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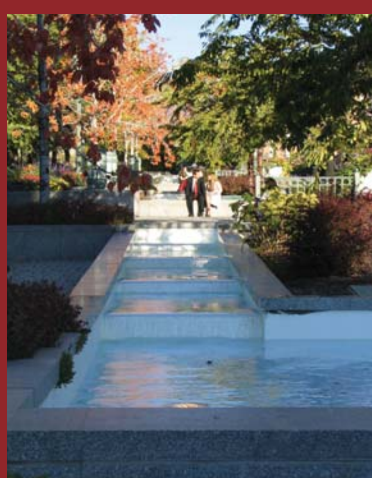
Rheology Bulletin



Salt Lake

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The *Rheology Bulletin* is the news and information publication of The Society of Rheology (SOR) and is published twice yearly in January and July. Subscription is free on membership in The Society of Rheology.

Change of address or letters to the editor: rheology@aip.org

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Dedicated to advancing the science of rheology: the study of deformation and flow of matter.

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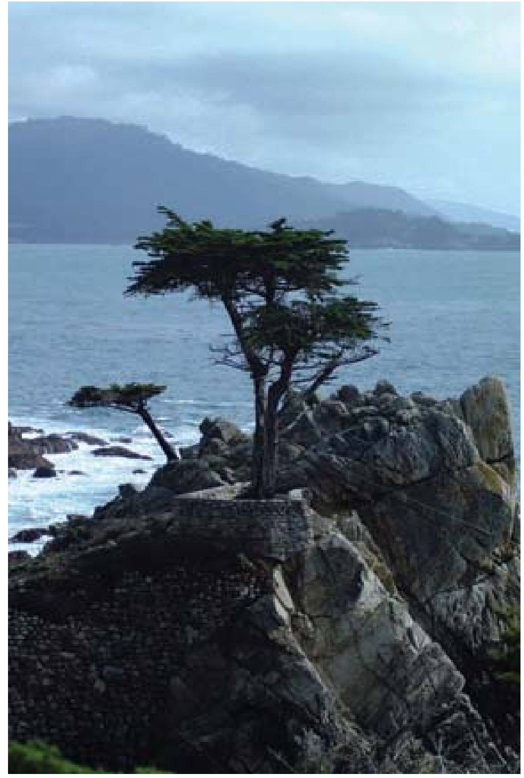
ICR 2008

Rheology 2008
monterey • california



The Society of Rheology invites you to participate in the XV[th] International Congress on Rheology (ICR), which will take place in Monterey, California USA from 3-8 August 2008. The Congress convenes every four years and brings together the world's leading rheologists to present the latest advances and developments in our field.

The 2008 Congress will take place at the Monterey Conference Center in Monterey, California. The host hotels are the Portola Plaza Hotel and the Monterey Marriott, with views of the famous Old Fisherman's Wharf and walking distance to Cannery Row and Monterey Bay Aquarium. Situated on the Monterey Bay, the largest marine sanctuary in the United States, the town of Monterey is an international vacation destination with incredible restaurants, exciting recreational facilities, and fascinating points of interest.

The Congress technical program has been designed to highlight significant topics in contemporary rheology. The opening plenary lecture on Monday morning will be presented by Paul Callaghan from the School of Chemical and Physical Sciences at Victoria University of Wellington, New Zealand. Prof. Callagahn's talk, "From molecules to mechanics: nuclear magnetic resonance and rheological insight," will give an overview of his efforts to combine the nanoscale probe capability of NMR with rheology to obtain information about soft matter. The Congress will include a closing plenary lecture on Friday afternoon by Fred MacKintosh from the Department of Physics and Astronomy of Vrije Universiteit, the Netherlands. Prof.

Organizing Committee (Local Arrangements)

Gerald Fuller (co-chair), Stanford University
Robert Powell (co-chair), University of California, Davis
Andrew M. Kraynik, Sandia National Laboratories
Susan Muller, University of California, Berkeley
Eric Shaqfeh, Stanford University

MacKintosh, an internationally respected researcher on soft matter physics, will speak on "Non-equilibrium mechanics of active gels and living cells." New to ICR2008, Prof. MacKintosh's lecture will be followed by a reception/lunch that will bring the Congress to a close early Friday afternoon. The Congress week will be filled with fourteen keynote lectures (including the SOR's Bingham lecture), contributed oral presentations organized into sixteen mini-symposia, a poster session, and social activities including a Wednesday afternoon excursion, a beach party, and a banquet. Attendees are encouraged to come to Monterey Sunday 3 August or earlier and to stay through the closing Friday afternoon reception.

Two short courses will be offered on the weekend before the Congress, 2-3 August 2008. A two-day short course on *Suspension Rheology* will be given by Jan Mewis and Norman Wagner. A one-day short course on *Surfactant Rheology - Self-Assembly and Microstructure Dynamics* will run on Sunday 3 August, taught by Pat Spicer and Srinivasa Raghavan. Those interested in both topics may take one day of the *Suspension* course followed by the *Surfactant* course. Details on the short courses are available in a separate article in this *Bulletin* (page 8) and on the web at www.rheology.org/ICR2008/ShortCourse/ShortCourse.htm.

The highlight of the ICR social calendar will be the Wednesday afternoon excursion, which is included for full delegates and for registered accompanying persons. There will be a choice of seven excursions, one for every taste. There are two choices for winery tour, the *Carmel Valley Wine Tour* and the *Steinbeck Country Wine Tour*. Both tours involve visits to multiple wineries and ample time for sampling. For those who prefer the sea, there is a *Big Sur Coastline Tour*. This tour takes participants by bus down the renowned Big Sur coast, to enjoy dramatic land and sea vistas along the way. Breathtaking scenery includes ancient redwood groves and a wide variety of California wildlife, including the ever-popular sea otter. If you prefer to be on the water, there is the *Monterey Marine Sanctuary Whale Watching Tour*. A short walk from the Convention Center takes us to Fisherman's Warf, the starting point for a cruise exploring some of the marine sanctuary's 276 miles of shoreline and 5,322 square miles of ocean. Whales in the bay during the summer months include Blue Whales, Sperm Whales, and Fin Whales, and Monterey Bay is abundant with all kinds of life from sea otters and sea lions to dolphins and pelicans.

For the more active conferees there are three excursions to choose from, the *Kayak Tour*, the *Bike Tour*, and *Golf at Poppy Hills*. The docent-guided *Kayak Tour* will

Program for Full Delegates

Sunday Afternoon Arrival
Sunday Vendor Displays Open
Sunday Evening Reception

Monday Opening Plenary:
Paul Callaghan (Rheo-NMR)
Monday Sessions
Monday Evening Reception

Tuesday Sessions

Wednesday Morning Sessions
Wednesday Afternoon Excursion, choice of:
Carmel Valley Wine Tour
Steinbeck Country Wine Tour
Big Sur Coastline Tour
Monterey Marine Sanctuary Whale Watching Tour
Kayak Tour
Bike Tour
Golf at Poppy Hills

Wednesday Night Beach Party
7:00 pm Pirate's Cove

Thursday Sessions
Thursday Evening Reception and Banquet

New!

Friday Morning Sessions
Friday late Morning Plenary:
Fred MacKintosh (Gels)
Friday Closing Ceremonies
Friday Reception/Lunch

New!

Saturday Morning Departure

Technical Program Co-Chairs
L. Gary Leal, U. California Santa Barbara
Ralph Colby, Pennsylvania State Univ.

explore the Monterey Bay up close, and participants will learn about the ecology of the bay, the history of the area, and about the biology and habits of the varied marine life. The *Bike Tour* explores the Monterey Bay coastline on a specialized 24-speed hybrid bike (helmet provided). Finally, for . . . well, you know who you are, there's *Golf at Poppy Hills*. Poppy Hills, located in Pebble Beach, California and designed by Robert Trent Jones, II, is a challenging, par-72 venue that weaves through the Del Monte Forest and plays host to several renowned tournaments, including the AT&T Pebble Beach National Pro-Am.

Monterey can be accessed conveniently with direct flights into Monterey Peninsula Airport from San Francisco, Los Angeles, and Salt Lake City. Ground transportation using express shuttles and buses can also be obtained from the San Francisco, Oakland, and San Jose Airports. A regularly scheduled service is operated by Monterey Airbus. The travel time by car from the San Francisco airport is approximately 2.5 hours. For more information on transportation and tours, visit the Monterey County Convention and Visitors Bureau (montereyinfo.org). For information about U.S. visa policy and procedures, visit UnitedStatesVisas.gov or Travel.State.gov.

