Effects of Fluid Viscosity on the Spray of a Swirl Atomizer in Trigger Sprayers

Shanshan Yao, Ji Zhang, Tiegang Fang*, and Jack Edwards
Department of Mechanical and Aerospace Engineering
North Carolina State University
Raleigh, NC 27695-7910 USA

Abstract

Swirl atomizers are widely used in both industry and daily life. This work focuses on experimental investigations of the effects of fluid viscosity on the spray development during the transient operations of a swirl atomizer in a trigger sprayer. In the experiments, water-glycerol mixtures were used to simulate different fluids with a wide range of viscosity variation. The transient dispensing piston displacement was measured by using a linear position sensor fixed together with the trigger. The trigger sprayer was controlled by an actuator with given dispensing motion curve. A high-speed digital camera was used to visualize the near-nozzle spray structure. The digital images of the sprays were further processed to analyze the spatial and temporal surface waves on the spray cone. From the experimental results, it is seen the fluid viscosity plays a very important role in controlling the fluid breakup and atomization. The spray cone angle also changes with the variation of the fluid viscosity. Different from the results of constant pressure swirl atomizers, the transient operation of a swirl atomizer results in significant variation of spray structure during the liquid dispensing process. The structure of early-stage and later-stage spray is discussed to further explain the experimental observation. Early stage spray develops very rapidly with a fully developed cone angle. During the late stage of the dispensing process the spray cone angle becomes smaller and the wave length of the surface waves on the spray cone surface becomes longer. For fluids with different viscosities, it is found that more viscous fluid leads to a smaller spray cone angle. The surface wave temporal frequency decreases with the increase of fluid viscosity.

Key words: Swirl Atomizer, Spray Visualization, Trigger Sprayers, Spatiotemporal Diagrams

*Corresponding author: tfang2@ncsu.edu