

A Polymer Flow Analyzer for both Shear and Elongational Determination

Introduction

Conventional melt flow testing considers only viscous flow behaviour of the material. Processes such as blown-film, blow-moulding or calendering also require consistent elastic material behaviour, which in turn calls for control and measurement to narrow limits.

One measurement, two results

The D-MELT measurement system consists of a top of the line, melt flow tester "mi40", and an integrated haul-off device. The special D-MELT test procedure measures two material properties with just one filling of the barrel: The standard-conforming melt flow rate (MFR) using the melt flow tester and melt elasticity (ME), measured with the Haul-Off fed by the melt flow tester. The short test time and ease of operation makes it ideally suited for quality control of extrusion materials, both for material producers and processors.



It is also possible to run the device without the haul-off as a normal melt flow tester. To run the combined test procedure, the system is connected to a special PC program that records and evaluates the data produced during the test. The user interface of the software is kept as simple possible and gives helpful guidance during the test.

D-MELT = mi40 + Haul-off

The MFR-Tester "mi40" is equipped with a full set of automatically selectable test weights. It is capable of measuring at temperatures up to 400°C. In the D-MELT device, it is assembled with a haul-off extensional rheometer. The servo driven winding drum can be accelerated to speeds of up to 45 m/min. The elongational property is measured with one of the ceramic coated guidance wheels, mounted on a highly sensitive force sensor with a resolution of 0,05mN.

The D-MELT test procedure

The combined test measures first the ME-value and afterwards the MFR-value. The ME-measurement basically takes place during the end of the melting time of the MFR-test.

To create an ME-test the user has to enter the target MFR-value. The software then calculates the velocity ramps displayed in green on the left graph of

Figure 1. During the test, speed, force and MFR-value are recorded. After the test a fitting function is applied to the force recorded during the actual measurement ramp. From the MFR-value tracked during

the ramp, the die exit speed is calculated and multiplied with a certain draw-down ratio. The force at that draw down speed is the ME-value. This correction step is necessary, because the actual measured MFR is often slightly different the target value.

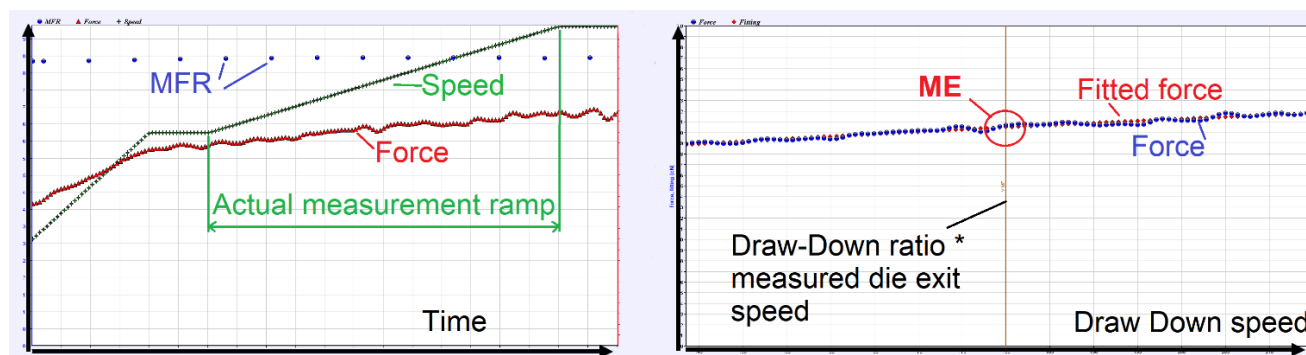


Figure 1: Real time data during test on the left; evaluated data after test on the right

After the ME-Test is finished, a higher load is applied to get to the MFR-test range faster. The MFR-test according to ISO 1133 or ASTM D 1238 is started shortly after the ME-test is over. Depending on the MFR of the material, the combined test takes 10-20 min.

Increased selectivity

The MFR is related to the mean molecular weight of the polymer and offers a good indication of the viscosity at low shear rates. The ME measured with the D-MELT relates to the molecular weight distribution and the branching structure of the polymer. Therefore it offers a good indication of the melt strength and drawability during processing. The following graph shows the forces recorded during D-MELT measurements done with two LDPE resins. Both have identical MFR values but vastly different ME test results.

