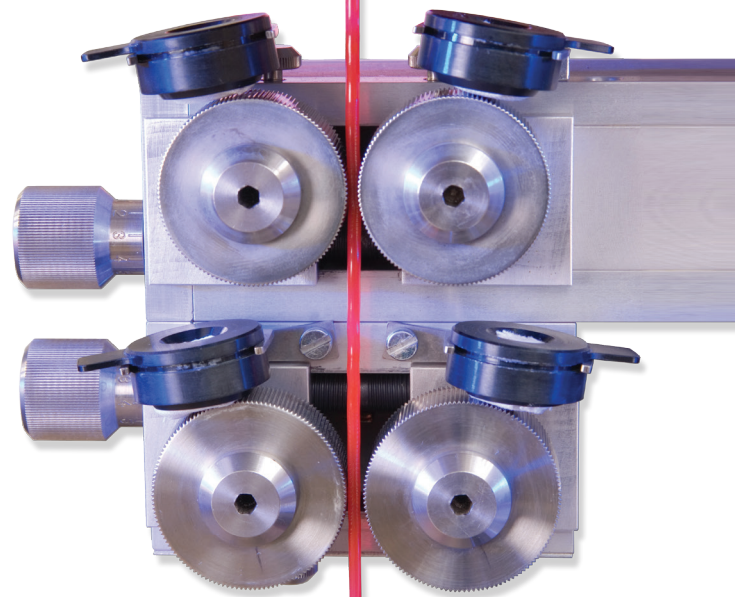


ELONGATIONAL TESTING

RHEOTENS AND HAUL-OFF



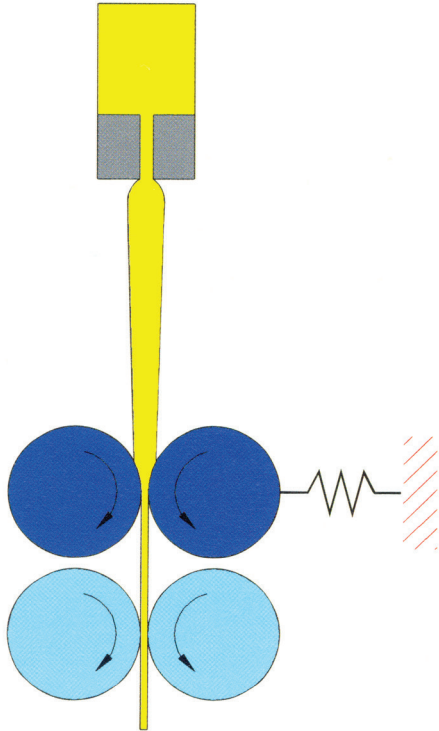
GÖTTFERT

Elongational Rheometer for Polymer Melts

It is well known that the elongational flow behavior which dominates many processing techniques can not be determined from shear experiments.

The patented RHEOTENS melt elongation testing technique has proven to be highly reproducible and sensitive and will differentiate even polymer melts showing small differences in molecular structure which can not be detected with analytical methods.

The RHEOTENS 71.97 offers the following new features:



Tandem pulley system (* patented)

An additional pair of pull-off wheels have been integrated to prevent sticking of the elongated polymer strand once it has passed the first pair of pulleys.

Extended speed control

In comparison with the previous model 60 % higher pull-off speeds are available now. The speed control is stepless variable up to 1900 mm/s (114 m/min) at an acceleration of 3200 mm/s².

Measurement range

The force measurement range extends from 0 to 2 N at a resolution of 0,001 N. The calibration runs automatically.

Software

The Windows® Software has been designed with the maximum possible user-friendliness. The evaluation functions were integrated into MS EXCEL®, so very comfortable and easy to adapt presentations or advanced processing methods are possible. A joystick provides the complete freedom for the controlling and initiating the experiment.

