Nucleation induced by elongational flow : time-resolved X-ray studies

Nucleation Induced by Elongational Flow: Time-resolved X-ray Studies

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Introduction

The behavior of polymer melts during solidification affects both the industrial processing conditions and product properties. New insights in the complex injection moulding process of semi-crystalline polymers, (PE, PP, PB and PET) are expected by applying new numerical models [1,2] together with an advanced description of morphological changes during flow.

Objectives

Time-resolved X-ray studies during elongational flow to provide morphological input data for modeling the injection moulding process.

Results

Synchrotron X-ray investigations ($\lambda = 0.0757\ nm$) have been performed on iPP ($M_w = 365\ kg/mol$) using an existing contraction flow cell [3].

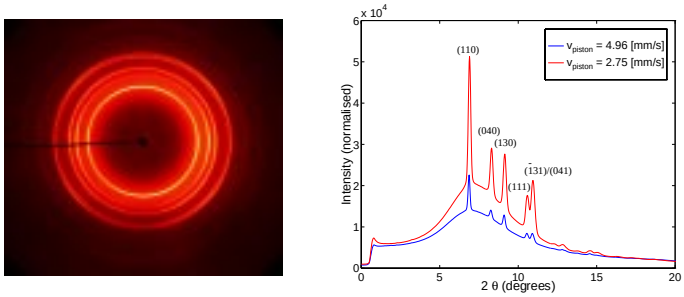

figure 1 *Left: 2D-WAXD pattern at piston velocity (v) 2.75 mm/s. Flow direction is vertical. Right: Along the Debye ring integrated WAXD intensity vs diffraction angle (2θ) at two velocities. $T = 170^oC$.*

- Flow-induced crystallization at 170^oC whereas no crystallization at 172 and 180^oC.
- At 170^oC alignment of molecular chains in flow direction and formation of crystals (*fig. 1, left*).
- Arcing of crystalline reflections (110), (040) and (130) along the equator due to crystal planes parallel to the flow direction.
- Larger degree of crystallinity at lower shear rates (*fig. 1, right*).

New Flow Cell

A new flow cell is developed with special features:

- Free stagnation point, where elongational strain can range up to infinite.
- Stress controlled flow.
- Temperature controlled with fast cooling.

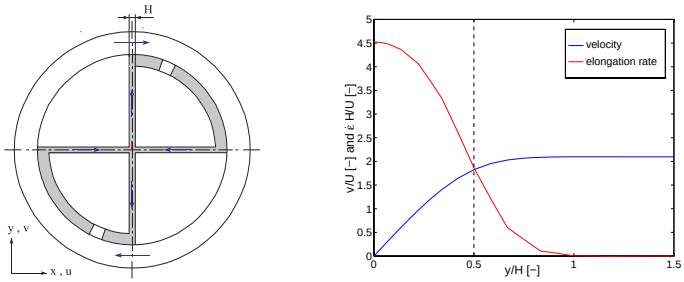

figure 2 *Left: Cross slot device. Moving the outer ring creates a stagnation flow (blue arrows). Right: Dimensionless velocity and elongation rate near the stagnation point on the red line in the left plot (H: channel height and U: mean velocity).*

A 3D analysis of the device provides quantitatively the strain and stress history experienced by a fluid element [4].

Conclusions & Future Research

- Preliminary experiments have proven the feasibility to visualize structural changes during flow.
- A new flow cell is constructed to provide well defined flow conditions.
- Novel information about morphological changes during elongational flow can be expected.

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