Registration for full delegates and student delegates includes access to all technical sessions and the vendor display, the program and abstract booklets, the CD of Congress Proceedings, selected social events, and coffee breaks. An extensive Accompanying Persons Program has been organized. Registration fees are $650 USD (before 15 April)/ $750 USD (after 15 April) for delegates, $200/$250 USD for student delegates, and $350 USD for accompanying persons (no deadline).

Student members of The Society of Rheology are invited to apply for travel grants to attend the International Congress on Rheology in Monterey. The deadline for applications is 29 February 2008. Details of the Travel Grant program, eligibility requirements, and a description of the application process are on the web at www.rheology.org/sor/annual_meeting/2008Aug/student.htm.

Important Dates

15 November 2007
Deadline to submit abstracts for oral presentations

1 February 2008
Authors informed of acceptance decisions

29 February 2008
Deadline to submit abstracts for posters

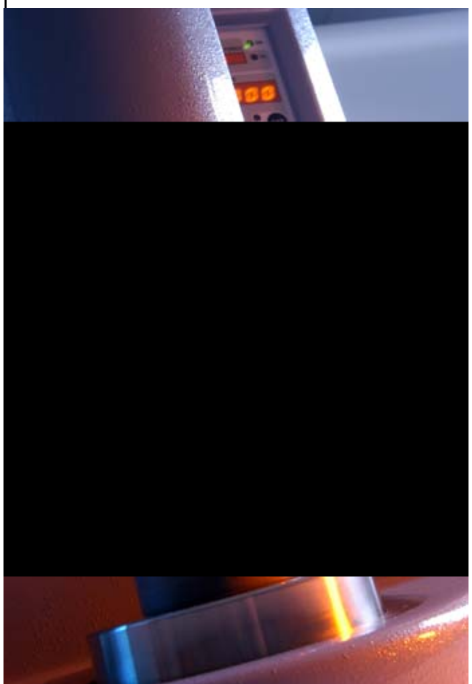
15 April 2008
Deadline for receipt of manuscripts in PDF form
Deadline for early registration
Deadline for speaker registration (otherwise the oral presentation will not be included in the program)
Deadline for early exhibitor registration

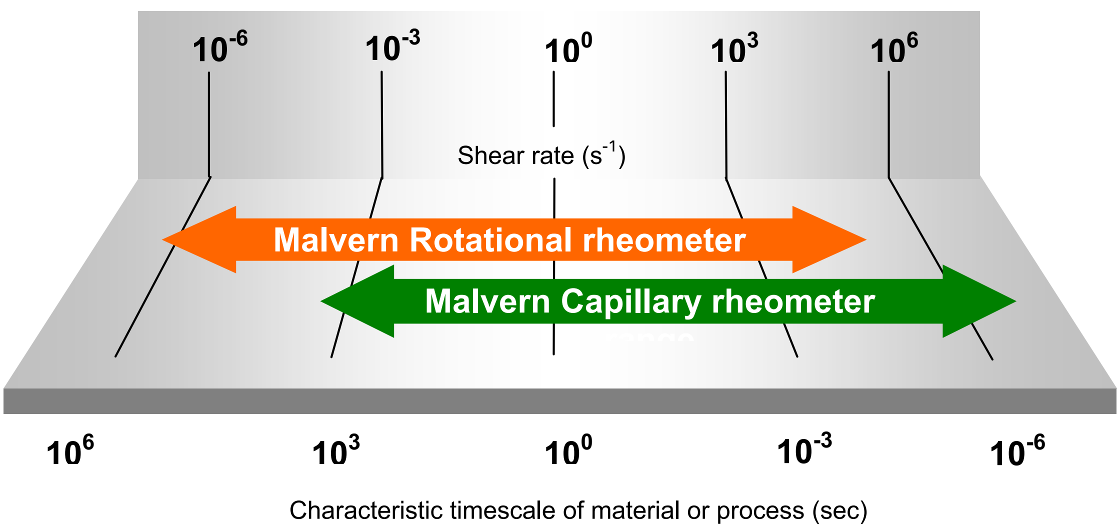
1 June 2008
Deadline for refunds (subject to administrative charge).

3-8 August 2008
XVth International Congress on Rheology (See program, p5)

8 August 2008
Closing Reception/Lunch (early afternoon) ***New!***

ICR 2008




10^{-6}
10^{-3}
10^{0}
10^{3}
10^{6}
Shear rate (s^{-1})
Malvern Rotational rheometer
Malvern Capillary rheometer
10^{6}
10^{3}
10^{0}
10^{-3}
10^{-6}
Characteristic timescale of material or process (sec)

ICR 2008

Short Courses Monterey

2-3 August 2008

Suspension Rheology

Jan Mewis
Department of Chemical Engineering
K. U. Leuven Belgium

Norman Wagner
Department of Chemical Engineering
University of Delaware USA

The course is designed to be an introduction to the rheology of colloidal dispersions with emphasis on practical measurement and interpretation of rheological measurements on colloidal dispersions. The object is to provide the participants with:

- Qualitative understanding of the various phenomena that contribute to the rheology of suspensions;
- Scaling relations and quantitative laws to predict the basic rheology of such systems;
- Strategies to measure, characterize and design suspensions with well defined processing or application properties.

This course is of interest to students and practitioners of colloid rheology in industry as well as academia. A basic understanding of physical chemistry is necessary with some familiarity with colloidal science and basic rheology helpful but not required.

The course is structured so as to build systematically upon the fundamental understanding of how various properties of colloids and their interactions lead to the observed rheological behavior. This starts with systems where only purely hydrodynamic effects are present (*i.e.* suspensions with non-colloidal particles). Next, colloidal particles are introduced; with Brownian motion but without any particle interaction force. After that, systems with additionally repulse interparticle forces are dealt with: *i.e.* colloidally stable systems. Finally, attractive forces are added which can lead to flocculated suspensions and colloidal gels. The methods of rheological measurement design and execution are discussed, treating the special difficulties that arise in the case of suspensions. Case studies will be analyzed to illustrate the basic concepts of the course. Special advanced topics are to be included depending on the interest of the students.

3 August 2008

Surfactant Rheology

Self-Assembly and Microstructure Dynamics

Patrick T. Spicer
The Procter & Gamble Company
West Chester, OH 45069, USA

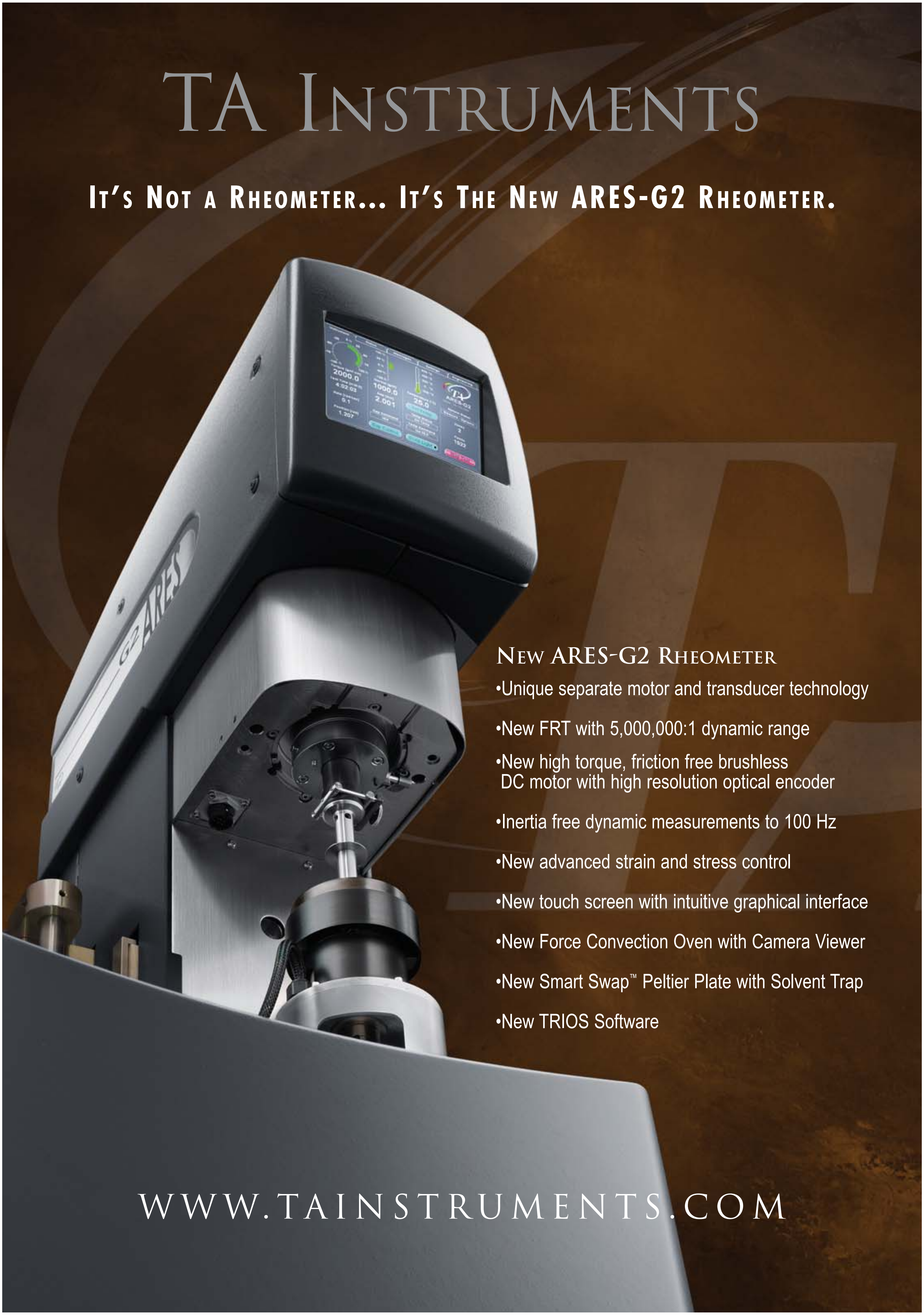
Srinivasa R. Raghavan
Dept. of Chemical & Biomolecular Engineering
University of Maryland, College Park USA