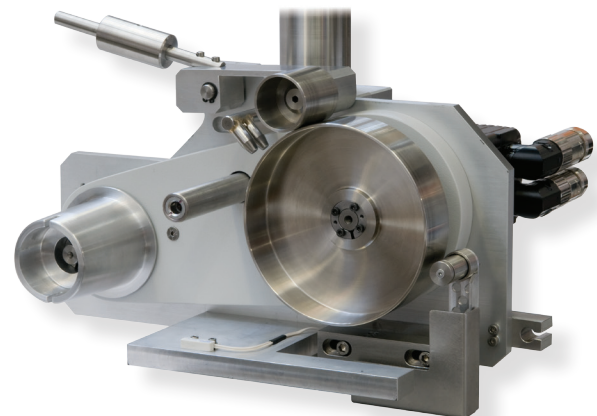
New functions are added

In addition to linear constant pull-off speed and constant acceleration, the exponential speed control has been added. The determination of the elongational viscosity function according to Prof. Wagner is an integrated element of the RHEOTENS and the HAUL-OFF.

RHEOTENS



HAUL-OFF



for even higher pull off speeds
stepless adjustable from 0-600 m/min
or 0-2000 m/min (Option)

From a technological trial on extension to the function of the extensional viscosity

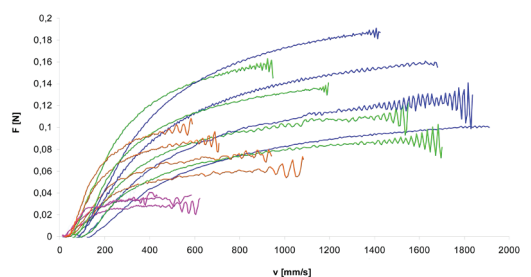


Figure 1:

In the technical elongation diagram

the maximum draw-off speed (v) is a relative measurement for the „elongation“ of the melt, while the maximum force (F) is a relative value for the melt strength.

The RHEOTENS test is a rather complicated function of the characteristics of the polymer, dimensions of the capillary, length of the spin line and of the extrusion history.

$$F = F(\text{Polymer}, \text{Geometry}, \text{Process conditions})$$

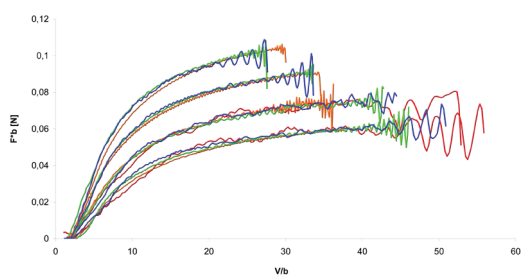


Figure 2:

The „Super-Master-Curve“

In the first step approach, invariance with respect to different mass flow rates can be found. This reduces the originally 16 RHEOTENS curves in our example to 4, whereby the shift factor is solely a function of the extrusion history.

With this, the pull-off force (F) is only based on:

$$F = F(\text{Polymer}, \text{Geometry})$$

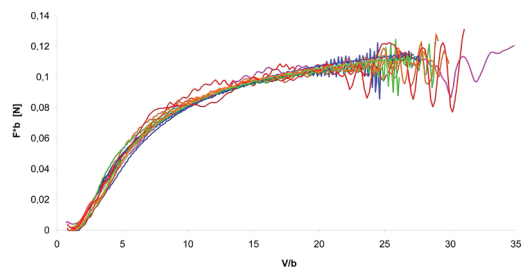


Figure 3:

The „Grand-Master-Curve“

In a further step towards integration, invariance with respect to capillary dimensions and the spin line length are considered. In the end all 16 RHEOTENS curves are reduced to the RHEOTENS-Grand-Master-Curve, which is solely a function of the polymer characteristics.

$$F = F(\text{Polymer})$$

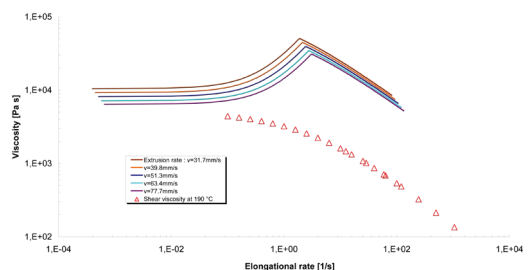


Figure 4:

