinning processing.

Table 4 Test Conditions

Instrument	: AGX-V precision universal testing machine
Load cell	: 100 kN
Test jig	: Fixed compression plates φ100 mm Metal spacers Length 70 mm × width 65 mm × thickness 30 mm
Software	: TRAPEZIUM X-V Single
Test speed	: 1,500 mm/min
Sampling speed (Hz)	: 10,000, 5,000, 1,000, 100, 20

Table 5 Specimen Details

Ceramic	: Alumina
Dimensions	: Φ5 mm sphere

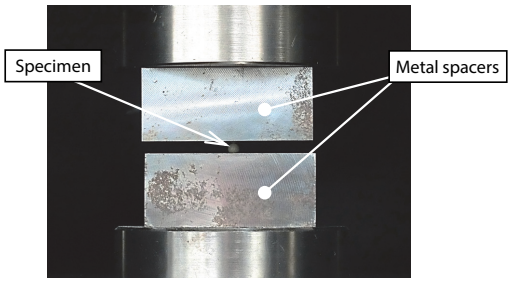

Fig. 3 Compression Test

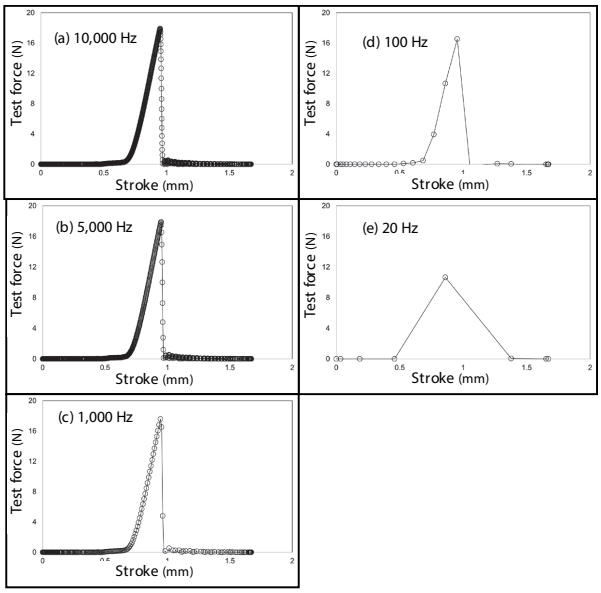

Fig. 4 Test Results

Fig. 4(a) shows the results obtained at 10,000 Hz, and Fig. 4(b) to (e) show the results at each processed sampling speed. Due to the shorter measurement time compared to the tensile test of resin (0.04 s), large discrepancy of the force peak value was observed also for the sampling speed of 1000 Hz. Table 6 shows the compressive strength and standard deviation at each sampling speed and the strength decrease ratio against the 10,000 Hz standard value. The data of Table 6 indicates that the lower the sampling speed, the higher the standard deviation and the data scatter becomes. Furthermore, the material strength obtained for the sampling speeds of 1,000 Hz, 100 Hz and 20 Hz is calculated with an error higher than 1 % compared to the strength standard value at 10,000 Hz. Therefore, for this test, a sampling speed of 5000 Hz or higher is necessary to accurately evaluate the material strength.

Conclusion

In this experiment, high speed strength tests of resin and ceramic materials were conducted, and the relationship between the sampling speed and measured strength values was confirmed. The results demonstrated that the peak point can only be accurately detected by testing at high sampling speeds.

As shown by the results, when conducting high speed test characterized by a short measurement time on brittle materials, the sampling speed is key for an accurate evaluation of the strength. Shimadzu AGX-V series fits this purpose, allowing high speed tests along with high sampling speeds up to a maximum of 10,000 Hz in order to detect correctly force peak and therefore the material strength.

Table 6 Test Results Sorted by Sampling Speed (Average Value, Number of Tested Samples: 5)

Sampling speed (Hz)	Compressive strength (kN)	Standard deviation (kN)	Strength decrease ratio* (%)
10000	18.87	0.86	-
5000	18.86	0.87	0.03
1000	18.60	0.91	1.40
100	15.32	3.15	18.8
20	10.79	3.70	42.8

* Percentage of strength decrease from strength at 10,000 Hz as standard.

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