PL-6- Morand Lambla Award

EXTENSIONAL RHEOMETRY OF POLYMER MELTS: PAST, PRESENT AND FUTURE

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Over the last 40 years, since the pioneering works of Cogswell, Meissner, Munstedt and others in the 1960's and 1970's, Extensional Rheology has been continually at the forefront of research in Rheometry because of its relevance to real-world flow situations and the difficulty in performing well-controlled, physically relevant experiments. In fact, the rheological properties of polymer melts in extensional flows are recognized to have a great relevance for polymer processing even when the elongational component of the flow is present to very low extents.

We will begin the presentation by reviewing the evolution of extensional rheometry of polymer melts over this period, from the original mechanical, purpose-built machines to today's highly engineered, small add-on accessories to rotational rheometers, discussing along the way the various instruments' advantages and limitations. We will conclude by pointing possible ways for the future development of the area and introduce a new instrument that was developed with the specific aim of overcoming the limitations of existing instruments.

Our own group has been working in this field since the late 1990's, having developed its own experimental capability in the form of a controlled-rate extensional accessory that adapts onto a rotational TA Instruments Weissenberg rheogoniometer and more recently a controlled-stress instrument that works under the same physical principle of a modified fiber wind-up or "half Meissner", *i.e.*, where one the ends of the sample is held fixed and the other is pulled between two counter-rotating rollers. Recently we have developed a new dual controlled-stress/rate extensional rheometer for high viscosity systems that again is adapted to a rotational rheometer, but has a real-time feedback control loop and can either work in "full Meissner", *i.e.*, with the sample pulled by two pairs of counter-rotating rollers, or "SER", *i.e.*, with the sample pulled by two fixed clamps, modes. Due to its unique combination of geometrical set-up and feed-back control loop it is possible for the first time to perform experiments on polymer melts both in controlled rate and controlled stress modes up until the point of physical rupture, which is not the case with other instruments such as the SER, or the Munstedt type of rheometers. The instrument is designated the CSER – Controlled Stress Extensional Rheometer. We also explore the possibility of controlling both the tensile stress and the strain rate to compare the physical information each of these modes of deformation yields both in terms of the flow behavior and the failure and rupture mechanisms.