Although primarily known as modifiers of aqueous interfacial tension, surfactants exhibit a rich array of rheological behaviors as a result of their complex phase behavior. Consumer products are an example of the commercial use of surfactants for their cleaning and surface-treatment properties but also to modify liquid rheology. Additional surfactant research areas include drug delivery, nanoparticle synthesis by templating, and biophysical studies of cell transport.

This course will cover aqueous surfactant system rheology and its relationship with the numerous equilibrium phases formed. However, it also addresses the kinetic processes that are equally important to biological and industrial applications. The course theme is the theoretical and practical microstructure of different systems, their characterization, and their relationship with the resultant system rheology. The material is quantitative but highly visual, reflecting the topic's beauty via numerous illustrative movies and applications. Examples are drawn from applications in consumer products, pharmaceuticals, and petrochemicals.

The surfactant rheology course will enable industrial researchers, graduate students, and faculty members to more readily apply and understand surfactant rheological variations at high and low concentrations and will connect disparate areas of research that typically do not overlap.

More information is available on the web at
www.rheology.org/ICR2008/ShortCourse/ShortCourse.htm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Misuse of the Term *Pressure* in Rheology

John M. Dealy
Department of Chemical Engineering
McGill University

Abstract

The symbol *P* is widely used to indicate an isotropic contribution to the total stress in describing the flow of non-Newtonian fluids, and whether explicitly stated or not, it is implied that the quantity referred to is the "pressure." However, in most non-Newtonian fluids with structural or flow-induced anisotropy, there is no uniquely defined isotropic contribution to the total stress tensor. In experiments intended to show the effect of "pressure" on rheological properties, the quantity measured is, in fact, one component of the stress tensor and should be properly identified as such. Failure to recognize this fact can lead to error in the reporting of the data intended to show the effect of "pressure" on rheological properties. A meaningful variable for comparing data from different types of instrument is the mean compressive stress, which is the negative of the mean normal stress, but this quantity is not equal to the pressure that is measured, and its relationship to any measured pressure varies from one flow geometry to another.

Introduction

We are so accustomed to using the term "pressure" in thermodynamics and classical fluid mechanics that we continue to use it in situations in which its meaning is indeterminate. In particular, when dealing with flows in which deformation leads to anisotropy of the normal stresses, "pressure" has no unique definition. Thus, when we introduce a scalar to represent a contribution to the total stress, we introduce ambiguity into our equations. The universal failure to recognize this ambiguity results in ambiguity in reporting data said to indicate the effect of "pressure" on rheological properties.

We begin by noting the conditions under which it is acceptable to talk about the pressure *P*. For a fluid that has been at rest for a long time, *i.e*. at equilibrium, the stress is isotropic, which means that the normal stresses are the same in three orthogonal directions. Using the usual sign convention that compressive stresses are negative, since pressure is defined as a positive quantity, one can write:

$$\sigma_{11} = \sigma_{22} = \sigma_{33} = -P \qquad (1)$$

Here σ_{ij} is a typical component of the total stress tensor. Devices for detecting pressure actually measure a particular normal stress component, and this can be said to be the pressure only if the stress is isotropic at the point of measurement. As we will see, except for the special case of a Newtonian fluid in simple shear flow, this is never the case in a flowing fluid. Most of this article deals with simple shear flow, and we will use the standard reference frame in which x_1 is the direction of flow, x_2 is the direction of the velocity gradient, and x_3 is the neutral direction. This is illustrated in Fig. 1.

Pressure plays a central role in thermodynamics as a state variable in equations of state. However, liquids, including molten polymers, are often assumed to be incompressible, in which case pressure becomes a strictly mechanical variable with no thermodynamic significance. While this assumption is convenient in solving fluid mechanics problems, it has the obviously unphysical implication that pressure has no effect on any physical property of the fluid. For example, if the density is unaffected by pressure, then the free volume is also unaffected, which implies that pressure has no effect on rheological properties.

For a viscoelastic fluid, if a deformation is sufficiently slow or small, the fluid is very close to its equilibrium state, the normal stress differences are zero, and it is appropriate to use pressure as a state variable. In other words, one can speak of the effect of pressure on linear viscoelastic properties such as the zero-shear viscosity and the storage and loss moduli. When the deformation is neither very slow nor very small, however, it is not in equilibrium, and classical thermodynamics is no longer strictly valid. Moreover, the normal stresses are not equal to each other, and there is no uniquely-defined scalar field that replaces pressure as a state variable.

A rheological constitutive equation for an incompressible fluid only specifies the stress to within an arbitrary isotropic component [1,2]. While this component is often given the symbol *P* and called "pressure", this is an unwise practice that leads to incorrect interpretations of experimental data. In order to avoid misunderstandings resulting from the use of the symbol *P*, we will call the as yet undefined isotropic contribution to the total stress π, which we

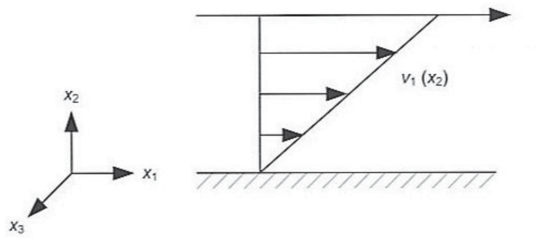

Figure 1: The shear coordinate system used in the text.

will consider, like the stress tensor, to be negative when the system is under compression. Thus, a rheological constitutive equation gives the "viscous" or "extra" stress tensor τ_{ij} as a function of the deformation field:

$$\sigma_{ij} = \tau_{ij} + \pi\delta_{ij} \qquad (2)$$

where δ_{ij} is the kronecker delta. It is important to note that since two new quantities τ_{ij} and π, are introduced in Eq. 2, it does not define either one of them. For given flow kinematics, if a constitutive equation giving the components $\tau_{ij}(t)$ for a given strain history is assumed, then the components of the extra stress can be calculated. If the components of the total stress tensor are then measured, the value of π at every point in the flow field can also be calculated. Thus, the expression for calculating π, given experimental values for the total stress components, depends on the choice of constitutive equation and the kinematics of the deformation. In the absence of a constitutive equation and a specified strain history, the scalar field π is indeterminate. Furthermore, there are very few flow fields in which all the components of the total stress tensor can be measured, so practically speaking, π is always indeterminate. And even if it could be calculated at each point in the flow, it has no known fundamental significance.

A constitutive equation may be written in such a way that the trace of the extra stress becomes zero when the fluid is at in its rest state so that $\pi = -P$ [3]. But this does not imbue π with any unique meaning when the fluid is subjected to a large, rapid deformation, and one is not at liberty to prescribe *a priori* that the trace of the extra stress be zero for any deformation.

