# Investigation of the flow characteristics of PET at different temperatures


### Author
Matthias Jährling
Thermo Fisher Scientific, Karlsruhe, Germany



### Keywords
PET, torque rheometer, viscosity, capillary rheology



## Abstract
Polyethylene terephthalate (PET), a thermoplastic polymer and part of the polyester group, is produced by polycondensation.

PET is processed in different ways and has a wide range of applications. The most common application is the production of all kinds of plastic bottles (production process injection blow molding) and the conversion into textile fibers.

Since the fifties of last century, PET has been used to produce very thin cast films, known under the name Mylar. PET has its own resin identification code, which helps to simplify the recycling of PET packages. As textile fiber (polyester), PET is also popular because of its additional useful properties. PET is crease-resistant, tearproof, weatherproof, and hydrophobic. Therefore PET is predestinated as sportswear material, which must dry fast.

Even in the food industry, PET is used as the preferred material. It can be processed in an amorphous state and is, in this form, absolutely achromatic and highly translucent. It's used for food-grade packaging and bottles (e.g., PET bottles). Because of its good texture compatibility, PET is also used as basic material for blood vessel implants. The glass transition temperature is about 80 °C. At about 140 °C, PET passes into the crystalline state. The melting point is at around 235 °C – 260 °C.


## Introduction
Polyethylene terephthalate (PET) is processed by melt extruding and then stretching the material up to 6 times the original length to form an endless high-yield point thread. To produce a product of consistent quality, it is of great interest for the processor to know how the flow characteristics of the molten polymer change as a function of the temperature and the shearing rate.

The Thermo Scientific™ HAAKE™ PolyLab™ QC Modular Torque Rheometer offers a fast and reliable method to investigate these flow characteristics. Unlike for traditional capillary rheometers, the test samples are measured with a laboratory extruder under conditions similar to those encountered during processing. Due to the continuous measuring principle, the effects of material degradation on the measuring results can be avoided.


HAAKE PolyLab QC Modular Torque Rheometer

## Materials and methods

### Test setup

HAAKE PolyLab QC with:

- HAAKE Rheomex 19/25 Single-Screw Extruder 19 mm with L/D = 25:1
- Screw 3:1 metering
- Rod capillary die with a rod capillary insert D = 1.5 mm and L/D = 20:1
- Die ring heater

### Temperatures

| | |
|---|---|
| **Extruder** | Zone 1 = 280 °C<br>Zone 2 = 280 °C<br>Zone 3 = 280 °C |
| **Die ring heater** | 280 °C |
| **Die** | 1. test = 275 °C<br>2. test = 285 °C<br>3. test = 295 °C |

## Results and discussion

The test data is evaluated with the HAAKE PolySoft Capillary Software.

Diagram 1 shows the flow curves (shear stress against shear rate), and diagram 2 shows the viscosity curves (viscosity against shear rate).

The curves show the typical shear-thinning effect for polymers. The curves demonstrate that, for this product, the influence of the temperature decreases for increasing shear rates. This means that the viscosity is independent of temperature fluctuations at higher shear rates.

## Summary

Recapitulating, we can say that the flow characteristics of polymer melts can vary at different processing temperatures. This becomes apparent, especially at low shear rates. With increasing shear rates, this influence becomes less and less. At very high shear rates, one can almost neglect the temperature effect.

With the HAAKE PolyLab QC system, Thermo Fisher Scientific offers a platform that allows customers to evaluate these effects and influences under conditions close to the production process.

### PET flow characteristics at different temperatures

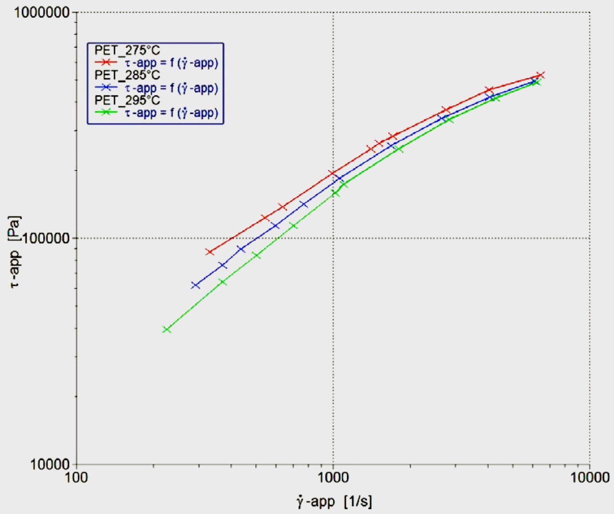


Diagram 1: Shear stress against shear rate.

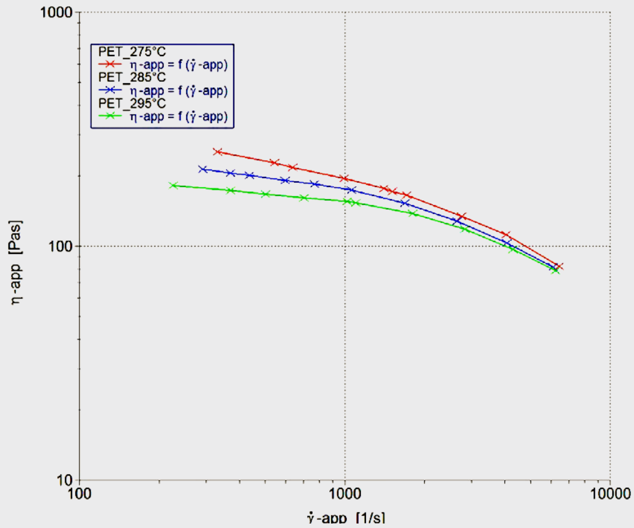


Diagram 2: Viscosity against shear rate.

Learn more at **thermofisher.com/polylabqc**