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Application News

MCT Series Micro Compression Testing Machine

Compression Testing of Toner under Room Temperature and High-Temperature Environments

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User Benefits

- Compression testing in accordance with JIS Z 8844 is available.
- It is possible to obtain the deformation strength for specimens that do not show clear fracture behavior.
- Compression testing is possible not only at room temperature but also in high-temperature environments.

■ Introduction

Toner used in printers and copiers is primarily made of resin with colorants adhering to it. By heating and applying pressure, the toner melts and adheres to the paper, allowing for printing. Laser printers that use toner offer advantages such as high speed, high quality, and durability. However, the energy consumption during toner melting is significant, posing environmental challenges. Therefore, the development of low-energy melting toners has attracted attention.

The Micro Compression Testing (MCT) machine enables the evaluation of toner strength by obtaining the fracture and deformation strength of microparticles. Additionally, by incorporating a high-temperature system, it is possible to heat the samples and conduct tests under actual temperature conditions. In this report, a case study of compression testing toner at room temperature (25 °C) and in a high-temperature environment (50 °C) is presented.

■ Deformation Strength

JIS Z8844 specifies the compression testing of microparticles. Fracture strength is used for samples that show clear fracture behavior, but for samples that show continuous deformation, such as elastoplastic and stretchable materials, the following deformation strength is used.

$$\sigma_{10\%} = \frac{F_{10\%}}{A}$$

$\sigma_{10\%}$: Deformation strength for a 10 % compression displacement of particle size [Pa]

$F_{10\%}$: Force for a 10 % compression displacement of particle size [N]

A : Representative area [m^2]
(Area equivalent to a circle, found from the particle size measured before compression)

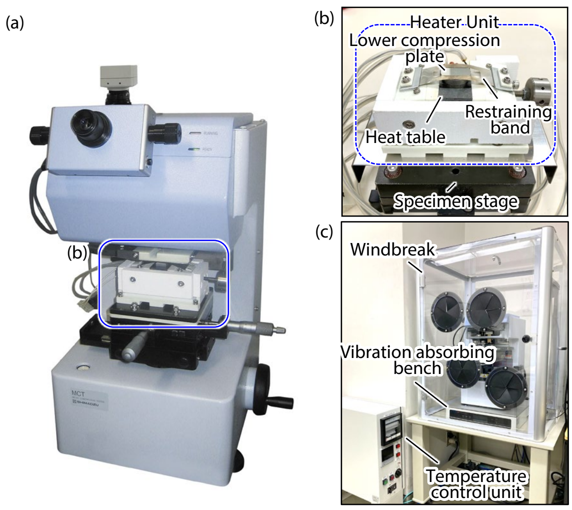

Fig. 1 MCT-510
(a) Equipment appearance (b) Heater unit (c) Example of equipment installation

■ Test Equipment

The MCT-510 micro compression testing machine with high-temperature unit (shown Fig. 1(a)) was used for the test. The main components of the high-temperature unit are the heater unit, the temperature control unit and the windbreak for the high-temperature system (see Fig. 1(b) and (c)). The heater unit is installed above the sample stage, and the lower pressure plate holding the sample is placed on the heating table and secured with a restraint band. Heat is transferred from the heater unit to the lower pressure plate and the sample, and the sample is heated. The system can evaluate the strength of samples heated in a temperature range of approximately 50 to 250 °C. When working in a heated environment, I keep the following points should be kept in mind.

- A windbreak is used to reduce the effect of outside air temperature changes.
- After the temperature has stabilized, the windbreak case door is not opened, and the test preparation work is carried out using the hole in the door.
- Wait at least 2 hours for the temperature to stabilize after changing the temperature.
- The indenter side is also heated to a high temperature by the indenter preheating treatment of 15 minutes to 1 hour.

■ Test Specimens and Conditions

Table 1 shows information for the sample used in this study, and Fig. 2 shows sample images. The sample is sprinkled onto the bottom pressure plate with a medicine spoon to prevent agglomeration, as shown in Fig. 2(a). In the test, one particle is chosen so that other particles are not compressed at the same time, as shown in Fig. 2(b). Table 2 shows the test conditions. For testing, particles were chosen that were close to spherical in shape and rated at 10 points, which is close to the median.

Table 1 Test Specimen Information

Specimen:	Two types of toner (sample A, sample B)
Particle Diameter (μm):	5.5 to 8.5

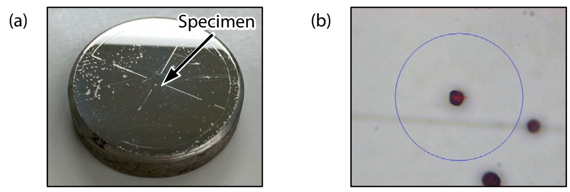

Fig. 2 Test Specimen
(a) On the lower compression plate (b) Particle observed with a microscope (objective lens magnification x50) (the blue circle indicates the area compressed by the flat indenter, Φ50 μm)

Table 2 Test Conditions

Testing Machine:	MCT-510 micro compression testing machine, Objective lenses, High-temperature unit
Indenter (μm):	Flat indenter Φ50 μm
Test Force (mN):	9.81
Loading Speed (mN/sec):	0.45
Temperature:	Room temperature (25 °C), 50 °C

■ Results

Fig. 3 shows sample images (Sample A, 25 °C) before and after the test. Fig. 3(a) focuses on the outer diameter of the sample to measure the diameter of the sample. Fig. 3(b) shows the specimen flattened by compression, and the focal position of the lower pressure plate and the outer diameter of the specimen coincide. Fig. 4 shows an example of a test force-displacement graph for samples A and B at 25 °C. Deformation strength is calculated from the test force against a compressive displacement of 10 % of the particle size. Because the diameter of the sample before the test was approximately 6.6 µm, the a and b values shown in Fig. 4(b) are used for the calculation. When the specimens were compressed by 10 %, the deformation strength of specimen B was larger than that of specimen A.

