Determination of uniaxial and planar extensional viscosity using a Rosand high-pressure capillary rheometer

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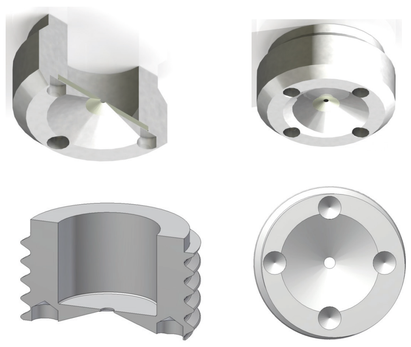
Introduction

Extensional viscosity (η_e) is a rheological characteristic that has a substantial impact on the processability of polymer melts and the final product's mechanical properties. η_e can be readily ascertained through entrance pressure drop (P_{en}) measurements using high-pressure capillary rheometers, orifice dies and the Cogswell method. However, during P_{en} measurements, polymer can adhere to the underside of the orifice die, leading to an overestimation of P_{en}, rendering the determination of η_e inaccurate.

New and Novel *FreeFlow* Dies

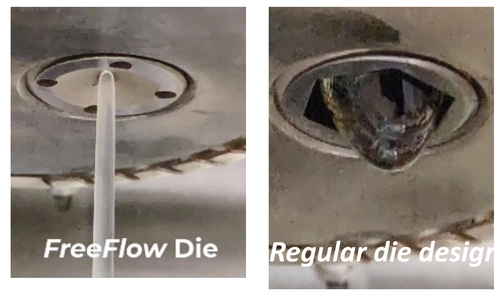
- Expanding on the pioneering work of Zatloukal, recent advancements in the design of ROSAND dies have led to the development of a new series of *FreeFlow* circular and rectangular orifice dies.
- Uniaxial and planar η_e can now be obtained effortlessly for various materials under controlled conditions.
- These innovative dies effectively eliminate the possibility of overestimating the entrance pressure drop, facilitating precise determination of both uniaxial and planar η_e.

FreeFlow Dies Design and Results

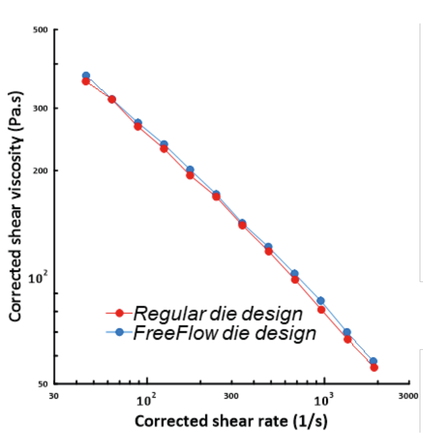


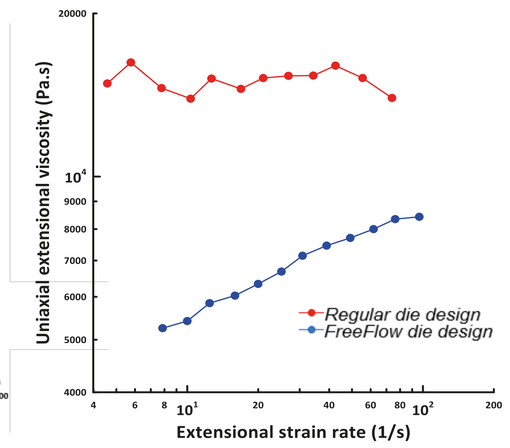
FreeFlow Die cross-section design

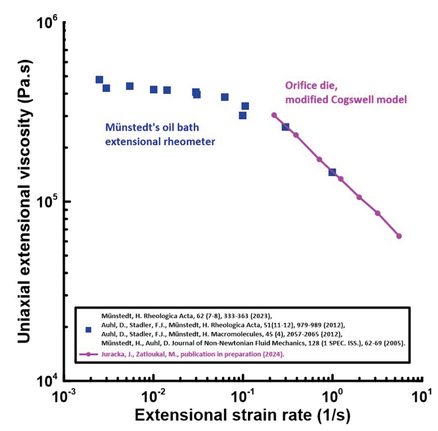
Scan QR Code for Video



LDPE extrudate from a *FreeFlow* die compared to a regular orifice die



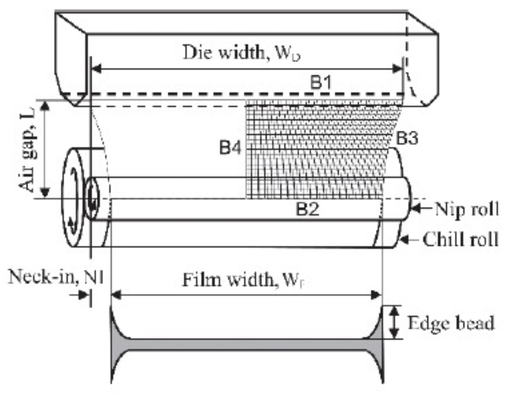




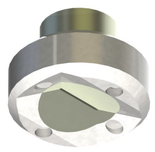
Despite significant differences in P_0 at low shear rates, in the long capillary rheometer dies there are no significant differences in the shear viscosity curves (left graph). However, the uniaxial extensional viscosity is extremely sensitive to the quality of the P_0 data (middle graph). The *FreeFlow* die design prevents sticking enabling properties such as strain hardening and strain softening (right graph) to be observed.

Planar Extensional Viscosity with Rectangular *FreeFlow* Die

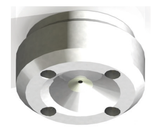
Neck-in (NI) and edge-bead in extrusion drawing in film-casting process reduce productivity and mechanical properties of the products. Neck-in tendency highly depends on viscoelasticity of the polymer.



$$NI \sim \left(\frac{\eta_p}{\eta_u}\right)_L^{\frac{1}{2}}$$



Rectangular *FreeFlow* orifice die enables determination of **planar extensional viscosity**



Circular *FreeFlow* orifice FreeFlow die enables determination of **uniaxial extensional viscosity**

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