HYPERBOLIC CONTRACTION FLOW AS AN EXPERIMENTAL METHOD FOR DETERMINATION OF EXTENSIONAL RHEOLOGY OF MEDIUM VISCOSITY FLUIDS

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Shear rheology is well established, both in theory and experiments whereas there is a lack of experimental methods for extensional rheology. Extensional rheological properties are important for a broad range of applications such as plastics processing, swallowability and mouthfeel of viscoelastic foods, baking and spraying. It is also a useful tool for testing the applicability of constitutive equations. Despite the documented influence of extensional rheological properties, it is seldom measured due to experimental difficulties. There is only one commercial equipment available and it is mainly suitable for low-viscosity fluids. There is a range of methods for experimental determination of extensional rheology described in literature, the majority aimed towards polymer melts. Most methods have limited applicability for medium-viscosity fluids such as foods and other biological systems.

Contraction flows are extensively studied and an experimental method has been developed based on contraction flow through a hyperbolic nozzle. The method is suitable for medium-viscosity fluids and has been validated by comparison with results from filament stretching and capillary breakup for shear thinning model fluids. The contraction flow method has been used to characterize food and medical systems, to predict the ability of fluid foods to be swallowed by persons with swallowing disorders, to quantify ropy mouth feel and to predict foaming behaviour of biopolymers.

The flow of Newtonian and Boger fluids through the hyperbolic contraction has been simulated and compared to various axisymmetric contraction configurations. The simulations showed that the hyperbolic configuration was superior over the other geometries in measuring at constant extension rate. No vortices were formed, the measuring range was broader and the extension rate was constant throughout the geometry unlike for the other configurations.