Crystallinity of polyethylene in uni-axial extensional flow

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Wednesday 17:30 Amalienborg NF33

Farady's instability in yield stress fluids

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When a horizontal fluid layer is subjected to vertical oscillations, its free surface becomes unstable to standing waves beyond a certain threshold. Faraday's instability in Newtonian fluids has been extensively studied. The interest to Faraday's instability in complex fluids is very recent and concerns mainly viscoelastic fluids. In the case of viscoplastic fluids, i.e. fluids that exhibit a yield stress, formation of persistent holes was observed experimentally rather than Faraday waves. In the present communication, we present an analysis of Faraday's instability for a viscoplastic fluid in terms of lubrication theory. It is worthy to note here that the classical linear theory can't be used. We consider a layer of an incompressible yield stress fluid on a horizontal plate that is subjected to a vertical sinusoidal oscillation of given amplitude and angular frequency. The rheological behavior of the fluid is described by the Herschel-Bulkley model. We suppose that the initial profile of the interface fluid-air varies over a horizontal length scale, L, i.e. initially the interface is not flat. Hence, in the basic state, a horizontal pressure gradient exists in the stationary fluid layer, induced by horizontal gradients in elevation and surface curvature. We assume that the mean depth of the fluid layer is much smaller than the horizontal characteristic length. The objective is to develop a thin-film style of model. After an appropriate scaling of all variables, the governing equations and the boundary conditions are rendered dimensionless. The leading order problem is integrated using the rheological flow. Finally, an equation relating the elevation of the interface fluid-layer to the horizontal flux of the fluid is obtained and solved numerically. Four different regimes were obtained depending on the amplitude oscillation and the Bingham number : (1) static layer, (2) weak spreading, (3) strong spreading and (4) unstable regime.

Symposium SM

Polymer solutions and melts

Organizers: Giovanni Ianniruberto and Qian Huang

Wednesday 13:00 Christiansborg SM24

Crystallinity of polyethylene in uni-axial extensional flow

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Flow history of polymer melts in processing greatly influences the crystallinity and hence the solid properties of the final material. A wide range of polymer processes involve extensional flows e.g. fiber spinning, blow moulding etc. However, due to instrumental difficulties, experimental studies on polymer crystallization in controlled uniaxial extension are quite rare compared to studies of crystallization in shear. Inherently uniaxial extensional flows are strong and simple relative to shear flows, in the sense that chain stretch is easily obtained and that the molecules experience no tumbling, hence much can be learned from studying polymers in extension. Recent advances in filament stretching rheometry now enable the performance of controlled uniaxial stretching of polymeric liquids even to high Hencky strains [1]. In addition the instrument allows for quenching at specific strains such that crystallization from a stretched state can take place. In this work we explore this feature in the attempt to link the nonlinear extensional rheology to the final morphology. We investigate polyethylenes (PE) of various chain architectures and observe that, even for complex architectures like long chain branched PE, the final morphology is determined by the stress at quench. This can be explained by realizing that nonlinearity in stress arises from changes in molecular configuration such as chain stretch. Hence the nonlinear stress response reflects the molecular configuration during stretching determining the final morphology [2].

[1] Román Marín, J.M. et al., J. Nonnewton. Fluid Mech. 194 , 14 (2013). [2] Graham, R.S. et al., Phys. Rev. Lett. 103 (11) , 1-4 (2009).

Wednesday 13:20 Christiansborg SM25

Modulus increase and crystallization evolution during gel spinning and post drawing of UHMWPE fibers

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We revisit the old problem of high modulus and high strength UHMWPE fibers from gel spinning and post drawing. The goal of this work as opposed to previous investigations is to understand the structure and modulus evolution as a function of strain and stress during the evolution of the fiber during processing. Two unique apparati have been built to monitor the stress and strain evolution in the gel spinning and post drawing unit operations. The gel spinning apparatus monitors the deformation of the polymer solution as a function of time and position during extrusion from the nozzle as a function of different temperatures, strain rates, and crystallization time. The stress and strain during post drawing is monitored using a filament stretching rheometer with novel sample plates to monitor the evolution of modulus and crystallization as a function