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BGR
Belgian Group of Rheology

NRV
Nederlandse Reologische Vereniging
Dutch Rheological Society

Thursday 15:00 Yellow Room FM10

Reconstructed dynamics of polymer melt extrusion instabilities

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Polymer melts exhibit a wide variety of instabilities during extrusion. These can be observed as extrudate patterns and range from relatively simple to chaotic structures. For a given extrusion geometry, the instabilities observed depend strongly on the molecular properties of the polymer melts. In this framework, we investigate the extrudate patterns up to the secondary instabilities exhibited during the extrusion of two industrial polymer melts, namely a linear low density polyethylene (LLDPE) and a low density polyethylene (LDPE). Our approach is based on the reconstructed dynamics of in situ mechanical pressure, i.e. we seek to create a topological equivalent of the phase space from experimental data. Overall, we believe that the in-depth analysis of transition sequences exhibited during the extrusion of polymer melts can be used as a a method of 'fingerprinting' polymer melts with respect to their molecular properties and processability. The experimental system features a capillary rheometer with a slit die equipped with highly sensitive pressure transducers. Simultaneously, spatio-temporal diagrams are acquired through an online image acquisition system located below the die exit. In addition, an axial force can be applied on the extrudate with the aid of a Rheotens device. After estimating the embedding parameters, the transition scenarios observed in the materials investigated are analyzed via the divergence of nearby trajectories. An exponential divergence of nearby trajectories in the reconstructed phase spaces is found for both materials at Weissenberg (Wi) numbers above the first critical Wi i.e. a maximal Lyapunov exponent can be determined. With respect to their dynamics, the two materials exhibit different behaviors. In the case of LDPE a monotonic increase of the maximal Lyapunov exponent is found as function of the Wi number. In contrast, for LLDPE a non-monotonic variation is observed. This change in behavior corresponds to the onset of the stick-slip instability in LLDPE.

Thursday 15:20 Yellow Room FM11

Systematic mode selection in thermal convection of complex fluids

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A nonlinear spectral approach is proposed to simulate the post-critical convective state for thermo-gravitational instability in Newtonian and complex fluid layer heated from below. The spectral methodology consists of expanding the flow and temperature fields periodically along the layer, and using orthonormal shape functions in the transverse direction. The Galerkin projection is then implemented to generate the equations for the expansion coefficients. Since most of the interesting bifurcation picture is close to criticality, a perturbation approach is developed to solve the nonlinear spectral system in the weakly post-critical range. To leading order, the Lorenz model is recovered. The problem is also solved using amplitude equations for comparison. The similarity and difference among the three models are emphasized.

Thursday 15:40 Yellow Room FM12

Guidelines for detection of the onset of Dean instabilities for Newtonian and viscoelastic fluid flows in curved ducts of square cross-section

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In flows through curved channels, the methods for detecting Dean instabilities suffer from lack of objectivity. In an attempt to overcome these difficulties, Fellouah et al1 established an objective criterion for the instability threshold: the transition from 2 to 3 peaks in the profile of the radial gradient of streamwise velocity in the vicinity of the curve outer wall, establishing 70° as the lower limit of angular position at which the onset of Dean instabilities occurs. However, this criterion is not completely objective: the plane, at which the radial gradient of the streamwise velocity is measured, is selected based on the location of the centre of the Dean instabilities at a supercritical Dean number (Dn). Since the centre of the instabilities moves with the growth of the vortices, the centre of the instabilities vary with Dn. So, this criterion does not allow the detection of weak Dean vortices located closer to the wall. In addition, due to the changes in the flow pattern in this kind of flows, it is difficult to establish a single objective criterion capable of identifying the onset of Dean instabilities. In this numerical study we propose guidelines to identify the location and the critical parameters at which the Dean instabilities are triggered. The guidelines are based on the analysis of changes in the profiles of velocity components and first-normal stress difference, supported by illustrations of streamtraces. For that we considered Newtonian and viscoelastic developing fluid flows, in an 180° curved duct of square cross-section. The governing equations were solved using a finite-volume method. The numerical simulations were done for different Reynolds numbers and Weissenberg numbers for the viscoelastic FENE-CR fluid model. Using these guidelines, we propose more accurate maps of the flow development, where it can be observed that the transition from one to two pairs of vortices occurs at an angular position upstream in the curve than that reported. 1Fellouah et al, E.J.Mech.B/Fluids 25(2006)505

Thursday 16:30 Yellow Room FM13

A very small process at a very high rate

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In the field of polymer processing one important objective of numerical modeling is to understand the time dependent flow phenomena that limit the general effectiveness and productive output of these shaping processes. Here, we analyze the multilayer flow dynamics and interface behavior of the glass fiber-optics coating process and improve upon the industrial standard to significantly increase the process efficiency.