Normal Stresses in a Newtonian Fluid

The simplest constitutive equation for a fluid is the incompressible Newtonian fluid model in which:

$$\tau_{ij} = \eta\dot{\gamma}_{ij} \qquad (3)$$

where η is the viscosity and $\dot{\gamma}_{ij}$ is a typical component of the rate-of-deformation tensor. The viscosity depends on temperature, pressure and composition but not on the deformation. Incompressibility can be prescribed in terms of either the rate of deformation tensor or the velocity vector $\vec{v}$:

$$\mathrm{tr}(\underline{\dot{\gamma}}) = 2\nabla \bullet \vec{v} = 0 \qquad (4)$$

Inserting (3) into (2), taking the trace, and making use of (4), we obtain:

$$\pi = \frac{1}{3}\mathrm{tr}\left(\sigma_{ij}\right) \text{ (Newtonian fluid)} \qquad (5)$$

But this is the definition of the mean normal stress. Thus, in an incompressible Newtonian fluid, π is identical to the mean normal stress.

$$\pi = \sigma_m \text{ (Newtonian incompressible fluid)} \qquad (6)$$

For the special case of a Newtonian fluid in simple shear flow, the diagonal components of the rate of deformation tensor are all zero. Thus, from Eqs 2 and 3, the normal stresses are all equal to each other and to π. In other words, in an incompressible Newtonian fluid in simple shear, the stress is isotropic, and pressure has the same meaning that it has in a fluid at rest.

$$\pi = \sigma_{11} = \sigma_{22} = \sigma_{33} = -P \qquad (7)$$

(Newtonian fluid in simple shear)

In the fluid mechanics of Newtonian fluids, one can define the negative of the mean normal stress as "pressure." However, except in simple shear flow, the normal stresses in a Newtonian fluid are not all equal, and the mean normal stress has no fundamental mechanical or thermodynamic significance. In other words, there is no known mechanism by which the properties of a fluid element react to this particular scalar field. Nevertheless, it is a well defined quantity, and in theory it can be measured, although it is rarely possible to measure all three normal stresses at every point within a material while it is being deformed. Thus, if one desired to measure the effect of compressive stresses on a property, the only obvious choice of independent variable is the mean normal stress.

Flow of Viscoelastic Fluids

In a large, rapid deformation of a viscoelastic fluid, the stress is not isotropic, and the quantity π is not directly related to the mean normal stress or any other function of the normal stresses. Thus it is not justified to use the word "pressure" in describing the state of a viscoelastic fluid that is not in or very close to its equilibrium state. And while a Newtonian fluid is at equilibrium as long as it is at rest, a viscoelastic fluid must have been at rest for time longer than its longest relaxation time to be "at rest". Total normal stresses of themselves have no rheological significance in an incompressible fluid, and it is only normal stress **differences** that are meaningful. The quantities actually measured are total or gauge normal stresses, but either a second total normal stress is also measured, or there is a free surface exposed to low-viscosity medium at a known pressure. For a flowing viscoelastic fluid there is no well-defined "pressure" that can be defined or measured.

There is an isotropic contribution to an extra stress that is used in dumbbell models of polymer solutions [2]. This term is proportional to kT and represents the contribution of the beads of the dumbbells to the stress. It has no effect on rheologically meaningful quantities but may be carried along in order that the extra stress will vanish in a solution that has been kept at rest and at a constant temperature for an indefinite period of time [3].

It is demonstrated below that in any viscometric flow, *i.e.*, one that is, from the point view of a fluid element, indistinguishable from simple shear, the absolute magnitude of the mean normal stress in a polymeric fluid is always different from the environmental pressure to which any free surface of the sample is exposed. This is because the first normal stress differences are not zero except in the limit of very slow or very small deformations, when linear viscoelasticity is manifested. In simple polymeric liquids N_1 is normally positive, and N_2 is negative but considerably smaller than N_1, but this is not the case in systems such as stiff molecules that form liquid crystals and certain suspensions, when N_1 can be negative.

The remainder of this article deals exclusively with shear flows, but we note here that in uniaxial extension, where the surfaces of the sample are exposed to an environment at an ambient pressure P_a, the mean normal (tensile) stress is given by:

$$\sigma_m = \frac{1}{3}(\sigma_T - 2P_a) \qquad (8)$$

where σ_T is the tensile stress in the sample.

Flow in Tubes and Slits

For pressure-driven flow, starting from either Cauchy's equation or a simple force balance in the flow (x_1) direction, one can derive a relationship between the gradient in the normal stress in this direction σ_{11} and the shear stress at the wall. But what is actually indicated by a pressure transducer mounted flush with the wall of the flow channel is $-\sigma_{22}$, the normal stress in the direction of velocity gradient, evaluated at the wall. If the flow is fully developed, and if viscous heating and the effect of pressure on viscosity and normal stress differences are neglected, then the normal stress differences are independent of the axial coordinate x_1, and the gradient in the axial normal stress equals the gradient in the wall normal stress. Thus, it is possible to determine the viscosity without reference to an undefined isotropic contribution to the stress. And if the normal stress differences are known for the fluid of interest as functions of shear rate, the other normal stresses and the mean normal stress can be calculated. As noted above while the mean normal stress has no known theoretical significance, it is at least a well-defined scalar field describing the level of tensile stress.

If a wall pressure sensor is not mounted flush with the wall but communicates with it by means of a small hole, the measurement is subject to pressure-hole error [4]. But if two or more identical pressure holes are used at various axial locations, the pressure-hole error, also called the hole-pressure, will be the same for each measurement and will cancel out when differences are calculated.

The Effect of "Pressure" on Rheological Properties

Failure to understand the issues raised above introduces an error in the comparison of data from different instruments intended to reveal the effect of "pressure" on rheological properties. Reports of "the effect of pressure on viscosity" have been based on the use of capillary, slit, concentric cylinder and sliding plate rheometers. Much of the work in this area has been cited by Koran and Dealy [5] and by

Cardinaels *et al*. [6]. What measure of the state of compressive stress in the fluid should be used to compare data obtained using various techniques? As we have seen, it is not appropriate to speak of pressure, and the only other well-defined scalar field that provides some measure of the state of compressive stress is the mean normal stress. We will now analyze several rheometrical flows in terms of the relationship between the normal stress that is measured (and incorrectly called the pressure of the sample) and the mean normal stress. For purposes of this demonstration we will assume that the first normal stress difference of the fluid is positive and is known as a function of shear rate. We will further assume that the second normal stress difference is $-aN_1$ where a is approximately 0.2 [Ref. 7, pp 367, 368]. At the same time, it is noted once again that there are systems in which the normal stress differences do not behave like this.

In slit flow, the output of a pressure transducer mounted flush with the wall of the flow channel is the negative of the total wall normal stress, which is $-\sigma_{22}$. Since the normal stresses decrease along the flow, the quantity called pressure is the average of the measured values, which we will call the measured pressure P_M. We can relate the other normal stresses to this by means of the measurable normal stress differences as follows:

$$\sigma_{11} = \sigma_{22} + N_1 = -P_M + N_1 \qquad (9)$$

$$\sigma_{33} = \sigma_{22} + aN_1 = -P_M + aN_1 \qquad (10)$$

Thus, the mean normal stress is:

$$\sigma_m = \frac{1}{3}\left[\left(-P_M + N_1\right) - P_M + \left(-P_M + aN_1\right)\right] = -P_M + \left[(1+a)/3\right]N_1 \qquad (11)$$

The mean normal stress is negative, because the sample is under compression, so for convenience we define the mean compressive stress σ_c as $-\sigma_m$. Thus,

$$\sigma_c = P_M - \left[(1+a)/3\right]N_1 \qquad (12)$$

Thus, the mean compressive stress is less than the measured pressure.

There are several types of high-pressure Couette rheometer, and the analysis depends on how the system is pressurized and where the pressure is measured. A more straightforward case is cone-plate flow, where the only surface of the sample that is exposed to the pressurized environment is the outer rim. If the sample is trimmed flush with the outer edges of the cone and plate, the measured pressure P_M is $-\sigma_{rr}$. We now express the mean normal stress in terms of this measured quantity.

$$\sigma_{\theta\theta} = \sigma_{rr} + N_2 = \sigma_{rr} - aN_1 = -P_M - aN_1 \qquad (13)$$

$$\sigma_{\phi\phi} = \sigma_{\theta\theta} + N_1 = \left(\sigma_{rr} - aN_1\right) + N_1 = \left[-P_M + (1-a)N_1\right] \qquad (14)$$

$$\sigma_c = -\sigma_m = P_M - \frac{1}{3}\left(1-2a\right)N_1 \qquad (15)$$

where σ_{rr} is the normal stress in the radial (neutral) direction, $\sigma_{\theta\theta}$ is the normal stress in the angular direction (direction of motion), and $\sigma_{\phi\phi}$ is the normal stress in the azimuthal (velocity gradient) direction. Once again, the mean compressive stress is less than the measured pressure.

