Breakup of Viscoelastic Liquid Curtain

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Abstract

Liquid curtains are susceptible to instabilities at the interface, which can grow, triggering a breakup process. This process can be divided into two different stages: the rupture stage and retraction. The first, driven by van der Waals force, occurs when a small instability grows until it pinches-off the sheet. The second, driven by capillary forces, induces the growth of the hole caused by the pinch-off, leading to the full disintegration of the liquid sheet. Experimental analyses have shown that thinner stable liquid curtain can be obtained with viscoelastic liquids. The underlying physical mechanisms associated with increased stability are, however, not fully understood. This work presents a numerical analysis of the effect of viscoelasticity on the stability of a thin liquid sheet during both stages of the breakup process. The time evolution of planar and axisymmetric perturbations and rim retraction in a Newtonian and an Oldroyd-B liquid sheet is evaluated using the asymptotic expansion of the flow variables and a fully-implicit time integration scheme. The results show that the liquid rheological behavior has a strong effect on the growth rate of the disturbance and retraction velocity. The elastic forces act to hinder the rupture and retraction stages and consequently increase the breakup time and stability of the curtain.