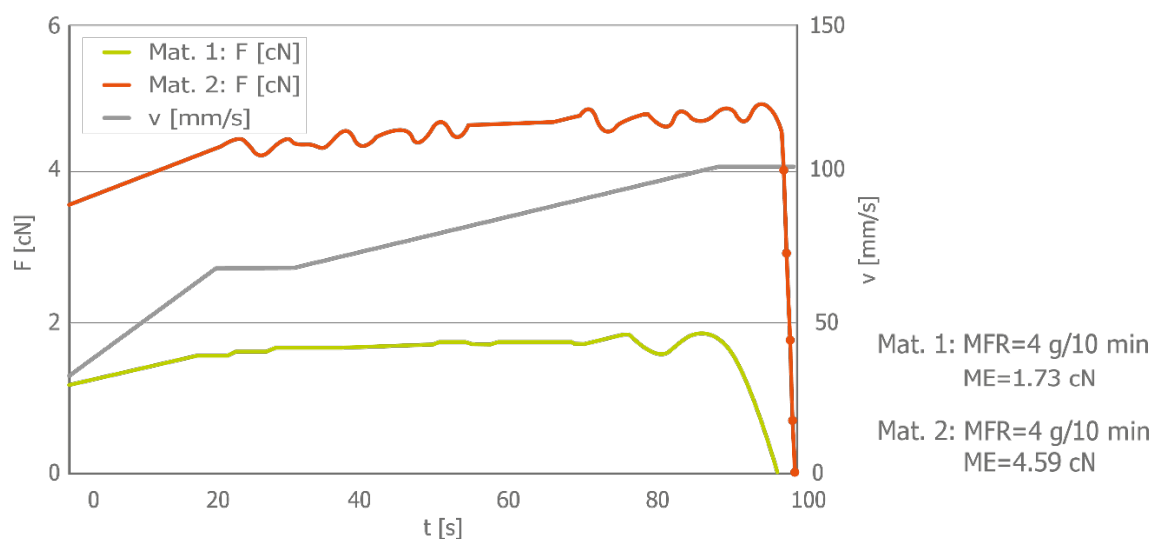


Figure 2: Two LDPE resins with similar MFR and different ME

The D-MELT makes it possible to detect this difference in melt strength with a quick and easy QC-test.

Excellent correlation to the Rheotens test

The Rheotens is an established elongational rheometer used mainly for material development. It is fed either by a capillary rheometer or extruder with great capabilities and therefore the choice for R&D. The D-MELT compliments the Rheotens and provides QC with a more affordable and easier way to measure elongation properties. It is optimized for a short test time, lower capital investment and simpler use of operation. A comparison between D-MELT and Rheotens tests with three different LDPE resins shows an excellent correlation between the ME measured with the D-MELT and the strand break force F_{rt} detected with the Rheotens.

