Application News

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

Evaluation of the Flow Characteristics of General Purpose Plastics

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User Benefits

- The temperature rise method makes it possible to easily evaluate the flow characteristics of resin with respect to temperature.
- The use of a cylinder cooling fan (optional) enables cooling in a short time with low noise and reduces cycle time during testing.

■ Introduction

Thermoplastics have the property that they soften when heated and harden when brought back to room temperature, but soften when heated again, so they can be used repeatedly. There are various types of thermoplastic resins, such as polyethylene terephthalate (PET) used in plastic bottles and polypropylene (PP) used in kitchen utensils, etc., and their flow characteristics at high temperatures when softened are different from each other. Therefore, it is necessary to evaluate the flow characteristics of the resin material at various temperatures in order to produce good quality molded parts. The Flowtester is effective for such evaluation, and the temperature rise test is a simple method for measuring the flow characteristics of the resin with respect to temperature. This article shows an example of a typical general-purpose resin that has been tested by the temperature rise method.

■ Test Samples and Conditions

Four materials were used: polyethylene (PE), polypropylene (PP), polyvinyl chloride (PVC), and polycarbonate (PC). The CFT-500EX type Flowtester (Fig. 1) was used for the measurement. This device is a canalicular rheometer that measures the viscous resistance of the melt as it passes through the canaliculus. It can be measured under actual molding conditions or similar test conditions to obtain highly practical data.

Fig. 1 CFT-500EX

The tests were performed on 1.2 g pellet-shaped samples, and the temperature rise test was performed. The detailed conditions are shown in Table 1.

Table 1 Test Conditions

Test Method:	Constant heating rate method
Die Diameter:	1 mm
Die Length:	1 mm
Beginning Temperature:	100 °C
Ending Temperature:	300 °C
Heating Rate:	5 °C/min
Test Pressure:	0.98 MPa
Preheating Time:	300 sec
Sample Size:	1.2 g (formed into pellets)

The constant heating rate test starts at a low temperature and ends at a high temperature. Therefore, in order to perform the next measurement, it is necessary to cool the cylinder, etc., and there is a lineup of optional products for quick cooling. The cylinder cooling piston inserts a piston-shaped component that emits compressed air into the cylinder for cooling. The cylinder cooling fan (Fig. 2) can be attached to the lower part of the heating furnace with one touch, and cooling is performed by the air flow of the fan. Both can significantly reduce the time to cool down, but cylinder cooling fans provide faster cooling with lower noise.

Fig. 2 Cylinder Cooling Fan

■ Results

The temperature rise test is a method of testing while increasing the temperature at a constant rate over the course of the test time. In this test, it is possible to continuously measure the process of the sample from the solid region to the transition region and the rubbery elastic region to the flow region. The softening temperature Ts when the sample moves from the solid region to the transition region and the flow beginning temperature Tfb at which the sample flows out can be measured. The flow curve of the constant heating rate method exhibits the behavior shown in Fig. 3. Table 2 shows the temperature and curve obtained by the constant heating rate method.

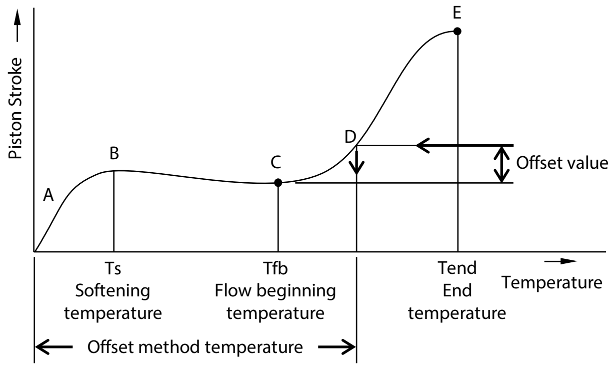

Fig. 3 Stroke-Temperature Graph

Table 2 Name and Definition of Each Value

Symbol	Name	Definition
AB	Softening zone (Softening curve)	Stage in which the sample is deformed by the compressive load and its internal porosity is gradually reduced.
TS	Softening temperature	Temperature at which the internal porosity is eliminated, and the sample becomes a transparent substance or phase that is apparently homogeneous and has a homogeneous stress distribution.
BC	Stop zone (Stop curve)	Zone in which the piston position does not clearly change within a limited period of time and sample outflow from the die orifice is not clearly seen.
Tfb	Flow beginning temperature	Temperature at which the piston slightly goes up due to thermal expansion of the sample and then it clearly starts going down again.
CDE	Outflow zone (Outflow curve)	Zone in which the sample clearly flows out from the die orifice.