In a sliding plate rheometer the imposed pressure P_M is approximately $-\sigma_{11}$, and this is related to the mean compressive stress as follows:

$$\sigma_c = P_M + \frac{1}{3}(2-a)N_1 \qquad (16)$$

In this case, the mean compressive stress is greater than the measured pressure.

The usual practice in reporting the effect of "pressure" on viscosity is to plot viscosity versus P_M, but we see from the above analyses that to compare data from different instruments, it is σ_c that should be used as the independent variable. Another way of looking at this is that if data from two instruments are compared by plotting viscosity versus P_M, each set of data should be shifted on the P_M axis by the amount indicated by the above equations. Unfortunately, this is not feasible at the present time, as even if N_1 and N_2 at ambient conditions have been measured for the polymer of interest, nothing is known about the effect of σ_c on the normal stress differences.

(continues page 26)

Montgomery T. Shaw Receives SOR Distinguished Service Award

Monty Shaw with his wife Maripaz celebrate at the Salt Lake City banquet.

by Andy Kraynik, SOR Past President

Montgomery T. Shaw received the Distinguished Service Award of The Society of Rheology at the 79th Annual Meeting in Salt Lake City. The ceremony may have come as a surprise to Monty, but not to any member of the Society in the past three decades. He is the eighth recipient of this honor, which is awarded infrequently at the discretion of the Executive Committee for exceptional service to the Society.

Monty has served the Society in elected office as Secretary (1977-1981), Member-at-Large (1983-1985), and Treasurer (since 1997). He has also served on the Bingham Award Committee (1989-1991), the Nominating Committee (1991), and as Technical Program Chair for the 62nd Annual Meeting in Santa Fe (1990). An appointment to the position of Associate Editor for Finance (1995-1997) prepared him for his current office, where he has overseen substantial growth in the financial resources and financial responsibilities of the Society. Monty's tenure as Treasurer followed that of Ed Collins, who had received the second Distinguished Service Award in 1986 and served as Treasurer for a total of twenty-six years. Monty may not break Ed's record, but then again no one has overheard him to say that he won't try. It's hard to imagine a time when Monty won't be serving the Society in some capacity – the position of Society Historian may not exist, but we all know the perfect candidate!

Monty Shaw receives his award from President Andy Kraynik.

Monty received BChE and MS degrees in chemical engineering from Cornell University in 1966, and a PhD in chemistry (1970) from Princeton University, where he studied under the late Professor A.V. Tobolsky. He then worked in the R&D department of the Union Carbide Corporation in Bound Brook, NJ until 1977, when he joined the faculty of Chemical Engineering at the University of Connecticut. He now serves as Interim Head of the new Chemical, Materials and Biomolecular Engineering Department at UConn. Monty is associated with the nearby Institute of Materials Science where he conducts research on polymer solution and blend thermodynamics, polymer rheology and processing, and polymer aging. He has received numerous rewards for his research and scholarship.

Monty is an avid outdoorsman. His wife Maripaz is well known to many members of the Society and his son Steven is an Associate Professor in the Electrical and Computer Engineering Department at Montana State University in Bozeman.

Outdoorsman/Treasurer Shaw explores Utah after the 2007 SOR Meeting.

Salt Lake City Hosts 79th Annual SOR Meeting

The opening reception in Salt Lake City drew an enthusiastic crowd.

The Society of Rheology held its 79th Annual Meeting in Salt Lake City, Utah USA during the week of 7-11 October 2007. Our host was Jules Magda from the Department of Chemical Engineering at the University of Utah, assisted by Andy Kraynik from Sandia National Labs, New Mexico. More than 300 registrants and 14 exhibiting companies enjoyed the facilities at the Salt Lake City Hilton during a mild October autumn within sight of the beautiful mountains of the Wasatch range.

The 60th Bingham medal was awarded in Salt Lake to John Brady, Chevron Professor of Chemical Engineering at the California Institute of Technology, Pasadena CA USA. Brady, who has been the editor of the *Journal of Rheology* since 2005, presented the Bingham lecture on "Single particle motion in colloids: from microrheology to osmotic propulsion."

Brady is well known for his contributions in suspension rheology, particularly as the originator, with G. Bossis, of the simulation technique known as Stokesian dynamics. At the Bingham Lecture Brady was introduced by his PhD thesis advisor, Andreas Acrivos, currently at the Levich Institute for Physico-chemical Hydrodynamics at the City University of New York. In addition to microrheology (asking, provocatively, is it rheology?), Brady took time to make a pitch for additional scientific credit to be given to the early 20th century researcher William Sutherland. The well-known Stokes-Einstein relationship is usually credited to work published by Einstein in 1905, but appearing the same year, and earlier, was the same relationship in a paper by William Sutherland. Thus, the Stokes-Einstein-Sutherland relationship is born.

The technical sessions opened with a plenary presentation by Fabian Waleffe from the Department of Mathematics at the University of Wisconsin, Madison.

(continues page 18)

Noro Ramahatafandry and her husband, new Bingham Medalist John Brady, celebrate in Salt Lake.

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Bingham medalists present in Salt Lake City included: Morton Denn, Henning Winter, John Brady (2007 medalist), Gary Leal, Andreas Acrivos, Gerry Fuller, Ronald Larson, William Russel, John Dealy, and Chris Macosko.

Waleffe spoke on “Exact coherent states: controlling turbulence and transition.” The Wednesday plenary presentation was given by Jennifer Lewis from the Department Materials Science and Engineering at the University of Illinois, Urbana. Lewis’ presentation on “Novel ink designs for direct writing in three dimensions” showed how precise control of flows on nano- and micro-scales can lead to important applications in the printing industry.

The social program at the SOR meeting was jam-packed, as usual. The Sunday reception, hosted by TA Instruments, took place at the Alpine Ballroom of Hilton and welcomed all to the meeting. On Tuesday evening the awards reception, sponsored by Xpansion Instruments, served as a gathering place before the Bingham banquet at which Brady was roasted by no fewer than four presenters. Andy Acrivos (with some prompting from the audience), Jon Higdon (fellow Churchill Scholar at Cambridge with Brady), and former Brady students Roger Bonnecaze and Jeff Morris covered every aspect of Brady’s persona, personal and professional, injecting humor while making clear their great respect for the 2007 Bingham medalist.

For many attendees the poster session is a most enjoyable part of the meeting, as there is opportunity for casual interaction

The *JOR* Publication Award went to a large group of collaborators, several of whom were present in Salt Lake. *Journal of Rheology* Editor John Brady (at right) congratulates the coauthors arriving, from left to right, Chris Macosko, Jan Plog, Christian Clasen, Werner-Michael Kulicke, and Gareth McKinley.

within a stimulating scientific environment. In Salt Lake the refreshments at the poster session were sponsored by Anton-Paar USA. For student attendees, the Student Poster Competition is much anticipated, and the recipient of that prize in 2007 was Mukund Vasudevan from Washington University in St. Louis (see article page 21). Conference bags were sponsored by Malvern Instruments.

As the Salt Lake meeting drew to a close we were reminded that our next meeting will be the International Congress on Rheology, taking place in 2008 in Monterey, California USA in less than a year. Details on ICR2008 may be found in this *Bulletin* (page 4).

Application for Membership in The Society of Rheology

Any student, scientist or engineer with an interest in the deformation or flow of matter is invited to join The Society of Rheology. Members receive the *Rheology Bulletin*, the *Journal of Rheology* and *Physics Today*. There are no academic or geographic requirements for membership. Complete and send a copy of this application form to the address below.

I wish to apply for membership in The Society of Rheology dating from January _______________ (year)

last name:

first name:

department:

institution:

work address:

city:

state/province:

postal code: (work address appears in the directory)

mail address:

city:

state/province:

postal code: (publications sent to the mail address)

country:

phone:

fax:

e-mail:

affiliation: academia ☐ industry ☐ government ☐ (check most appropriate)

annual dues: regular member ($40) ☐ student member ($25) ☐ (include copy of student ID)

credit card: AMEX ☐ MasterCard ☐ Visa ☐ exp. date:

card number:

signature: ____ date: _____________________

Please enclose remittance in US dollars drawn on a US bank payable to "The Society of Rheology" and mail to Janis Bennett at AIP, Suite 1NO1, 2 Huntington Quadrangle, Melville, NY 11747-4502, 516-576-2403, 516-576-2223 (fax). A member subscription to the *Journal of Rheology* is only for your personal use. By your signature below, you agree not to loan or give any issues of this journal to a library or other lending institution without written permission from The Society of Rheology.

signature (required):____ date: _____________________

Society Business

NEWS

SoR Student-Member Travel Grants Available for ICR2008

Student members of The Society of Rheology are invited to apply for travel grants to attend the International Congress on Rheology in Monterey. The deadline for applications is 29 February 2008. Details of the program, eligibility requirements, and a description of the application procss are on the web at www.rheology.org/sor/annual_meeting/2008Aug/student.htm.

