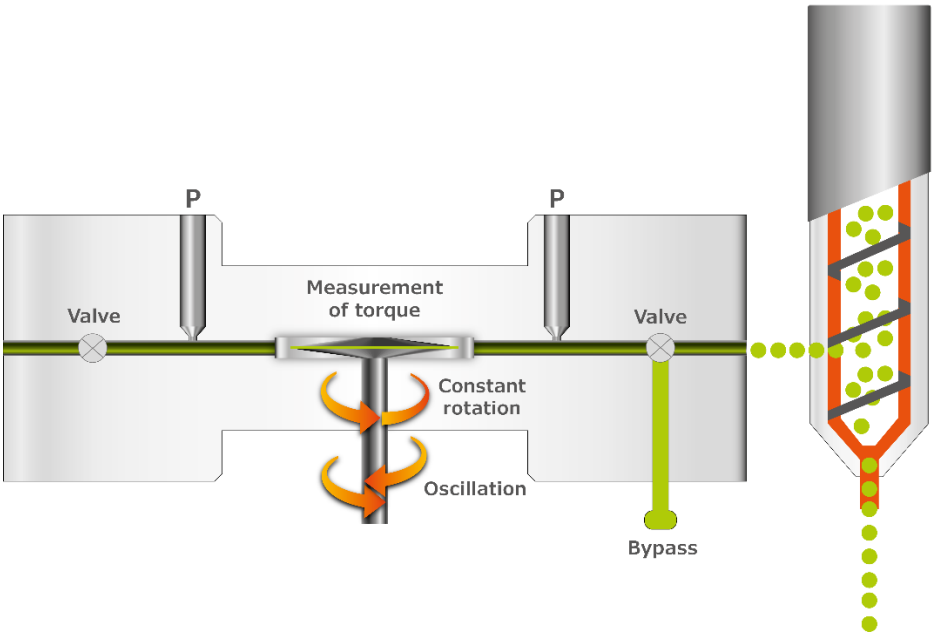
Measurement of Viscoelastic Properties of Polymer melts – continuously, online: Rotational Online Rheometer (ROR)

The rheological characterization of polymer melts sees basically two mayor measurement techniques to determine both, polymer structure and flow behavior.

Rotational rheometers (RR) with plate/plate or cone/plate geometries are the reference technique to determine polymer structure. Especially the dynamic measuring mode with varying frequency is the required condition to measure viscoelastic behavior of polymer melts. Due to the fact that RR can measure at relative low frequencies, slight structure changes can be determined. Next to polymer structure determination, measurement of flow behavior of polymer melts under processing conditions plays a significant role in polymer rheometry. All mayor polymer processing methods are out of the measurement range for RR due to their limitation to higher deformation rates than 100 Hz. Capillary rheometers (CR) are widely used to complete the range of testing under large deformation under process dependent processing conditions.

As RR are classic laboratory testing devices with time consuming sample preparation and handling, a derivative of CRs are the Online Process Capillary Rheometers which can be integrated into the polymerization phase or downstream into the processing process. These rheometers provide live data of the viscosity function in a large shear rate range.

The flow, generated in CRs does however not allow the measurement of viscoelastic properties, compared to the features of RR.



The new developed ROR (Rotational Online Rheometer) combines for the first time the characterization under processing condition, as well as the measurement of the viscoelastic flow behavior online in a continuous mode!

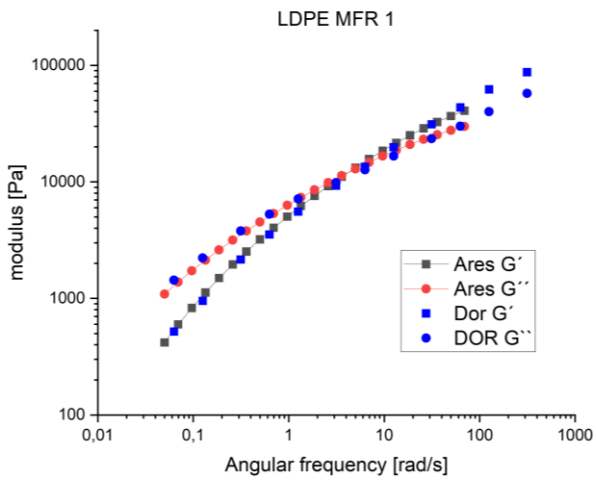
In the first application, ROR operates online feeded by a lab-extruder or gear pump.

