Application Note LR-33

Viscosity measurement of LDPE samples with the same MFR value

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Keywords:

- Torque Rheometer
- Extruder Capillary Rheology
- LDPE
- MFR

Abstract

In the plastics industry, measuring the melt flow rate (MFR) is one of the simplest and most frequently used test methods for finding out about the flow behaviour of polymers. The following case, taken from actual practice, will show that this method of determining the melt characteristics of a substance is not always sufficient. The two LDPE (low-density polyethylene) samples in this investigation both had the same MFR value, but displayed different modes of behaviour in practice when they were being processed.

Introduction

The described two LDPE samples were produced by different suppliers. The samples showed both a MFR value of 4.0 g/10 min. But one of the LDPE caused major problems in production.

Materials and Methods

Polymer: LDPE

Test arrangements

- Torque rheometer:
  Thermo Scientific
  HAAKE RheoDrive 4
- Analysis software
  Thermo Scientific
  HAAKEPolySoft OS
- Laboratory single screw extruder:
  Thermo Scientific
  HAAKE Rheomex 19/25 OS
- Extruder screw:
  L = 25 x D
  compression ratio 2:1
- Melt pump with bypass
- Slit capillary die: 0.8 x 2.0 mm
- Melt-pressure sensors.

Test conditions

- Extruder feeding zone:
  liquid cooled
- Temperature profile extruder:
  180° / 240° / 280 °C
- Temperature of melt pump:
  280 °C
- Temperature at die:
  280 °C
- Speed of extruder:
  100 rpm
- Speed of melt pump:
  5 to 60 rpm (programmed).

Test procedure

The polymer pellets are molten and homogenized in the extruder.
Via a bypass valve the melt is directed into the melt pump. (Fig. 1)
The melt pump transports a defined volume, dependent on the speed of the pump, through the slit-capillary die.
From the capillary geometry and the volume flow the apparent shear rate can be calculated.

$$\dot{\gamma} = \frac{6 \bullet Q}{W \bullet H^2}$$

With pressure transducers the pressure drop in the capillary is measured. From the capillary geometry and the pressure drop the shear stress is calculated.
The apparent viscosity is then calculated from the apparent shear rate and the shear stress.

$$\tau = \frac{H}{2} \bullet p'$$

The analysis software, after the application of a correction process, calculates the true viscosity value.

$$\eta = \frac{\tau}{\dot{\gamma}}$$

By stepwise raising the speed of the melt pump the melt viscosity at various different shear is measured.

Thermo Scientific HAAKE PolyLab OS Torque Rheometer

Results and Discussion

The diagram (Fig. 2) shows the results of the viscosity measurement with the two LDPE samples in one graph. It can be clearly seen that the samples display the same viscosity behaviour at low shear rates. However, widely different shear rates emerged during processing, and it can be seen from the graph that at higher shear rates there are clear differences between the samples.

The MFR method was not able show these differences, because it only measures one point of the viscosity behaviour and this at low shear rates.

Summary

This test shows that it is possible to differentiate between the two samples with the extruder capillary rheometer. The MFR method was not able to give any different readings, because it only measures one point of the viscosity behaviour and this at such low shear rates.