New Award from the Society of Rheology?

By Lynn Walker, ExCom Member-at-Large 2005-2007

The Society of Rheology currently presents the following awards: Bingham medal (annually), Poster Presentation Award (annually), Publication Award (annually) and the Service Award (intermittent). During the business meeting held at the 2007 Meeting in Salt Lake City, a presentation was made about the need for new awards and possible formats for new awards.

The pros and cons of giving additional awards were first discussed. There seemed to be a general agreement from the audience that theSociety should consider offering more awards. The Society membership is large enough to support more awards without diluting the meaning of the current awards. Additional awards will provide publicity for the Society and recognition of its members.

Several different options for new awards were presented and more were offered during the discussion. The possible awards suggested were: an early career award (targeting a researcher under the age of 35 or 40), a best thesis award, a graduate research presentation award, and an award for innovation in industrial rheology. During the discussion, suggestions were made regarding the pragmatics of an award process, pros and cons of the different options, concerns over conflict with existing awards (specifically the award given at the poster session), and comparisons that could be made to awards given by other societies. A vote was not called on this issue, instead it was decided that the Executive Committee should make decisions and present a formal proposal at a future date. An unofficial poll was taken by show of hands for the different awards. There was considerable support for the early career award. Support for a thesis award or some type of award for industrial innovation was also shown, but with less enthusiasm.

The topic will be discussed at the March meeting of the Executive Committee. At that time, it is likely that the ExCom will decide on the best options for new awards. Members of the Society with comments, ideas or suggestions should contact any member of the Executive Committee prior to March with input.

SOR Always Needs Volunteers: Consider Getting Involved

Members of The Society of Rheology who are interested in getting more involved with Society affairs are encouraged to contact a member of the Executive Committee to express interest. Standing committees on Membership and Education are reconstituted with every election. Volunteers are also needed from time to time for *ad hoc* assignments that benefit the Society, such as serving as a representative of the SOR to external committees. Contact current committee members for more information on the duties that these positions involve. See page 3 for a list of committee members and Society officers and representatives.

Contribution from Washington University St. Louis Receives SLC Student Poster Award

Mukund Vasudevan received the SOR Student Poster Presentation Award at the 79th Meeting of The Society of Rheology in Salt Lake City in October 2007 for his poster entitled, “Self-similar shear thickening behavior in CTAB/NaSal surfactant solutions.” Vasudevan is a student at Washington University in St. Louis, in the Department of Energy, Environmental and Chemical Engineering. Co-authors on the research were Amy Shen, Bamin Khomami, and Radhakrishna Sureshkumar.

Vasudevan’s research is concerned with the rheological properties of wormlike surfactant solutions that undergo a phase transition from a solution phase to a gel-like phase upon increasing the shear rate above a critical value. In their study, Vasudevan and coworkers investigated the effect of salt concentration on rheological behavior in the shear-thickening regime.

Poster session chair Rajesh Khare from Texas Tech University presents Student Poster Presentation Award winner Mukund Vasudevan with his prize check of $200.

A Chance to Branch Out!

The 13th International Congress of Biorheology and the 6th International Conference on Clinical Hemorheology will take place 9-13 July 2008 in State College, Pennsylvania, USA
www.outreach.psu.edu/programs/isbisch/
(held every three years).

¡Caminaron sobre el agua! (Let’s walk on water!)

The shear-thickening properties of cornstarch/water mixtures are well known to rheologists, and many school outreach programs use this system for great “wow!” effect. But have you ever wondered if you could run across a pool of it?

A screen image from *El Horimiguero*’s web site showing their rheological experiment.

The question has been addressed definitively by the Spanish television program *El Hormiguero* (Spanish for “The Anthill”). *El Hormiguero* uses humor to address a wide variety of topics, including science. On 9 October 2006, host and producer Pablo Motos and companion “Flipy the scientist” ran repeatedly across a pool of cornstarch/water that appears to be about 1.5 meters wide, 3 meters long and 1 meter deep. A cement truck had been called in to effect the mixture. A video of their antics is available on the show’s website (www.cuatro.com/multimedia/video.html?xref=20061009ctoultnot_3.Ves) and is also posted on YouTube.com (search for “cornstarch water pool” or “non-Newtonian”).

The cornstarch/water system has come to be known as *oobleck*, and the standard recipe for oobleck is approximately 1 part water to 1.5–2 parts cornstarch. The word ooblech, besides invoking a common reaction to the fluid, refers to a Dr. Seuss children’s book, “Bartholomew and the Oobleck,” which features a green goo that gums up everything it touches.

Bingham Nominations Sought

Nominations are invited for the 2008 Bingham Award, which will be presented at the XVth International Congress on Rheology in Monterey. The Bingham Award is presented annually to an individual who is a resident of North America or a member of the Society who has made outstanding contributions to the field of rheology. The deadline for nominations is 15 January 2008. Additional information and revised guidelines for preparing a nomination can be found on the SOR website at www.rheology.org/sor/awards/Bingham/nom2008.htm.

Minutes of the ExCom Meeting

Sunday 7 October 2007
Salt Lake City, Utah USA

Attending: Andy Kraynik, Monty Shaw, Tim Lodge, Joao Maia, Albert Co, Bob Prud'homme, Dan Klingenberg, Skip Rochefort, Marie-Claude Heuzey, Lynn Walker, John Brady, Janis Bennett, Susan Muller, Gerry Fuller, Norm Wagner, Mike Solomon, Jaye Magda, Gary Leal, Bob Powell, Pat Mather, Faith Morrison.

President Kraynik called the meeting to order at 8:30 am in the Granite Boardroom of the Hilton Salt Lake City Center. Past-President and Acting Secretary Susan Muller read the minutes of the last Executive Committee meeting. The minutes were approved after correcting a typo in the first two words.

Monty Shaw provided a financial report. The *Journal of Rheology* is making a profit, primarily due to online subscriptions. Advertising revenue for the *Rheology Bulletin* has increased since last year. The financial position of the Society is sound. Janis Bennett proposed that if a member pays for an online subscription during the fall renewal cycle (typically September), their online subscription begins as soon as payment is received and their IP is set up and continues through the following December. This motion was made and passed. Monty Shaw discussed the accounting difficulties associated with meetings; frequently meeting accounts start two to three years before the meeting with payment of a deposit to the hotel, and accounts are not completely cleaned up and closed until the March after the meeting. Thus meetings do not fit easily into the year-to-year accounting that we report for all other Society activities.

John Brady gave the *Journal of Rheology* Editor's Report. Submissions reflect a slight diminution in time. This may correct itself by year's end. Brady presented submissions by country of origin for the past year. South Korea had 100% acceptance rate, followed by 80% from Belgium. Overall acceptance rates for manuscripts are 45%, days from receipt to first decision are 87, days from receipt to final decision are approximately 112.

Skip Rochefort reported as the SOR representative on the AIP Liaison Committee for Under-Represented Minorities. This committee is charged with coordinating diversity initiatives among AIP member societies and encouraging participation by under-represented minorities. Skip discussed the possibility of the SOR supporting K-12 outreach activities and a travel grant for undergraduates in under-represented groups who are working in rheology to attend the annual meeting.

Jaye Magda reported on the SLC meeting. The reservation for the Monday night reception at the Museum of Utah Art & History was cancelled by the museum due to construction delays. Registration is currently 301 registrants; additional on-site registrations are anticipated. Approximately 40 students are taking one or the other short course. There are 14 exhibitors. Exhibitors and sponsors are providing a significant amount of support for the meeting.

Lynn Walker lead a discussion of a new Society of Rheology award, directed at either graduate student or an early career award (under 35 or 40). Lynn will present the advantages and disadvantages of such awards for discussion with the membership at the Business Meeting.

Gerry Fuller led a discussion of the ICR, which will serve as the SOR Annual Meeting for 2008. Gerry cautioned that Monterey is an expensive venue, and that attendees should be cautioned about the high cost of lodging. The SOR has negotiated a very good rate for Monterey; while lower cost options are available some distance away, parking in Monterey is extremely difficult and expensive. Gary Leal discussed the Technical Program and important deadlines for the conference proceedings.

