One-Dimensional Numerical Simulation of the Nonlinear Instability Behavior of an Electrified Viscoelastic Liquid Jet

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Abstract : Instability and breakup of electrified viscoelastic liquid jets are involved in various applications such as inkjet printing, fuel atomization, the pharmaceutical industry, electrospraying, and electrospinning. Studying on the instability of electrified viscoelastic liquid jets is of theoretical and practical significance. We built a one-dimensional electrified viscoelastic model to study the nonlinear instability behavior of a perfecting conducting, slightly viscoelastic liquid jet under a radial electric field. The model is solved numerically by using an implicit finite difference scheme together with a boundary element method. It is found that under a radial electric field a viscoelastic liquid jet still evolves into a beads-on-string structure with a thin filament connecting two adjacent droplets as in the absence of an electric field. A radial electric field exhibits limited influence on the decay of the filament thickness in the nonlinear evolution process of a viscoelastic jet, in contrast to its great enhancing effect on the linear instability of the jet. On the other hand, a radial electric field can induce axial non-uniformity of the first normal stress difference within the filament. Particularly, the magnitude of the first normal stress difference near the midpoint of the filament can be greatly decreased by a radial electric field. Decreasing the extensional stress by a radial electric field may found applications in spraying, spinning, liquid bridges and others. In addition, the effect of a radial electric field on the formation of satellite droplets is investigated on the parametric plane of the dimensionless wave number and the electrical Bond number. It is found that satellite droplets may be formed for a larger axial wave number at a larger radial electric field. The present study helps us gain insight into the nonlinear instability characteristics of electrified viscoelastic liquid jets.

Keywords : non linear instability, one-dimensional models, radial electric fields, viscoelastic liquid jets
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