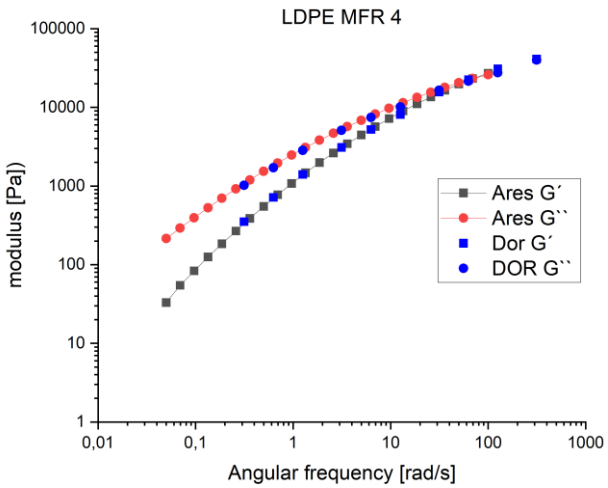
Oscillatory- and transient shear

The ROR offers frequency sweeps between 0.06 -314 rad/s. Also, transient sweeps between 0,01-500 1/s enhances the capabilities of this first time dynamic online-rheometer.

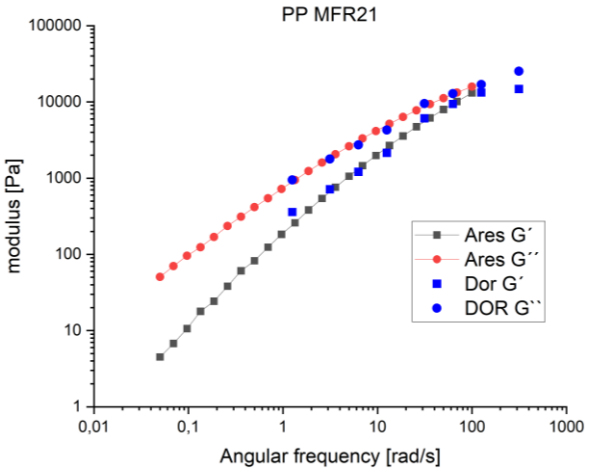
Very good agreement between ROR and rotational rheometer data for branched Polyolefines!

First results are presented to prove reliability in comparison of ROR measurements with standard RR technology. A range of Polyolefines were tested with linear and branched structure both with high and low Meltindex numbers.



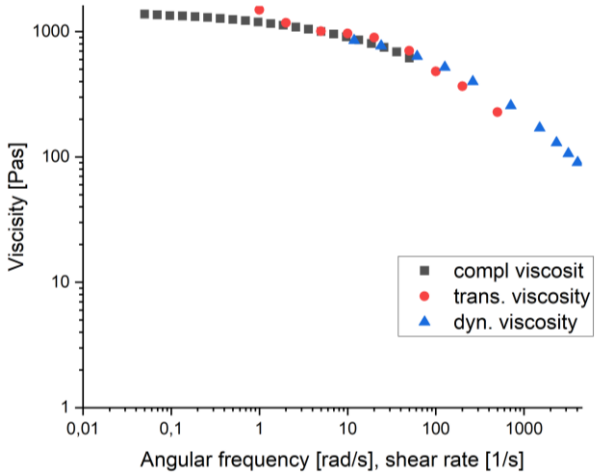


The Figures show LDPE's with MFR of 1 and MFR of 4 respectively with G'- and G"-functions both, for the ROR as well as RR. Very good agreement over a wide frequency range can be shown.



The figure describes a linear PP with MFR of 21. Data also confirm good agreement between ROR and RR measurements.