Andy Kraynik discussed officer succession. Andy also provided a brief update on the 2010 Santa Fe meeting. Pat Mather described preparations for the 2011 Cleveland meeting. Pat reported that membership in the SOR is stable at approximately 1500 members. Andy mentioned that since the International Congress will be held in Europe in 2012, the next SOR meeting after Cleveland will be a winter meeting in 2013; proposals for that meeting will be solicited at the Business Meeting.

Albert Co presented voting statistics (percentage of votes by country) and submission statistics for the SLC meeting. A motion was made to no longer offer overhead projection as a visual aid option on the submission website for future meetings. The motion passed.

Janis Bennet reported that Fred Dylla is the new Executive Director and CEO of AIP, replacing Marc Brodsky. AIP's membership director, Lorrie Carlin, directed Janis to mention *ConferenceDirect*, who works with other AIP member societies to negotiate meeting contracts. The Executive Committee expressed skepticism but will look into this further.

Mike Solomon reported for the Education Committee. Morrison and Giacomin had 18 students in their "Beginning Rheology" course; Squires, Anna, Doyle, and Breedveld had 25 in "Microfluidics for Rheologists." Short courses at the 2008 ICR meeting in Monterey will be a 2-day "Suspension Rheology" course by Mewis and Wagner, and a 1-day "Surfactant Rheology – Self-Assembly and Microstructure Dynamics" course by Spicer and Raghavan.

Bob Prud'homme volunteered to review honoraria and prize amounts on the traditional 4-year cycle at the Spring 2008 Executive Committee meeting.

Faith Morrison has turned over all issues related to *Rheology Bulletin* Advertising to AIP. This has worked out very well. Morrison discussed succession issues for the *Bulletin* Editor once she becomes SOR Vice President. She discussed difficulties in putting older versions of the *Rheology Bulletin* on the web; she and Albert Co are working to resolve these issues.

The meeting entered Executive Session at 4:24 pm. The meeting was adjourned at 5:00 pm.

Minutes of the Business Meeting

Tuesday, October 9, 2007
Salt Lake City, Utah

Andy Kraynik called the meeting to order at 6:15 p.m. in the Alpine East room of the Hilton Salt Lake City Center. The minutes of the previous Business Meeting in Portland, Maine were read and approved without addition or correction.

Each officer report and each committee report presented at the Executive Committee meeting (see above) was presented and accepted. A motion was entertained to keep the Bingham Award nomination deadline in mid-January rather than advancing it to mid-December in conjunction with the advanced annual meeting date (August ICR). The membership voted resoundingly to keep the deadline in mid-January. Lynn Walker led a discussion about new awards. Majority support was expressed by the membership for considering the creation of (1) a thesis award, (2) an early career award, and (3) an award for industrial and pragmatic application of rheology. John Dealy led a discussion about reducing the library subscription rate for the *Journal of Rheology* to lessen the growth rate of Society reserves. Andy Kraynik passed the gavel of the Society to incoming President Bob Prud'homme.

The meeting was adjourned at 6:55 p.m.

Treasurer's Report

Treasurer's Report

To the Membership:

Those of you who attended the Society's Annual Business Meeting in Salt Lake may recall that there were some 2008 budgeting uncertainties that were dependent on the financial prognosis for the International Congress. The Membership consequently approved a budget that allowed for minor changes to appear in the final version published in January.

According to the latest reports on abstract submission, the financial situation for the ICR is now quite promising, so the 2008 Budget has been tightened up with a return to the usual breakeven position for an annual meeting. However, with a more liberal student-travel policy for the ICR, the anticipated disbursement for this line item has been increased. While the accounting for Salt Lake City has not been completed, the indications are that the final position for the meeting will be positive. Thus the financial picture for the Society remains very favorable as the end of 2007 approaches.

Respectfully submitted,
Montgomery T. Shaw, Treasurer

The Society of Rheology, Inc.
Balance Sheet

(all amounts, USD)	2007 August	2006 Year End	2006 August	2005 Year End	2004 Year End
Assets					
Cash in checking account	43,583	9,777	43,322	12,721	29,012
Securities	0	0	0	0	0
Balance in AIP account	1,241,602	1,185,978	1,099,125	1,056,188	976,655
Total Assets	1,285,184	1,195,755	1,142,447	1,068,909	1,005,667
Liabilities and Net Assets					
Liabilities					
Deferred revenue	0	129,339	0	132,396	155,969
Total Liabilities	0	129,339	0	132,396	155,969
Net Assets					
Publication reserve	450,000	450,000	450,000	450,000	450,000
Student travel grant reserve	10,000	10,000	10,000	10,000	10,000
Annual Meeting reserve	300,000	200,000	300,000	200,000	100,000
Operating reserve	100,000	100,000	100,000	100,000	100,000
Unrestricted	425,184	306,416	282,447	176,513	189,698
Total Net Assets	1,285,184	1,066,416	1,142,447	936,513	849,698
Total liabilities and net assets	1,285,184	1,195,755	1,142,447	1,068,909	1,005,667

Journal of Rheology
Receipts and Disbursements

	2008 Budget	2007 Projection	2007 August	2007 Budget	2006 Year End
RECEIPTS					
Subscriptions	170,000	181,500	171,391	177,100	171,729
Reprint Sales	10,200	17,413	8,261	13,500	10,105
Ad Sales	36,000	30,353	19,062	35,000	35,650
JORO revenue	41,000	53,076	50,200	36,000	42,280
Miscellaneous	1,000	1,000	0	1,000	7,190
TOTAL RECEIPTS	258,200	283,342	248,915	262,600	266,954
DISBURSEMENTS					
Ads	7,000	11,047	6,553	9,500	7,199
Reprints, Single Copy	1,900	2,203	1,195	5,400	1,647
Paper, Printing	20,000	22,607	13,668	29,638	18,502
SOR Editorial	41,000	44,489	27,100	42,000	39,534
Production	30,000	36,335	21,010	55,000	29,841
Fulfillment	6,425	5,987	3,871	6,625	6,364
Distribution	20,100	17,797	12,796	20,833	18,724
Electronic publishing	35,000	33,058	22,654	43,000	33,570
Miscellaneous	4,800	6,071	2,294	6,000	5,494
TOTAL DISBURSEMENTS	166,225	179,595	111,141	217,996	160,874
Net	91,975	103,748	137,773	44,604	106,080

easurer's Report

The Society of Rheology
Receipts and Disbursements
(all amounts, USD)

	2008 Budget	2007 Projection	2007 August	2007 Budget	2006 Year End
RECEIPTS					
Dues	56,000	52,750	52,050	55,000	55,040
Interest	58,000	65,174	42,168	53,000	52,862
Journal of Rheology	258,200	283,342	248,915	262,600	266,954
Mailing List Sales	0	0	0	0	-66
Bulletin Advertising	5,000	17,224	13,480	10,000	3,105
Annual Meeting (net)	0	3,845	38,454	0	-4,671
Short Course (net)	0	1,571	15,707	0	-5,797
TOTAL RECEIPTS	377,200	423,906	410,774	380,600	367,427
DISBURSEMENTS					
AIP Dues Bill & Collect.	11,000	11,670	7,226	11,000	10,779
AIP Adm. Services	11,000	8,140	5,008	9,500	10,311
AIP Mem. Soc. Dues	8,000	7,909	5,272	7,700	7,936
Contributions and Prizes	1,900	1,877	1,677	1,900	329
Journal of Rheology	166,225	179,595	111,141	217,996	160,874
Bulletin	12,000	14,767	14,767	9,000	16,773
Bingham Award	7,000	5,000	0	7,000	5,000
Executive Cmt. Meetings	8,000	10,985	9,785	8,000	10,460
Pres. Discretionary Fund	1,500	0	0	1,500	159
Treas. Discr. Fund	1,500	400	0	1,500	0
Bulletin Editor Discr. Fund	1,500	0	0	1,500	
Progr. Chm. Discr. Fund	2,000	4,000	0	3,000	0
Webmaster Discr. Fund	3,000	1,800	0	3,000	0
Office Expenses	3,000	3,301	2,669	4,000	2,234
Banking Services	100	0	0	100	20
Liability Insurance	7,500	4,970	0	7,500	3,823
Membership Broch. & Appl.	500	300	0	500	432
Accountant	2,100	0	0	2,200	1,925
Student member travel	24,000	10,309	11,771	12,000	0
Annual meetings, future	4,000	15,510	10,433	9,000	8,601
Website	1,000	300	484	1,000	282
Miscellaneous	500	0	0	500	0
TOTAL DISBURSEMENTS	277,325	280,832	180,234	319,396	239,940
Net	99,875	143,074	230,539	61,204	127,487

the end

Pressure, continued from page 13

For the special case of very low shear rates, where it is η_0 that is measured, the pressure is essentially isotropic, and it is appropriate to speak of the effect of pressure. Also, if P_M is much larger than N_1, the uncertainty in using P_M in place of σ_c will probably be within the experimental uncertainty. For example, Park *et al*. [8] used several types of rheometer to study the effect of "pressure" on the viscosity of a styrenic polymer. Not only was the mean compressive stress unknown, but its relationship to the measured pressure varied from one rheometer to another. They estimated that the maximum value of the first normal stress difference, over the range of shear rates involved, at 12 MPa applied pressure (P_M) was 0.4 MPa, while that at 70 MPa was 1.3 MPa. Thus, the uncertainty in the mean compressive stress was 4% at most, which was within the range of experimental uncertainty.