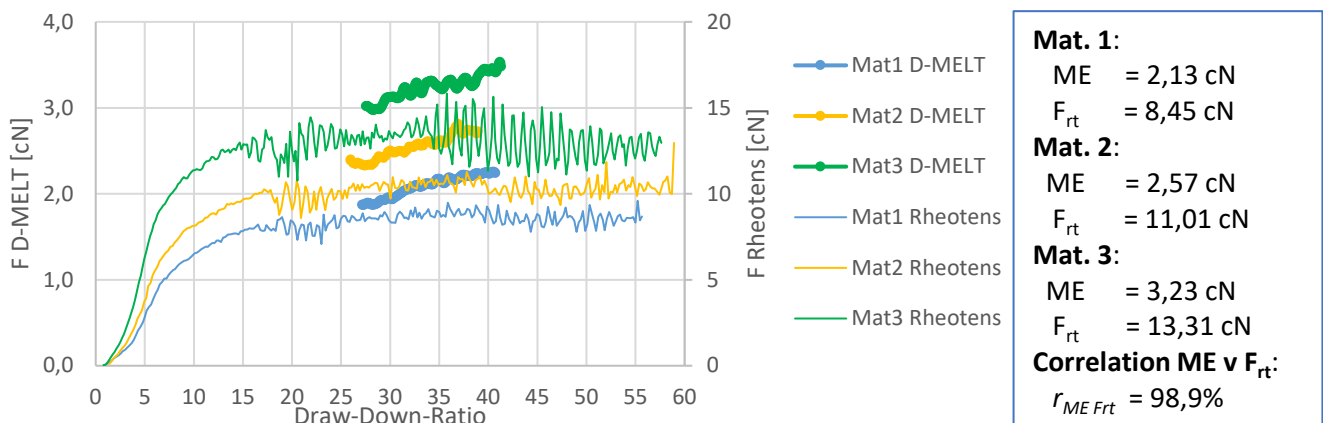
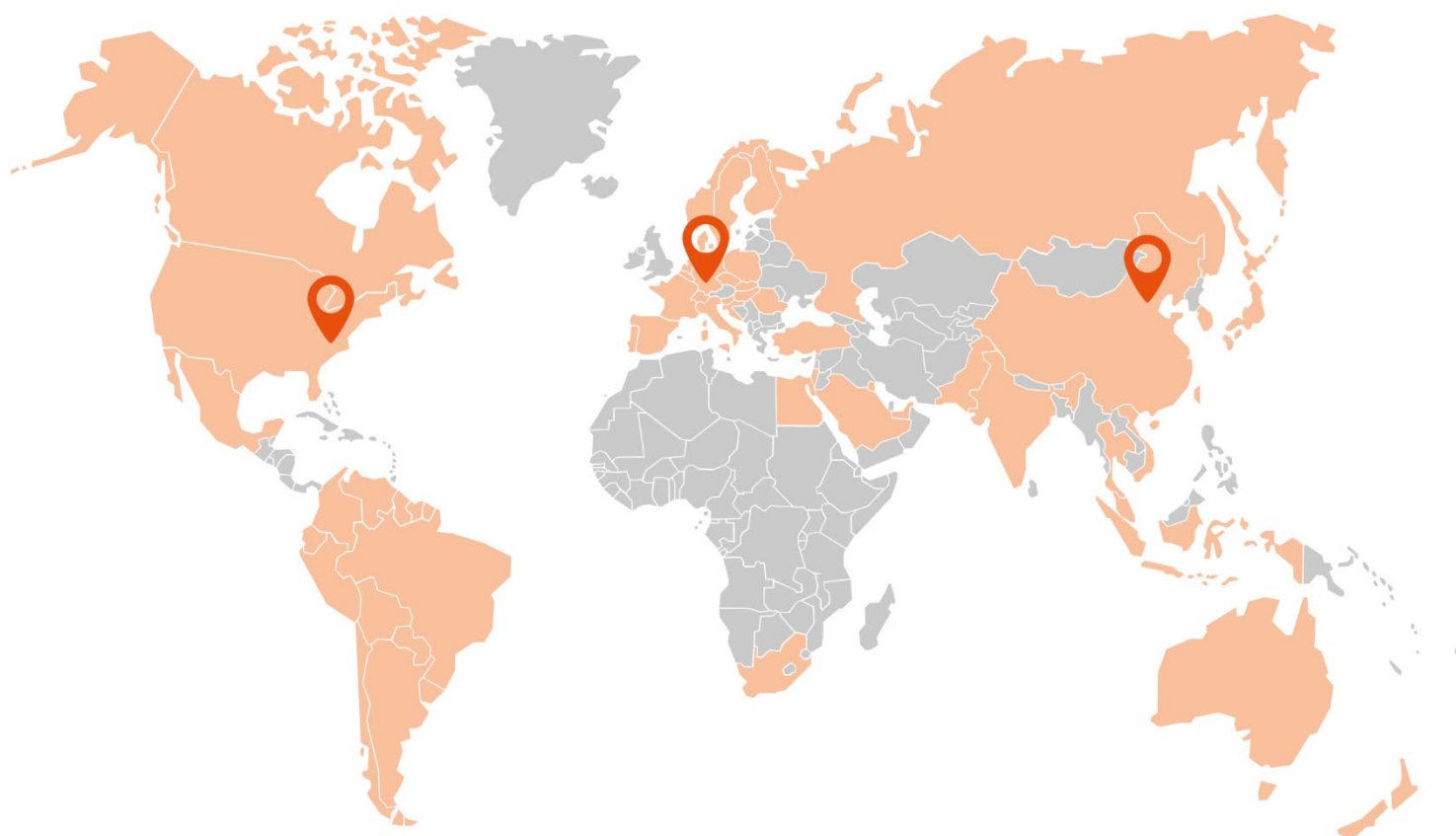


Figure 3: Comparison between Rheotens and D-MELT results of 3 LDPE resins

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