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Constant Test Force Extrusion Type Capillary Rheometer Flowtester CFT-EX Series

Application News

Evaluation of the Temperature Characteristics of Toner

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User Benefits

- It is possible to calculate characteristic values such as softening temperature, outflow start temperature and offset method temperature from a single temperature rise test.
- The powder sample is press molded and can be efficiently measured with a small sample amount.

■ Introduction

Toner is a powder about 5 µm in size and is used in laser printer printing machines and copiers. The printing process is as follows. First, four images, usually separated into four colors, are exposed to different photoreceptors and developed. The four developed four-color toner images are transferred to a transfer belt and then transferred to paper. Finally, heat and pressure fix the toner to the paper to complete the color print[1]. If the melting temperature and melt viscosity of the four colors of toner are different, blurring and poor fixing will occur, resulting in poor print quality. To avoid this, the characteristic temperature of toner flow must be similar to that of the four color toners.

This article presents an example of measuring the flow characteristics of four different color toners.

■ Test Conditions

The CFT-500EX shown in Fig. 1 was used as the test equipment. This device is a canalicular rheometer that measures the viscous resistance of the melt as it passes through the canaliculus. For details of the device, see related applications[2]. Test conditions are listed in Table 1.

Fig. 1 CFT-500EX

Table 1 Test Conditions

Test Method:	Constant heating rate test
Die Diameter:	0.5 mm
Die Length:	1 mm
Beginning Temperature:	50 °C
Ending Temperature:	200 °C
Heating Rate:	5 °C/min
Test Pressure:	0.98 Mpa
Prehearing Time:	240 sec
Sample Size:	1 g (formed into pellets)
Melt Viscosity Calculation:	Offset method (5 mm)

■ Test Sample

The samples were four types of toner with different colors (cyan, magenta, yellow, black) used in the same color laser printer. A fine, light, powdery sample, such as toner, can splatter or spill out of the die hole when it is placed in the test space (cylinder). For such samples, pressing it with a press using a granulator makes it possible to mold it into a shape that is easy to place into the sample space (Fig. 2). The granulation method using the granulator shown in Fig. 3 is as follows.

1. Weigh the sample and insert it into the hole of (1) the preforming die unit.
2. Set (2) the plunger in the hole of (1) the preforming die unit.
3. Operate the handle of the hand press and press the top edge of (2) the plunger with the press shaft to compress and shape the specimen.
4. Place (3) the sample extraction die at the bottom of the granulator.
5. Push the top edge of (2) the plunger with the hand press to extrude the molded sample.

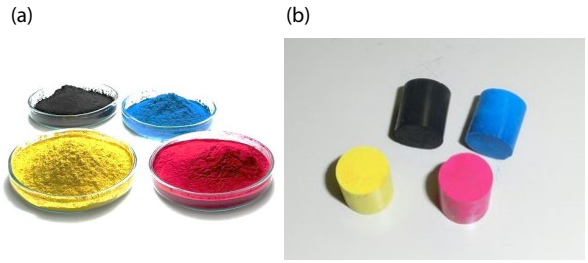

Fig. 2 Test Samples
(a) Before Granulation (b) After Granulation

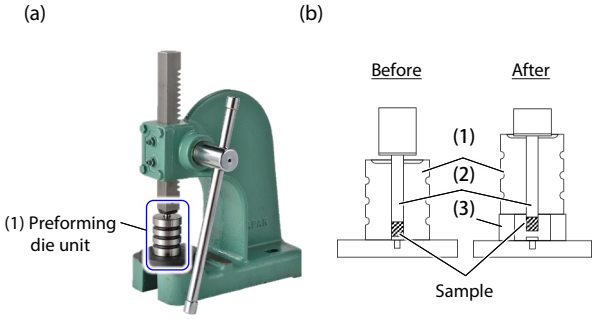

Fig. 3 Preforming Attachment
(a) Hand Press (b) Before and after Preforming

■ Measurement Method

The constant heating rate method is a test in which the temperature rises at a constant rate over time. In this test, it is possible to continuously measure the processes in the sample from the solid region to the transition region and the rubbery elastic region to the flow region, and to measure the softening temperature Ts at the transition from the solid region to the transition region and the flow beginning temperature Tfb at which the sample flows out. The flow curve of the constant heating rate method exhibits the behavior shown in Fig. 4.

The temperature rise test uses two methods to determine the point at which the characteristic value is obtained. This section introduces the offset method. As shown in Fig. 4, the characteristic value is obtained at the point where the piston stroke advances by a set offset value with respect to the stroke value at Tfb. Temperature and viscosity at this point are defined as offset method temperature and offset method viscosity.

