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

Application News

Measurements of Fluidity of Glass Fiber Reinforced Plastic (GFRP)

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User Benefits

- Measurement under high pressure conditions similar to molding conditions is possible.
- Since the samples are extruded with a constant test force, even high-viscosity materials can be tested with high accuracy.

■ Introduction

Glass Fiber Reinforced Plastic (GFRP) is a composite material formed by solidifying glass fibers with plastic. It is widely used in various fields such as construction, electrical and electronic equipment, and transportation due to its low cost, light weight, and durability. GFRP using short glass fibers can also be manufactured by injection molding. The appropriate temperature and pressure for injection molding vary depending on the type of resin and mold material, and improper conditions can cause molding defects such as inadequate filling, overfilling, sinking, and voids. Furthermore, the resin contained in GFRP can absorb moisture in a controlled environment, leading to changes in the material's properties and consequently changing the appropriate molding conditions. Therefore, it is important to conduct measurements under high pressure conditions similar to molding conditions and properly manage the materials.

This article introduces examples of evaluation of viscosity differences and fluidity due to molecular weight in GFRP, as well as examples of viscosity changes due to moisture absorption.

■ Samples and Test Conditions

As shown in Table 1, the tests were conducted using different molecular weight polycarbonate (PC) resins containing 33 % glass fibers (GF). The test conditions are listed in Table 2.

Table 1 Samples Information

Sample No.	Component	Molecular Weight	GF Percentage
(1)	PC/GF	17,000	33 %
(2)	PC/GF	22,000	33 %
(3)	PC/GF	26,000	33 %

Table 2 Test Conditions

Test Method:	Constant temperature method
Die Diameter:	1 mm
Die Length:	10 mm
Test Temperature:	280 °C
Test Pressure:	1.96 MPa
Preheating Time:	300 s
Sample Size:	1.5 g

CFT-500EX model flowtester (Fig. 1) was used for the tests. This device is a canalicular rheometer that measures the viscous resistance of the melt as it passes through the canaliculus.

With the structure shown in Fig. 2, the sample filled in the cylinder is heated from the periphery and melted, and a constant pressure is applied from the top through the piston. The sample melted through a die with a small hole is extruded to obtain the melt viscosity.

This principle is the same as the widely used international melt flowrate (MFR) measuring machines, but the flowtester offers a wide range of pressure choices. It can be tested under or close to actual molding conditions to obtain highly practical data.

Fig. 1 CFT-500EX

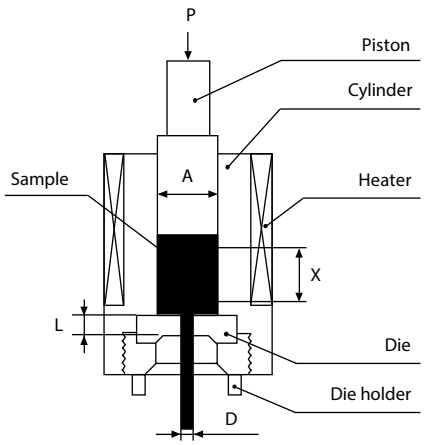

Fig. 2 Test Concept Diagram

The viscosity is calculated by calculating the flowrate, obtaining the shear rate and shear stress, the ratio of which corresponds to viscosity, as shown in the following equation:

(1) Flowrate Q

$$Q = \frac{X}{10} \cdot \frac{A}{t} \ (cm^3/s)$$

t: Measurement time(s)
X: Apparent displacement(mm)
A: Piston cross sectional area (cm^2)

(2) Apparent shear rate γ

$$\gamma = \frac{32Q}{\pi D^3} \cdot 10^3 \ (s^{-1})$$

D: Die orifice diameter (mm)

(3) Apparent shear stress τ

$$\tau = \frac{PD}{4L} \ (Pa)$$

P: Test pressure(Pa)
L: Die length(mm)

(4) Apparent viscosity η

$$\eta = \frac{\tau}{\gamma} = \frac{\pi D^4 P}{128LQ} \ (Pa \cdot s)$$

■ Results

Fig. 3 shows an overlay of the results on a stroke-time graph, and Table 3 summarizes the test results. It can be seen that slope, which corresponds to the magnitude of the shear rate, is large in (1), and small in (3). As a result, the higher the molecular weight, the harder the flow and the higher the viscosity.

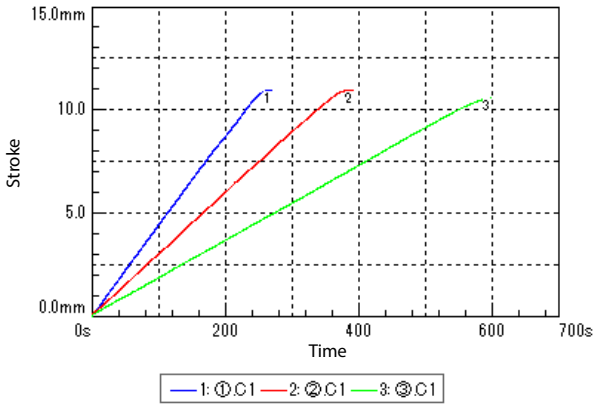

Fig. 3 Stroke-Time Graph

Table 3 Test Results (When Molecular Weight is Changed)

Sample No.	Component	Molecular Weight	GF Parcentage	Shear Rate (s^{-1})	Viscosity (Pa•s)
(1)	PC/GF	17000	33%	44.7	1,098
(2)	PC/GF	22000	33%	30.6	1,604
(3)	PC/GF	26000	33%	18.5	2,657

Then the change in viscosity of GFRP due to moisture absorption was measured using samples (1) with a molecular weight of 17000. After drying for 13 hours under vacuum at a temperature of 100 °C, the samples were left in a room with a humidity of about 50 % at a temperature of about 23 °C. The changes in viscosity were measured by conducting tests under the conditions of Table 2 for each of the standing times shown in Table 4. The test results are shown in Table 4 and Fig. 4. It can be seen that the moisture absorption of GFRP increases as the standing time increases, resulting in lower viscosity and higher fluidity. In addition, it was found that the viscosity decreased significantly for about 4 hours after being left standing in the room, and the decrease in viscosity became small after about 24 hours.

Table 4 Test Results (Change Conditioning Time)

Standing Time (h)	Shear Rate (s^{-1})	Viscosity (Pa•s)
0	44.38	1,105
0.25	46.84	1,047
0.5	47.35	1,036
1	47.38	1,035
2	50.41	973
4	53.03	925
8	55.54	883
24	58.77	834
48	58.61	837

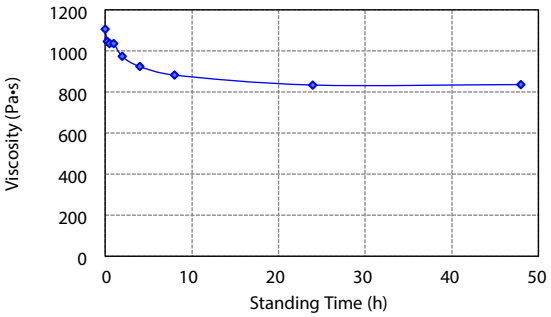

Fig. 4 Changes in Viscosity Due to Moisture Absorption

■ Conclusion

Since the viscosity of GFRP and other resins varies greatly due to moisture absorption, using uncontrolled resins can lead to injection molding failure. In addition, even with the same type of resin, different molecular weights cause differences in viscosity and fluidity. Before molding, it is necessary to measure the viscosity with a Flowtester to confirm that the viscosity is within the criterion, which will prevent injection molding defects.

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