Conclusions

In the deformation of a viscoelastic fluid, unless the deformation is either very small or very slow, it is inappropriate to use the term pressure to describe the state of the sample. If the kinematics of the deformation is specified and a constitutive equation is selected, then experimental values of the total stress components can be used to calculate the value of π at every point in the flow field, but it is not unique and has no fundamental significance. A well-defined scalar that describes the state of compressive stress in a polymeric liquid is the mean compressive stress σ_c. Any pressure that is measured in the environment to which a surface of the sample is exposed is only one component of the total stress tensor, and its relation to σ_c depends on the material and varies from one type of flow to another. This can lead to uncertainty in reporting the results of measurements of the effect of compressive stress on the rheological properties of viscoelastic fluids. In reporting the results of such measurements, while the quantity actually measured is a pressure, the relationship of this quantity to the mean compressive stress in the sample depends on the kinematics of the flow. For example, in slit flow, the quantity measured by a pressure transducer mounted in the wall is $-\sigma_{22}$, and for cone-plate flow the imposed pressure is equal to $-\sigma_{rr}$. A useful parameter for use in comparing data from different types of rheometer is the mean compressive stress, but to compute this from the measured pressure requires knowledge of the first and second normal stress differences as functions of shear rate and pressure.

Acknowledgement

Errors arising from the use of the term "pressure" in non-Newtonian fluid mechanics have troubled me for decades, but it was only when prodded by recent discussions with Prof. C. D. (Paul) Han of the University of Akron that I was inspired to write what I hope is a clear statement of the problem.

List of Symbols

- P Pressure
- P_M Measured pressure
- r Radial coordinate in cone-plate flow
- $\vec{v}$ Velocity vector
- $\underline{\dot{\gamma}}$ Rate of deformation tensor
- $\dot{\gamma}_{ij}$ Typical component of the rate of deformation tensor
- δ_{ij} Kronecker delta (δ_{ij} =1 when $i=j$; δ_{ij} =0 when $i\neq j$)
- η Viscosity of a Newtonian fluid
- θ Azimuthal coordinate in cone-plate flow
- π An isotropic contribution to the total stress (positive when compressive)
- $\underline{\sigma}$ Stress tensor
- σ_c Mean compressive stress = $-\sigma_m$
- σ_m Mean normal stress (trace of $\underline{\sigma}$)
- σ_{ij} Typical component of the total stress tensor
- σ_{11} Component of the normal stress in the flow direction (simple shear)
- σ_{22} Component of normal stress in direction of velocity gradient (simple shear)
- σ_{33} Component of normal stress in the neutral direction (simple shear)
- $\sigma_{\phi\phi}$ Component of normal stress in the azimuthal direction (cone-plate flow) = σ_{11}
- $\sigma_{\theta\theta}$ Component of normal stress in angular direction (cone-plate flow) = σ_{22}
- σ_{rr} Component of normal stress in the radial direction (cone-plate flow) = σ_{33}
- τ_{ij} Typical component of the extra stress tensor
- ϕ Angular coordinate in cone-plate flow (direction of rotation)

References

[1] R. G. Larson, Constitutive Equations for Polymer Melts and Solutions, Butterworths, Boston, London 1988.

[2] R.B. Bird, H.R. Warner, Jr. and D.C. Evans, "Kinetic theory and rheology of dumbbell suspensions with Brownian motion" *Adv. Polym. Sci.* 8 (1971) 1.

[3] G. Marrucci, "The free energy constitutive equation for polymer solutions from the dumbbell model" *Trans. Soc. Rheol.* 16 (1972) 321.
[4] C.D. Han and K. Kim, Measurements of pressure-hole error in flow of viscoelastic polymeric solutions. Effects of hole size and solution concentration, *Trans. Soc. Rheol*., 17 (1973) 151.
[5] F. Koran and J.M. Dealy, A high pressure sliding plate rheometer for polymer melts, *J. Rheol*. 43 (1999) 1279.
[6] R. Cardinaels, P. Van Puyvelde and P. Moldenaers, Evaluation and comparison of routes to obtain pressure coefficients from high-pressure capillary rheometer data. *Rheol. Acta* 46 (2007) 495.
[7] J.M. Dealy and R.G. Larson, Structure and Rheology of Molten Polymers, Hanser Publishers, Munich, Hanser Gardner Publications, Cincinnati (2006).
[8] H.E. Park, S.T. Lim, H.M. Laun and J.M. Dealy, "Pressure coefficient of melt viscosity; A comparison of experimental methods" submitted to *Rheol Acta*, Dec. 2007.

(Meetings, continued from back cover)

9-13 October 2011
83rd Annual Meeting of The Society of Rheology, Cleveland, Ohio USA, Pat Mather

2012

Summer 2012
XVIth International Congress on Rheology, location TBA (every four years; in 2012 in Europe)

See also:
www.rheology.org/sor/info/Other_Meetings.htm
www.rheology-esr.org/Meetings.php
www.appliedrheology.org/ (click on conferences)

The SOR Distinguished Service Award is given infrequently for outsanding service to the Society. Past recipients of the Distinguished Service Award gathered to congratulate Monty Shaw on his 2007 recognition. From left: John Dealy, Albert Co, Monty Shaw, Morton Denn, and Andy Kraynik.

CALENDAR OF RHEOLOGY CONFERENCES AND COURSES

2008

8-13 June 2008
University of Minnesota's Annual Rheological Measurements Short Course, Chris Macosko, Director, www.cems.umn.edu/rheology

15-19 June 2008
2008 Annual Meeting of the Polymer Processing Society, Salerno, Italy, G. Titomanlio, www.pps-24.com

2-3 August 2008
SOR Short Course on *Suspension Rheology*, byJan Mewis and Norman Wagner, Monterey, CA USA; option is available for participants to attend the first day of *Suspension Rheology* course on Saturday and the *Surfactant Rheology* course (below) on Sunday.

3 August 2008
SOR Short Course on *Surfactant Rheology - Self-Assembly and Microstructure Dynamics*, by Patrick T. Spicer and Srinivasa R. Raghavan, Monterey, CA USA

3-8 August 2008
XVth International Congress on Rheology and 80th Annual Meeting of The Society of Rheology, Monterey, CA USA, Gerry Fuller and Bob Powell, www.rheology.org/ICR2008/

24-30 August 2008
XXII International Congress of Theoretical and Applied Mechanics ICTAM 2008, Adelaide, Australia, prandtl.maths.adelaide.edu.au/ictam2008/

9-13 July 2008
The 13th International Congress of Biorheology and the 6th International Conference on Clinical Hemorheology, State College, Pennsylvania, USA, Herbert Lipowsky and Herbert Meiselman (www.outreach.psu.edu/programs/isbisch/; held every three years).

2009

Spring 2009
5th Annual European Rheology Conference AERC 2009, location TBA

15-18 June 2009
5th International Symposium on Food Rheology and Structure - ISFRS 2009, Peter Fischer, Zurich Switzerland (every 3 years; www.isfrs.ethz.ch)

Summer 2009
5th Pacific Rim Conference on Rheology, location tentatively Hokkaido, Japan, Hiroshi Watanabe (every 4 years)

17-18 October 2009
SOR Short Course on Rheology (topic TBA), Madison, WI USA

18-22 October 2009
81st Annual Meeting of The Society of Rheology, Madison, WI USA, Jeff Giacomin

2010

Spring 2010
6th Annual European Rheology Conference AERC 2010, location TBA

23-24 October 2010
SOR Short Course on Rheology (topic TBA), Santa Fe, NM USA

24-28 October 2010
82nd Annual Meeting of The Society of Rheology, Santa Fe, New Mexico USA, Andy Kraynik

2011

Spring 2011
7th Annual European Rheology Conference AERC 2011, location TBA

8-9 October 2011
SOR Short Course on Rheology (topic TBA), Cleveland, Ohio USA

(Meetings continues p27)