Rheol Acta (2011) 50:303–306
DOI 10.1007/s00397-011-0530-9

EDITORIAL

Viscoplastic fluids: from theory to application (VPF2009), Limassol, Cyprus, 1–5 November, 2009

Andreas N. Alexandrou · Georgios C. Georgiou · Guillaume Ovarlez

Received: 13 December 2010 / Accepted: 6 January 2011 / Published online: 21 January 2011

The 3rd meeting on "Viscoplastic Fluids: From Theory to Application" was held in the lovely coastal city of Limassol, Cyprus. It was organized by the Hellenic Society of Rheology, under the auspices of ESR, with the help and encouragement of Neil Balmforth and Ian Frigaard, who organized the 1st meeting held in Banff, Canada (22–27 October 2005). The 2nd meeting took place in Monte Veritá, Switzerland (14–18 October 2007). The goal of these workshops is to promote interactions between people from different communities working on viscoplastic fluids.

With 50 registered participants from 13 countries (see Table 1 and Fig. 1), the workshop was really an international event. The scientific program consisted of 28 oral communications, five poster contributions, and three invited talks. The workshop spanned different topics, such as physical processes involved in yielding, fluid mechanics, and industrial and other applications. All aspects were studied through experiments, numerical simulation, and mathematical modelling. A brief summary of the different presentations follows.

A. N. Alexandrou
Department of Mechanical and Manufacturing Engineering,
University of Cyprus, P.O. Box 20537, 1678 Nicosia, Cyprus
e-mail: andalexa@ucy.ac.cy

G. C. Georgiou (✉)
Department of Mathematics and Statistics,
University of Cyprus, P.O. Box 20537, 1678 Nicosia, Cyprus
e-mail: georgios@ucy.ac.cy

G. Ovarlez
Laboratoire Navier (UMR 8205 LCPC-ENPC-CNRS),
Université Paris-Est, 2 allée Kepler,
77420 Champs sur Marne, France
e-mail: guillaume.ovarlez@lcpc.fr

The opening invited talk by Gareth McKinley ("Adventures in elastocapillarity and viscoelastoplasticity") was dedicated to the memory of Professor Vladimir Entov (1937–2008). In the first part of his talk, McKinley presented work from his collaboration with Entov concerning the exploitation of free surface flows for characterizing the elongational properties of low viscosity elastic fluids. Experimental results on capillarity-driven necking of liquid bridges obtained by Entov and coworkers were also presented by Alexandrou, who in addition presented supporting numerical simulations of viscoplastic filaments in pure extension. While the experimental results were obtained in Moscow over 12 years ago, the simulations and analysis were recent. The objective of the work was to explain the failure of the extensional rheometer used in the experiments to predict the effective viscosity of not only viscoplastic but also of Newtonian fluids. Indeed the simulations showed that the classical flow assumptions typically used in the analysis were not valid. The result showed that in the extension of viscoplastic filaments two unyielded rings develop above and below the area of minimum radius. It was shown that proper analysis using these regions can be used to determine rheological constants making the extensional rheometer an effective method for testing such fluids.

The other two invited talks were delivered by Morton Denn ("Issues in the flow of yield-stress liquids") and Ken Walters ("The yield stress concept—Then and now"), who reviewed and discussed major conceptual issues concerning the flow of yield stress fluids. New ideas on the ongoing debate about the classification of yield stress fluids have also been presented by Bonn, who showed that rigorous experimental protocols allow the unambiguous determination of a true yield stress;