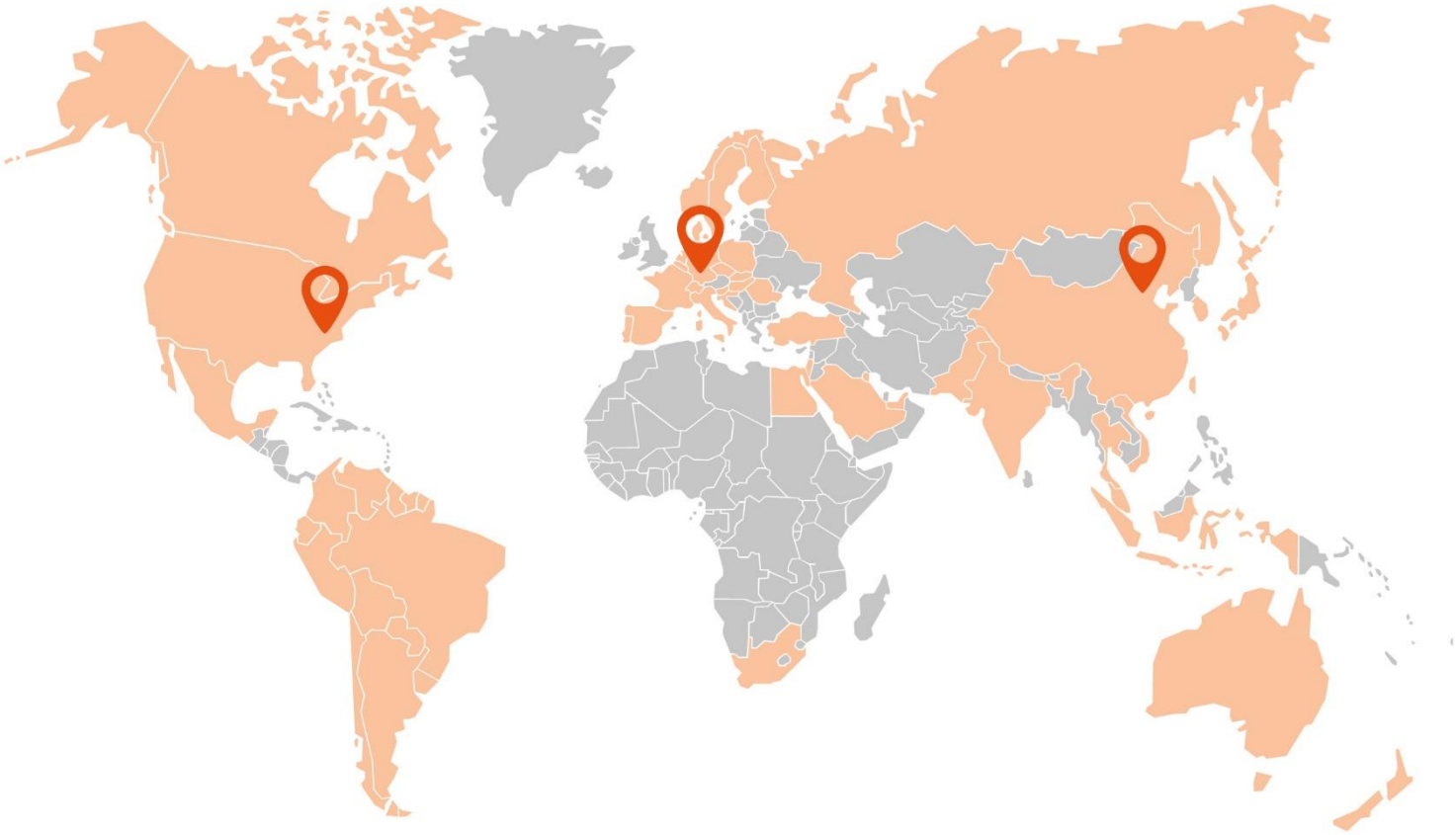
Prove of Cox-Merz rule!



Transient viscosity has been measured with ROR to prove the validity of Cox-Merz rule. On the left data are shown from transient viscosity of Rotational Online Rheometer (trans. Viscosity) and a rotational laboratory rheometer in oscillatory mode(compl. Viscosity), comparing with dynamic viscosity measured with a capillary rheometer with steady-state deformation. Within the measurement range, data from all three instruments coinside well on a unifying curve, which proves the validity of Cox-Mertz rule for this material!

Summary

The new ROR is an industrial prove rheometer with oscillatory flow deformation operating continuously and fully automatic with a linked feeding extruder. One application is the monitoring of polymer manufacturing control. Especially if there is a need to collect viscoelastic flow properties online from and during the polymerization process.



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