Thermodynamics of viscoelastic rate-type fluids and its implications for stability analysis

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Analysis of finite amplitude stability of fluid flows is a challenging task even if the fluid of interest is described using the classical mathematical models such as the Navier–Stokes–Fourier model. The issue gets more complicated when one has to deal with complex models for coupled thermomechanical behaviour of non-Newtonian fluids; in particular the viscoelastic rate-type fluids.

We show that the knowledge of thermodynamical underpinnings of these complex models can be gainfully exploited in the stability analysis. First we introduce general concepts that allow one to deal with thermodynamically isolated systems, and then we proceed to thermodynamically open systems. Next we document the applications of these concepts in the case of container flows (thermodynamically isolated systems), and in the case of flows in containers with non-uniformly heated walls (mechanically isolated but thermally open system). We end up with mechanically driven systems such as the Taylor–Couette flow.