Breakup of shear-thinning liquids subject to controlled disturbances

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Abstract

Shear-thinning solutions were prepared by dissolving different concentrations of Xanthan gum in de-ionized (DI) water or a mixture of DI water/glycerin. The solutions were prepared to have the same zero-shear viscosities (~0.26 Pa.s at 23°C) by adjusting the polymer concentration, from 0% (Newtonian) to 0.10 % wt. (which corresponds to the semi-dilute regime), and the proportion of glycerin in the solvent. 0.5 % wt. of sodium chloride was added to reduce the elastic behavior. Power law indices for these liquids range from 0.44 to 1.0. The liquids were pumped through a piezo-electric nozzle that imposed initial disturbances with dimensionless wavenumbers ranging from 0.2 to 0.8. Jet contours were recorded using high-speed video images and analyzed using camera software. Shear-thinning behavior was found to have a significant effect on drop formation and jet stability. The structure of the jet prior to breakup (beads-on-string) and the consequent formation of satellite drops was dependent on the imposed jet wavenumber for the perturbation amplitude chosen. It was shown that the key rheological parameters governing the satellite formation are the infinite-shear-rate viscosity and the power law index. The zero-shear viscosity had no influence. Finally, comparison to available elastic jet breakup data shows that shear-thinning has an effect opposite to that of elasticity.

Key words: shear-thinning, jet breakup, satellite drop.

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