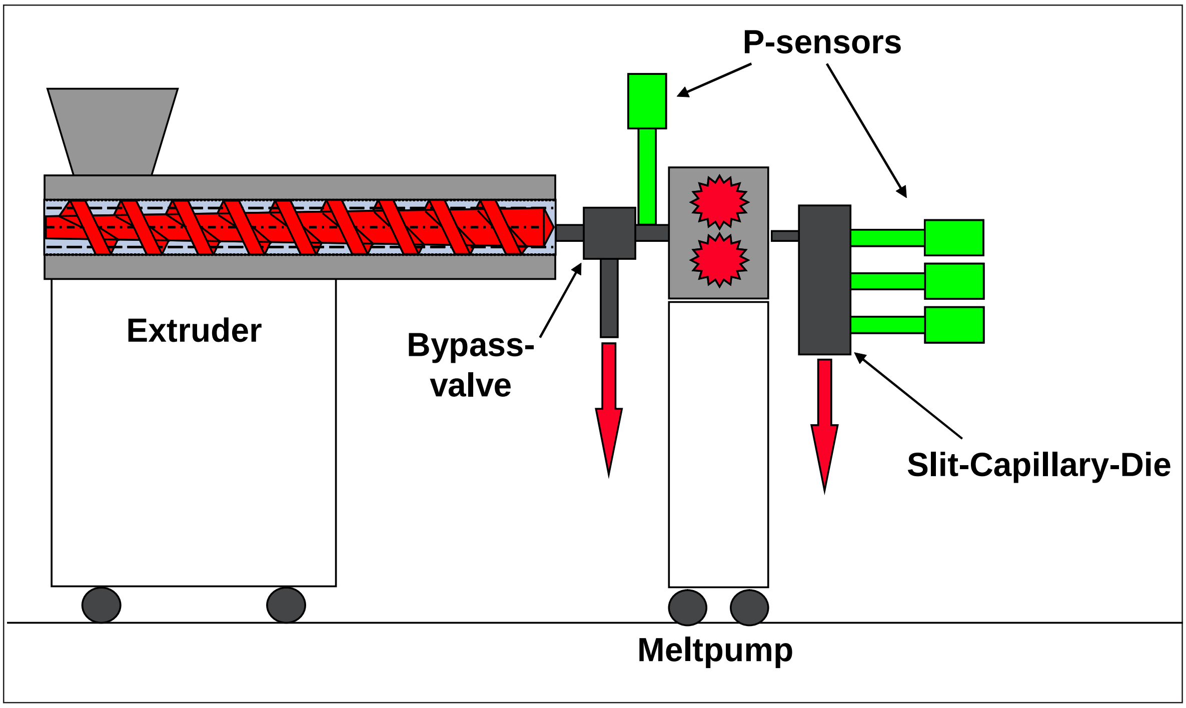

Fig. 1

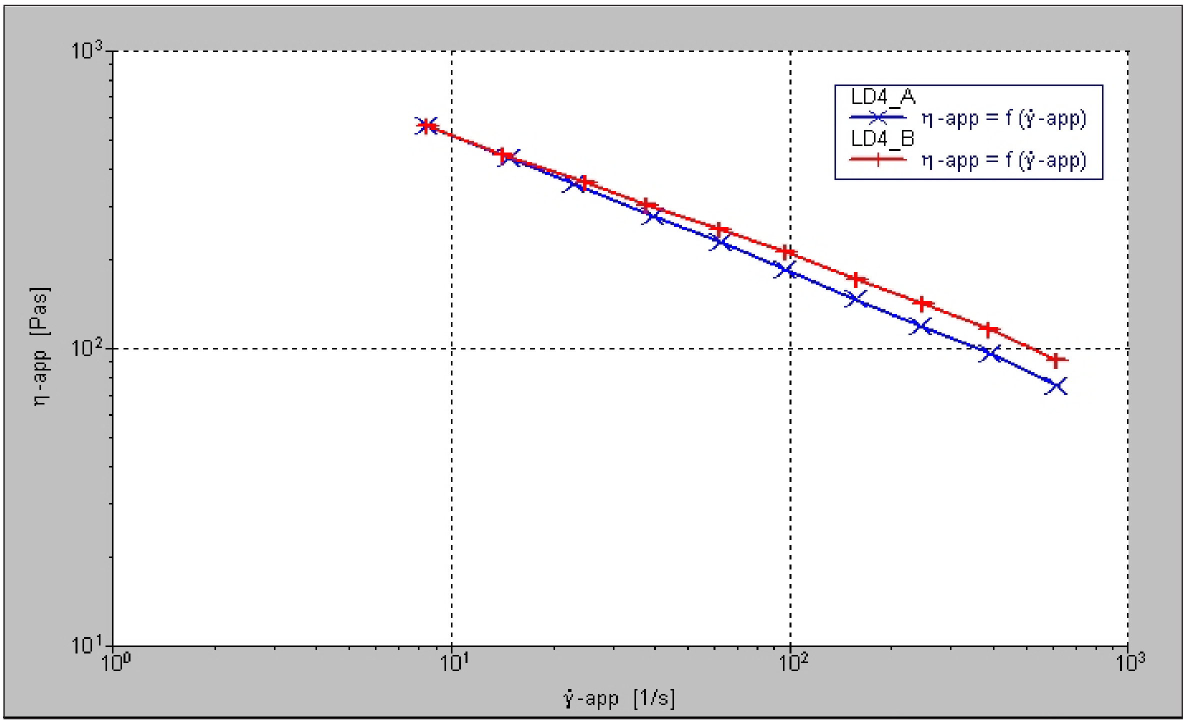

Fig. 2

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