Table 1 List of the participants

Andreas N. Alexandrou	University of Cyprus, Cyprus
Pierre Ballesta	IESL, FORTH, Greece
Neil J. Balmforth	University of British Columbia, Canada
Volfango Bertola	University of Edinburgh, United Kingdom
Daniel Bonn	University of Amsterdam, The Netherlands
Teodor I. Burghelea	University of Erlangen-Nürberg, Germany
Guillaume Chambon	Cemagref-Centre de Grenoble, France
Nicholas Constantinou	University of Cyprus, Cyprus
Philippe Coussot	Université Paris-Est, France
Anne Davaille	Université Paris 6, France
Morton M. Denn	City College of New York, USA
John R. de Bruyn	University of Western Ontario, Canada
Paulo de Souza Mendes	Pontificia Universidade Católica, Brasil
Neville Dubash	University of Washington, USA
Inna Elyukhina	South Ural State University, Russia
Abdoulaye Fall	University of Amsterdam, The Netherlands
Admilson Teix. Franco	Fed. Univ. of Technology-Parana, Brasil
Ian Frigaard	University of British Columbia, Canada
Georgios C. Georgiou	University of Cyprus, Cyprus
Assia Ghemmour	Cemagref-Centre de Grenoble, France
Ioan R. Ionescu	Université de Paris 13, France
Silvio LM Junqueira	Fed. Univ. of Technology-Parana, Brasil
Olga Lavrenteva	Technion, Israel
Jim McElwaine	University of Cambridge, United Kingdom
Gareth McKinley	MIT, USA
Christel Métivier	Université de Grenoble, France
Evan Mitsoulis	NTU Athens, Greece
Miguel Moyers-Gonzalez	University of Canterbury, New Zealand
Ekaterina Muravleva	Russian Academy of Sciences, Russia
Larisa Muravleva	Lomonosov Moscow State University
Mônica F. Naccache	Pontificia Universidade Católica, Brasil
Marina K.A. Neophytou	University of Cyprus, Cyprus
Avinoam Nir	Technion, Israel
Guillaume Ovarlez	Université Paris-Est, France
Yannis Papaharilaou	IACM, FORTH, Greece
George Petekidis	University of Crete, Greece
Michael F. Petrou	University of Cyprus, Cyprus
Harald Pleiner	Max Planck Institute, Germany
Simon A. Rogers	IESL, FORTH, Greece
Vladimir Shelukhin	Lavrentyef Inst. of Hydrodynamics, Russia
Edson José Soares	Fed. Univ. of Espirito Santo, Brasil
Helen Sweeny	University of Bristol, United Kingdom
Roney L. Thompson	Universidade Federal Fluminense, Brasil
John Tsamopoulos	University of Patras, Greece
Alexander Vikhansky	University of London, United Kingdom
Demetris Vlassopoulos	University of Crete, Greece
Ken Walters	University of Aberystwyth, United Kingdom
Kerstin Wielage-Burchard	University of British Columbia, Canada
D. Ian Wilson	University of Cambridge, United Kingdom
Christos Xenophontos	University of Cyprus
Andreja Zupančič	University of Ljubljana, Slovenia

he also pointed out the connection between thixotropy and shear banding. Shear banding has also been reported by Fall in MRI/rheometric experiments with dense granular suspensions, where it finds its origin in the competition between viscous and gravity forces.

Several talks dealt with advanced rheometric techniques to investigate in more detail the behaviour of yield stress fluids. McKinley discussed the strained-controlled large amplitude oscillatory shear (LAOS) technique for identifying and characterizing apparent

Fig. 1 The participants of VPF2009 at the hotel lobby in Limassol, Cyprus

yield stress responses in elastoviscoplastic materials. LAOS was also applied in experiments carried out in Crete by Rogers and Vlassopoulos on soft colloidal glasses and by Ballesta and Petekidis on colloidal hard sphere glasses and gels. These authors also reported systematic experiments with well defined protocols aimed at rationalizing glassy dynamics and related phenomena, such as shear banding. Ovarlez has presented an experimental investigation of the 3D behavior of yield stress fluid thanks to a new device coupling a rotational flow and a squeeze flow; he showed that the observed behavior help explaining the phenomenon of shear-induced sedimentation. Chambon has presented an in-depth investigation of viscoplastic surge fronts thanks to an innovative inclined channel whose bottom is constituted by an upward-moving conveyor belt. Eluikhina showed how oscillating cup viscometry can be used for the characterization of viscoplastic fluids.

Using Carbopol as a suitable viscoplastic fluid and the need for guidelines in preparing its samples were emphasized in the previous two meetings. John de Bruyn presented careful, nicely designed experiments with Carbopol, for which he was awarded the best-talk prize. He used shear rheometry, microrheology, and small angle light scattering in order to investigate the bulk rheology and the micro-scale properties and structure of dilute suspensions of Carbopol. Carbopol gels were then used as model yield stress fluids in several studies. Coussot chose to present MRI results of the extrusion flow properties of various materials, in particular Carbopol whose behavior closely matches theoretical flow profiles of Herschel–Bulkley fluids. Burghelea investigated the solid-fluid transition of a Carbopol gel under shear thanks to both flow ramps and dynamic elastic moduli measurements. Lavrenteva and Nir evidenced interactions between gravity driven viscous drops in Carbopol gels. Experimental observations of capillary phenomena, occasionally combined with slip, exhibited by a viscoplastic commercial hair gel have been reported by Bertola. Carbopol gels were also used as model suspending fluids for studying the behavior of suspensions of non-colloidal particles in yield stress fluids: Ovarlez showed in particular that their nonlinear properties (yield stress, consistency) can be predicted once their linear properties (elastic modulus) are known; Ghemmour studied the particles trajectories, and thus the forces exerted onto them, when these suspensions flow down an inclined plane.

