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OPTIMIZATION OF BISTABLE VISCOELASTIC SYSTEMS

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Abstract

Viscoelastic fluids appear in many industrial applications, e.g. food and plastic processing due to the presence of biological cells and synthetic polymers, respectively. It is the elastic character of these small constituents that give rise to exceptional fluid properties. Within modeling this elastic behavior is often described by a statistical ensemble of flexible dumbbells (that is two point masses connected by a spring) in what is collectively referred to as differential constitutive equations.

We consider the flow of a viscoelastic flow in a symmetric cross geometry. For small driving pressures the flow is symmetric, but beyond a certain critical pressure the symmetric flow becomes unstable; two stable asymmetric solutions appear, and forcing of the unstable symmetric flow beyond the critical pressure gives rise to increased resistance.

We have combined a state-of-the-art model for viscoelastic flow with topology optimization [1] in a high level finite element package (COMSOL) [2]. We use this framework on the cross geometry with the aim to reduce the critical driving pressure corresponding to the point of bistability. This quantity is, however, not explicitly contained in the solution, so we opt for a heuristic approach based on the dissipation ratio between the asymmetric and unstable symmetric flow solutions. We find a solution that reduces the driving pressure required for bistability, and furthermore is in agreement with the ideas of experimental researchers [3].

Previously we have used this combination to find a novel material layout for a viscoelastic rectifier [1] and verified the performance experimentally [4].

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