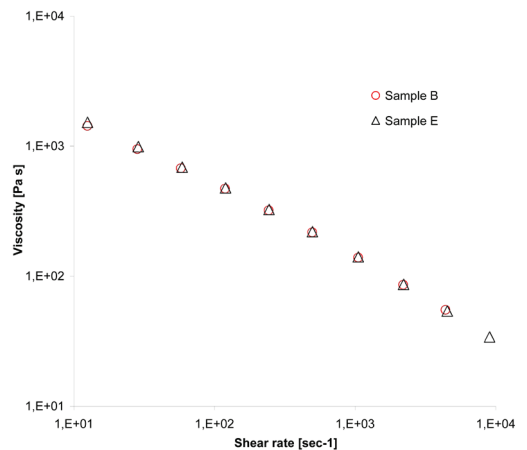
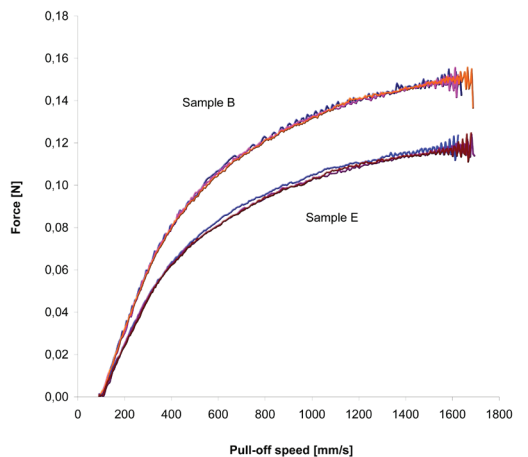
The effective elongational viscosity

Now, the effective elongational viscosity can be determined by using a simple analytical model.

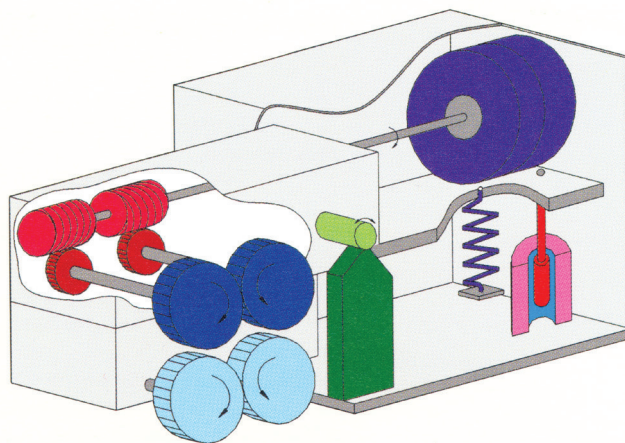
The elongational viscosity, as a function of the elongational rate, is composed of the „visco-elastic-start-up“ with increasing elongational viscosity and the purely viscous elongation with decreasing viscosity, shown here also at different extrusion conditions.

The determination of the elongational viscosity is a software routine of the RHEOTENS and based on the work done by Prof. Wagner and coworkers at the IKT, University of Stuttgart / Germany. Literature references are gladly given on demand.

„RHEOTENS curves allow you to differentiate between the smallest differences in the behavior of your batches, otherwise not detectable with shear experiments“



The material producer has found that sample B has a wider molecular distribution ($MW/Mn = 11.1$), versus sample E ($MW/Mn = 10$). Sample B and E were run three times (with the respective curves lying on top of each other). The RHEOTENS curves (picture left) show significant changes in the melt strength between the two batches. This information could not have been gathered by looking at the viscosity curves (picture right).



Function drawing:

RHEOTENS 71.97 with tandem pulley system, which can be retrofitted also to older devices.

THIS IS RHEOLOGY



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