In a workshop held in the homeland of the late professor Tasos Papanastasiou, a number of presentations paid a deserved tribute to his memory, with the use of his regularized model or its Herschel–Bulkley variant in numerical simulations of viscoplastic flows, such as fountain flow and calendering (Mitsoulis and Alexandrou) and the viscoplastic displacement of a Newtonian fluid in a capillary plane channel (Thompson). Wielage-Burchard and Frigaard also considered the displacement flow of a viscoplastic fluid and showed numerically that flow pulsation appears to make the residual wall layers thicker. Tsamopoulos presented simulations of the pressure-driven injection of a viscoplastic material inside a pipe or between parallel coaxial disks, predicting wall detachment of the advancing front under certain conditions in agreement with experiments. On the other hand, E. Muravleva and L. Muravleva reported results obtained with the

augmented Lagrangian method for unsteady flows of ideal Bingham fluids in 1- and 2-D geometries, putting emphasis on the evolution of rigid zones and the stopping times in the case of cessation. The augmented Lagrangian method was also adopted by Ionescu in solving the shallow flow of a viscoplastic fluid on a plane slope.

Other numerical simulations were communicated by McElwaine (discrete element method simulations of unsteady granular flows) and Vikhansky (lattice-Boltzmann method to simulate two-phase viscoplastic flows). Balmforth, Dubash, and Slim used a model based on an asymptotic expansion in order to simulate the extensional dynamics of viscoplastic filaments and compared their results with experiments. Frigaard also reported ongoing and recent work on viscoplastic lubrication in a core-annular setting. Métivier presented linear stability results for the Rayleigh–Bénard Poiseuille flow of a viscoplastic fluid with temperature-dependent plastic viscosity.

A new constitutive equation addressing the elastic behavior of viscoplastic fluids was proposed by Naccache and De Souza Mendes. The latter author also presented a new thixotropy model, which is based on the assumption that structured fluids are viscoelastic fluids, obeying a modified Burger's model with structuring-level-depending parameters. A general model based on transient elasticity and its extension for viscoplastic fluids was derived by Pleiner.

Analytical results presented in the workshop included asymptotic solutions of the flow of a Bingham fluid between eccentric cylinders (Shelukhin), and solutions describing natural and Marangoni convection in a double layer of a Newtonian fluid and a viscoplastic one with a concentration-dependent yield stress (Lavrenteva and Nir).

Supporting the application-oriented goals of the workshop, Wilson showed how theory can be applied in the case of paste engineering. He also reviewed studies on freezing fouling of waxes in crude oils and presented experimental results on model solutions of food fats. Other applications of fluids with yield stress presented in the workshop included hemodynamics with emphasis on the effects of the various volume expanders on blood rheology (Zupančič), and the rheological characterization of self-compacting concrete from slump flow experiments (Neophytou; Constantinou).

The workshop would not be possible without the financial support of the Department of Mathematics and Statistics, and the Department of Mechanical and Manufacturing Engineering of the University of Cyprus, the Cyprus Tourism Organization, and the Cyprus Department of Antiquities. We are also particularly grateful to Mrs. Athenoula Sophocleous (VPF-2009 secretary) and Mr. Chrysostomos Eleftheriou (VPF2009 web master and technical support), who contributed to the success of the meeting.

The success of the first three meetings has encouraged their continuation with the same format. The 4th meeting will be held in Rio de Janeiro, Brazil, November 6–10, 2011 (http://web.me.com/mnaccache/VPF2011/Home.html).

This special issue includes peer-reviewed articles that are representative of the themes and scientific quality of VPF2009. We are grateful to the contributors and reviewers for their diligent efforts. We also thank the editors of Rheological Acta for agreeing to publish the contributions in this special issue.