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INVENTION FOR FLUID CHARACTERIZATION, BASED ON TOPOLOGY OPTIMIZATION

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Abstract

We are all used to handling liquids in our everyday lives. From getting the ketchup out of the bottle and enjoying the smoothness of a chocolate mousse, to modern paints and wood care products that do not stain. It all depends on getting the fluids to flow in the right way.

A new proprietary microchip technology for analyzing the fluidic properties of liquids is presented. This invention aims at performing real-time continuous characterization of Non-Newtonian fluids, and the development of the invention relies heavily on topology optimization of the involved microfluidic channel geometries.

The invention is a generalization of a standard Micro-Slit Viscometer, which measures viscosity from the pressure drop generated as the fluid passes through a channel of well-known cross-section, at a well-defined flow-rate. Exchanging the simple channel geometry with a more complex, structurally optimized version makes the invention capable of not only measuring the viscosity but also e.g. the shear-thinning properties of the fluid (i.e. fluids, where the viscosity decreases as a function of increasing local shear-rate)

The structural optimization of the channel geometries consists of first applying a high-level implementation of topology optimization [1], and then from these results base a simple shape optimization of the final channel design. In the present case, the invention has to distinguish between two types of liquids whose flow properties have been modeled numerically. The objective is then to maximize the sensitivity of the device response towards differentiating between the two fluids.

The invention has a clear commercial aspect, as one realization can be a low cost, continuous, in-line rheology monitoring instrument. This device will have a clear application in a decentralized monitoring of fluid flow properties at larger production plants – a task not presently affordable with state-of-the-art instruments. Presently, we are developing a prototype device for characterizing paints and enamel at a larger Danish paint-production company, funded by a Proof-of-Concept grant from the Danish state. Furthermore, large international companies are showing great interest in the further development of the invention.

[1] L. H. Olesen, F. Okkels and H. Bruus, A high-level programming-language implementation of topology optimization applied to steady-state Navier-Stokes flow, Int. J. Num. Meth. Eng. **65**, 975 – 993 (2006)