Thursday 16:50 Yellow Room FM14

A turbulence model for FENE-P fluids in the whole range of drag reduction

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It has been known for quite sometime that the addition of polymers to turbulent flows of Newtonian fluids can dramatically reduce the turbulent friction coefficient (By as much as 80% as found experimentally) with a concomitant effect upon all other associated quantities.
In this work a tensorially consistent near-wall four equation model is developed in the context of Reynolds-averaged Navier-Stokes (RANS) equations to model turbulent flow of dilute polymer solutions up to the maximum drag reduction, by utilizing the Finitely Extensible Nonlinear Elastic-Peterlin (FENE-P) rheological constitutive. Eight sets of DNS data are used to analyze budgets and behaviors of relevant physical quantities, such as the nonlinear terms in the FENE-P constitutive equation, the turbulent kinetic energy transport equation, the wall normal Reynolds stress transport equation and the dissipation transport equation.
Closures were developed in the framework of the k-e-v^2-f model , used for the first time with viscoelastic fluids by Iaccarino et al [1], for the viscoelastic stress work, the viscoelastic destruction of the rate of dissipation, the viscoelastic turbulent viscosity, and the interactions between the fluctuating components of the conformation tensor and of the velocity gradient tensor terms. Calculated polymer stress, velocity profiles and turbulent flow characteristics are all in good agreement with current DNS data over wide range of rheological parameters, and show significant improvements over the corresponding predictions of Iaccarino et al [1] for FENE-P fluids.

References

[1] G. Iaccarino, E.S.G. Shaqfeh, Y. Dubief, Reynolds-averaged modeling of polymer drag reduction in turbulent flows, Journal of Non-Newtonian Fluid Mechanics 165 (2010) 376-384

Thursday 17:10 Yellow Room FM15

Viscoelastic turbulence in micellar solutions

Marc A. Fardin[1], Gareth H. McKinley[2], Sandra Lerouge[3], and Sebastien Manneville[1]
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In the past twenty years, shear-banding flows have been probed by various techniques, such as rheometry, velocimetry and flow birefringence. In micellar solutions, many of the data collected exhibit unexplained spatiotemporal fluctuations. Recently, we have shown that those fluctuations can originate from a purely elastic instability of the shear-banding flow. In some cases, the flow of micellar solutions can exhibit elastic turbulence, with our without shear-banding. I shall review the current state of our understanding on such cases.

Thursday 17:30 Yellow Room FM16

Nonlinear dynamics of turbulent drag reduction by polymers

Graham, Michael D., Xi Li, Wang Sung-Ning, Jae Sung Park
University of Wisconsin-Madison, Chemical and Biological Engineering

Minimal channel flow of Newtonian and drag-reducing polymer solutions is studied computationally. Even in the Newtonian limit, intervals of "active" and ``hibernating" turbulence exist, the latter displaying many features of the maximum drag reduction (MDR) asymptote observed in polymer solutions: weak streamwise vortices, nearly nonexistent streamwise variations and a mean velocity gradient that quantitatively matches experiments (i.e. the Virk log-law). Polymer stretching is very weak during hibernation. As viscoelasticity increases, the frequency of the hibernation intervals increases, leading to flows that increasingly resemble MDR. This observation can be explained with a simple mathematical model that posits that the lifetime of an active turbulence interval is the time that it takes for the turbulence to stretch polymer molecules to a certain threshold value beyond which the active turbulence is suppressed. These results and others indicate that the MDR dynamics are governed by an underlying Newtonian state -- a saddle point in phase space -- that is unmasked as viscoelasticity suppresses normal turbulent fluctuations.

of exocellular polysaccharides (EPS) in yoghurts (Cerning, Hassan et al.), and there have been attempts to correlate the thixopropic behaviour under shear to the ropiness (Folkenberg et al.) but up to now there is no clear mechanistic understanding on how EPS actually imparts ropiness. We show that ropiness can be related to the extensional elastic stresses developed by the EPS, that become dominant over the yoghurt matrix contributions in the extensional flow fields of a pooring operation (in essence the EPS acts as a semi-dilute high molecular weight dissolved polymer). We start with the experimental determination and quantification of ropiness through transient extensional rheology with Capillary breakup extensional rheology (CABER) measurements. We compare the breaking dynamics of typical ropy and a non-ropy yoghurt with similarly shear rheology and correlate the differing extensional rheology to model systems of isolated pure EPS in Newtonian matrix fluids. The results are evaluated in light of the current literature on extensional flows of dilute polymer solutions, and we discuss the relative influence of EPS concentration, molecular weight, chain architecture, solvent viscosity and quality. Hassan, A. N., et al. (2003). Microstructure and rheology of yogurt made with cultures differing only in their ability to produce exopolysaccharides. Journal of Dairy Science, 86, 1632-1638. Cerning, J. (1990). Exocellular polysaccharides produced by lactic acid bacteria. FEMS Microbiological Reviews, 87, 113-130. Folkenberg, D.M., et al. Sensory and rheological screening of exopolysaccharide producing strains of bacterial yoghurt cultures. International Dairy Journal 200616 (2), pp. 111-118