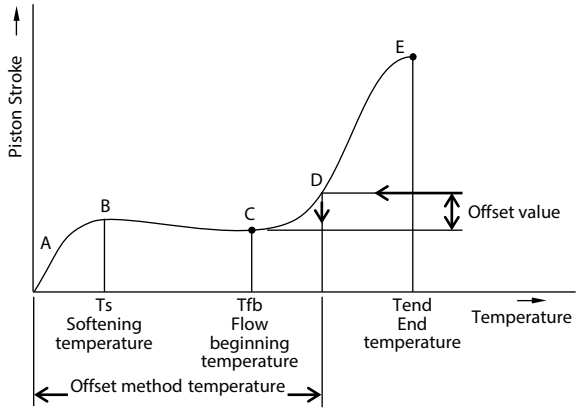

Fig. 4 Flow Curve Using Constant Heating Rate Test

The temperature rise test starts at a low temperature and ends at a high temperature. It is necessary to cool the cylinder from a high temperature to a low temperature when measuring multiple samples or times. After the test, the cylinder is forced to cool using a cylinder cooling fan (Fig. 5). This equipment can greatly shorten the time to lower the temperature, so the measurement can be carried out efficiently.

Fig. 5 Cylinder Cooling Fan

■ Results

Fig. 6 shows a superimposed stroke-temperature graph for each toner, and Table 2 shows the measurement results. The graphs of 2 and 3 almost overlap, and the graph of 1 is only moved upward as a whole. It can be seen that they are almost the same by looking at the softening temperature, the outflow start temperature, and so on. Only in 4 can it be seen that the start of flow has moved to the higher temperature side.

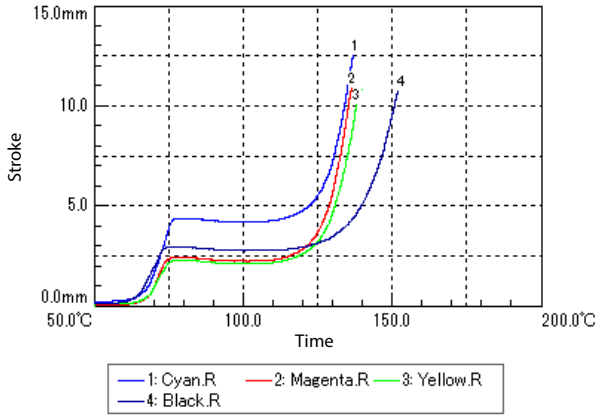

Fig. 6 Stroke-Temperature Graph

Table 2 Test Result

Sample Name	Softening Temperature (℃)	Flow Beginning Temperature (℃)	Offset Method Temperature (℃)	Offset Method Viscosity (Pa•s)
Cyan	76.8	105.1	132.5	248.2
Magenta	75.4	105.8	131.8	240.7
Yellow	76.3	104.8	133.5	285.8
Black	73.8	108.5	145.9	402.4

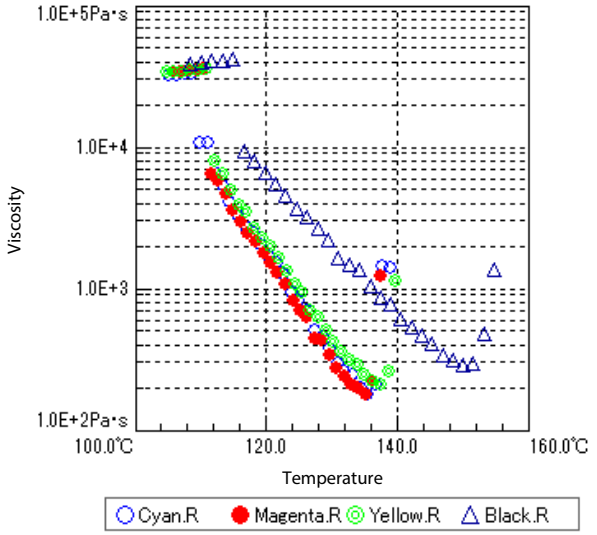

Fig. 7 Viscosity-Temperature Graph

Fig. 7 shows the viscosity-temperature graphs superimposed. Again, it can be clearly seen that the three colors other than black match.

■ Conclusion

Matching the flow characteristics of the toner around the fixing temperature helps to maintain the print quality of color laser printers. Thus, Flowtesters can play an important role in toner R & D and quality control.

<References>

1) Fujifilm Business Innovation Color Copy Mechanism https://www.fujifilm.com/fb/company/technical/shikumi/process (shown2023 January 26)
2) Evaluation of Flowability of Thermosetting Resins, Application news No. 01-00425

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