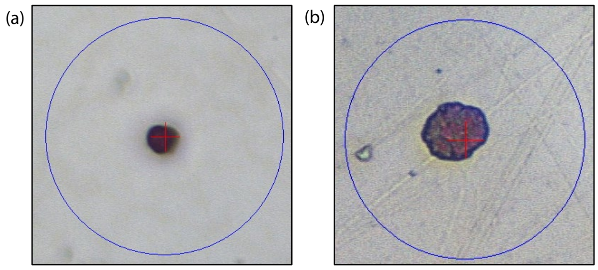

Fig. 3 Sample Images
(a) before and (b) after the test

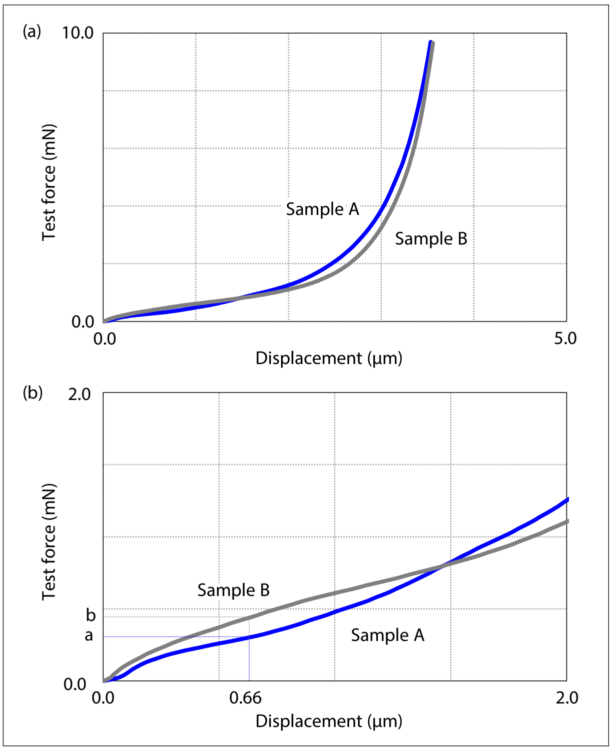

Fig. 4 Test Force – Displacement Graph (Types, Center Value)
(a) Full Scale (b) Enlarged View

Next, when the sample was observed while warmed to 50 °C, the diameter of the sample increased. It is presumed that the thermal expansion was caused by heating. When the compression test was carried out, the deformation strength of both samples was smaller than that at 25 °C.

Table 3 shows the test results (average values), and Fig. 5 shows the relationship between deformation strength and temperature for the two samples. The deformation strength of the samples tested in this study was in the following order, the deformation strength of sample B was higher than that of sample A, and the deformation strength of sample B was higher at 25 °C than at 50 °C.

Sample B (25 °C) > Sample A (25 °C) > Sample B (50 °C) > Sample A (50 °C)

Even though the size was measured with a microscope and a sample was selected that was close in size, the deformation strength was highly variable, with a coefficient of variation of over 20 %. For this reason, it is necessary to average out variations by conducting as many tests as possible.

Table 3 Results (Average)

Sample	Temperature (°C)	Diameter (µm)	Deformation strength $\sigma_{10\%}$ (MPa)	Coefficient of variation (-)
A	25	6.27	7.36	0.25
B	25	6.15	9.18	0.23
A	50	7.85	5.64	0.23
B	50	8.57	7.09	0.25

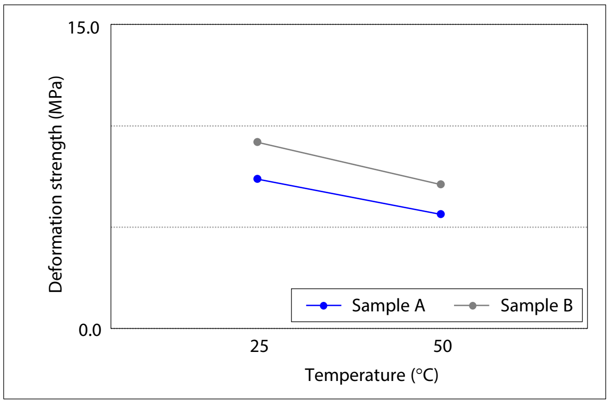

Fig. 5 Distribution of Deformation Strength $\sigma_{10\%}$ (Average)

■ Conclusion

This article has introduced examples of toner evaluation using the deformation strength specified in JIS Z8844. This instrument is ideal for particle characterization because it allows compression testing of individual particles. Furthermore, the use of a high-temperature system makes it possible to test in a heated environment, which is useful for the development and quality control of toners and similar samples.

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