Thursday 17:30 Blue Room LS2

Human blood shear rheology

Patrícia C. Sousa[1], João Carneiro[1], Fernando T. Pinho[2], Mónica S. N. Oliveira[3], and Manuel A. Alves[1]
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The investigation of the rheological properties of whole blood is of significant importance in order to predict pathological conditions. In this work, the rheological behaviour of human whole blood, under normal physiological conditions, is investigated experimentally. The blood samples were collected from two healthy donors of different genders with similar haematocrit levels (volume concentration of erythrocytes in blood), namely 41.3% and 41.6% for the female and the male, respectively. For the shear experiments, a rotational rheometer (MCR301, Anton Paar) was used. It was equipped with a plate-plate measuring system with a roughened surface to avoid wall slip. Prior to the measurements, a new experimental protocol was established to avoid cell sedimentation and promote the homogeneity of the blood sample during the rheological measurements. Steady-shear measurements were carried out to determine the flow curve for both samples and evaluate the effect of using anticoagulant (EDTA) on this rheological property. In addition to the shear-thinning viscosity of whole blood, we found that the addition of 1.8 mg/mL of anticoagulant does not affect the steady-shear viscosity, provided the measurements are done in a short enough time interval to prevent coagulation. Large amplitude oscillatory shear measurements of whole blood were also performed using strain control, to investigate the nonlinear viscoelastic response. Whole blood exhibits viscous and elastic attributes, but the dissipation was found to be larger than the storage properties.

Symposium MS

Polymer melts and solutions

Organizers: E van Rumbeke and H Watanabe

Thursday 14:00 White Room MS22

New Way to Characterize Percolation Threshold of Polymer Composites with Carbon Nanotubes using FT-Rheology

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The Carbon Nanotubes (CNTs) play an important role in materials science owing to their potential for modifying the shear viscosity (?) and other transport properties of polymeric materials at the percolated state. It is important from scientific and technological interest to analyze the minimal concentration of CNTs necessary to form this percolated network that is dramatically affected by melt processing. Therefore, to understand the transport properties at the melt state of these composites at small as well as large deformation close to percolation threshold, it is needed to optimize the processing condition in mixing, moulding, and extrusion. Motivated by this we investigated several polymer composites prepared with either Single Walled Carbon Nanotubes (SWNTs) or Multi Walled Carbon Nanotubes (MWNTs) in oscillatory shear at small and large deformation using a novel method developed in our group. The SWNTs and MWNTs are dispersed in two polyethylene (PE) matrices with different topology in different proportions. The Large Amplitude Oscillatory Shear (LAOS) experiments are performed on prepared samples and the distorted response of sinusoidal excitation has been analyzed using FT-Rheology1 and Stress-Decomposition using Chebyshev polynomials2. An interesting phenomenon of existence of minimum of intrinsic nonlinearity (Q0)3 with increasing CNTs fraction in PE matrix has been observed. The minimum corresponds to rheological percolation threshold which seems to be more sensitive than the usual way of detecting the percolation threshold based on material parameters in viscoelastic linear regime. We anticipate this new technique will enable

PO75

Numerical investigation of tube-tooling cable-coating flow for inelastic and viscoelastic fluids

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PO76

Structure and viscoelasticity of complexing biopolymers hydrogels

Svetlana R. Derkach, Nikoli G. Voron'ko, Alexandra A. Maklakova, Lyudmila A. Petrova, and Tatyana A. Dyakina
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PO77

Micro-scale flow of wormlike micellar solutions past a confined cylinder

Vera M. Ribeiro[1], Simon J. Haward[2], Paulo M. Coelho[3], and Manuel A. Alves[1]
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PO78

Elongational rheology of linear polymers by molecular dynamics simulations

Naomi Withey, Zuowei Wang, and Alexei Likhtman
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PO79

A thin layer model for deposition of thickened tailings

Sarah Hormozi, Ian Frigaard, and Neil Balmforth
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PO80

Kinetics of molar mass build-up and degradation in a Polyethylene terephthalate melt

Michael Härth and Dirk W. Schubert
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PO81

Flow-induced alignment of colloids in shear-thinning viscoelastic fluids

Igor Santos de Oliveira, Wouter K. den Otter, and Wim J. Briels
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PO82

Flow transition of Newtonian fluid past soft bilayer

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PO83

Conductive polystyrene/carbon nanotube composites having enhanced dispersion and their rheology and electrical conductivity

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PO84

Viscoelastic Instabilities in Concentric Annuli with Outer Cylinder Rotation

Mohammadali Masoudian, Laura Campo-Deaño, and Fernando T. Pinho