IFPRI Project Abstract

Spray characterization at industrially relevant conditions

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Project Objective:

The present work is a continuation of our research on the atomization of high viscosity and polymeric fluids. Previous experiments indicated that the filaments of highly viscous and polymeric fluids may stretch significantly more than low viscosity Newtonian fluids. The objective of the present research is to determine the mechanism of the breakup of such filaments the size distribution of the droplets formed after their breakup.

Approach:

1. Measure spray droplet size of polymeric fluids.
2. Experimentally characterize and model the breakup of stretched polymeric filaments.
3. Develop a model for the atomization of polymeric fluids using the filament breakup mechanism.

Recent Results:

We generated polyethylene oxide filament by stretching a small amount of liquid between two thin rods. A high-speed video camera is used to capture the evolution of filament from its formation to its breakup. We categorized the evolution of the filament into three stages: thinning of the liquid bridge, formation of beads-on-string structure and coalescence and breakup of beads-on-string structure. For a filament with initial thickness h_0, the thickness of filament decreases exponentially until $h_f = (G/2)^{1/3} h_0$ such that surface waves appear, where G is the non-dimensional elastic modulus of fluid. We identified two mechanisms for the formation of different generations of beads. The size of the first-generation beads can be predicted using Rayleigh-Plateau instability by treating the polymeric fluid as a Newtonian fluid with zero-shear viscosity. The size of higher generations beads can be estimated by $d_n/d_{n+1} = (2 + 3Oh/\sqrt{2})^{1/2}$. We propose a model to predict the size of different generations of beads, which results in a Gamma distribution. In the final stage, an energy balance can provide an estimation of string thickness and force in the beads-on-string structure. This also provides a breakup criterion for the breakup of the filament and is useful when the external force or stretch rate is applied.

Next Steps:

We will apply the current filament breakup model to our atomization models to predict the droplet size distribution in the spray of polymeric fluids. We will validate this model with our previous experimental result from pressure-swirl and twin-fluid nozzles.