The temperature rise test uses two methods to determine the point at which the characteristic value is obtained. The 1/2 method is introduced here. As shown in Fig. 4, 1/2 of the difference between the outflow end point Smax. and the minimum point Smin. of the flow curve is determined, and the point A obtained by adding X and Smin. is used as the point to obtain the characteristic value. The temperature and viscosity at this point are defined as 1/2 method temperature and 1/2 method viscosity.

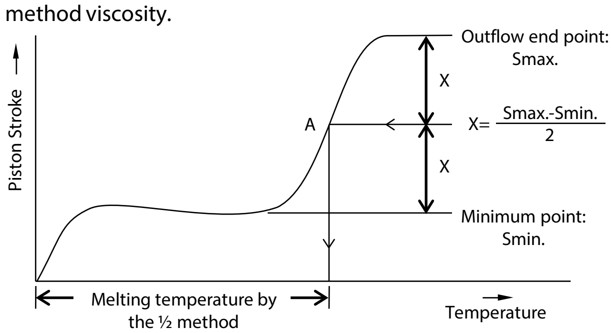

Fig. 4 Calculating the Melt Temperature with the ½ Method

Fig. 5 shows a superimposed "stroke-temperature graph" for each polymer. When looking at the PE shown in blue and the PP shown in red, the temperature at the last point of the graph (the end of the flow of the sample) is about 230 °C for both, but the temperature at which the outflow starts is about 30 °C lower for the PE than for the PP. In other words, PE has a smaller slope of the curve after the start of the outflow, indicating a slow decrease in viscosity with increasing temperature. In this way, the difference in the shape of the graph shows the difference in the characteristics of each sample.

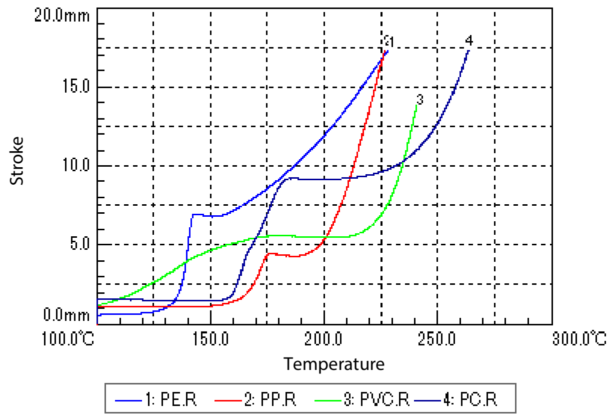

Fig. 5 Stroke-Temperature Graph

Table 3 shows typical values obtained from the temperature rise test. It can be seen that both temperature and viscosity vary greatly from sample to sample.

Table 3 Test Result

Sample Name	Softening Temperature (°C)	Flow Beginning Temperature (°C)	½ Method Temperature (°C)	½ Method Viscosity (Pa•s)
Polyethylene	142.4	153.6	203.6	16,370
Polypropylene	175.6	187.2	215.6	5,716
Polyvinyl chloride	175.3	208.2	234.4	6,138
Polycarbonate	183.1	205.1	253.9	10,590

■ Conclusion

In the constant heating rate test, in addition to being able to measure the temperatures at which the sample changes, in other words the temperature at which the sample softens and the temperature at which outflow begins, the viscosity can be calculated at the temperature after outflow begins. In this way, the constant heating rate test is very convenient for checking fluidity over a wide temperature range. On the other hand, measurements are taken while the temperature is rising, so there are effects such as delay in thermal conduction into the sample. Therefore, for accurate measurement of viscosity the constant temperature test method is appropriate.

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