# Secondary Atomization of Newtonian Liquids in the Bag Breakup Regime: Comparison of Model Predictions to Experimental Data

V. Kulkarni, D.R. Guildenbecher†, P.E. Sojka*

Maurice J. Zucrow Laboratories,
School of Mechanical Engineering,
Purdue University, West Lafayette, IN, U.S.A.

vkulkarn@purdue.edu , drguild@sandia.gov, sojka@ecn.purdue.edu

**Abstract**

Secondary atomization refers to the fragmentation of liquid drops due to aerodynamic forces exerted by a surrounding gas-phase. It is important in the context of combustion applications as improved understanding of the underlying physical phenomena can lead to better engine efficiencies. In the current work we examine one aspect of the secondary atomization process i.e., the deformation of an inviscid drop when exposed suddenly to a flowing air stream. As outlined by Guildenbecher et al. (2009) depending on the air velocity and the fluid properties we observe a range of different deformations and fragmentation behavior. The bag breakup mode is one such deformation/fragmentation process characterized by flattening of the spherical drop leading to the formation of a bag bounded by a thick rim which eventually collapses to form smaller droplets. The present work seeks to advance the current understanding by comparing experimental evidence with theoretical predictions. The experimental setup comprises of a high-speed digital imaging system along with backlight illumination. This is used to capture details of bag/rim breakup and the ensuing fragmentation. Bag initiation time is computed from the set of videos obtained for various *We* corresponding to the liquid drop. Drop size measurements are obtained from PDA to supplement these results. The theoretical analysis is essentially divided into two parts. The first part deals with computing bag breakup times, and the corresponding topological evolution of the drop is estimated along the lines of scaling arguments available in the literature (Villermaux, 2009). This is in slight contrast to the Rayleigh-Taylor type mechanism which is often posited as the mechanism of bag deformation (Zhao, 2011). Theoretical predictions show no dependence of the maximum extent of the bag on *We* which is consistent with experimental findings. The model correctly predictes $We_{cr}$, which marks the transition from the vibrational to the bag process. In the second part, a linear stability model (Gast, 1991) is used to compute the drop sizes obtained after capillary breakup of the ring. It must, however, be noted that the model for the rim breakup requires information of the characteristic inner and outer toroidal radii which are obtained from the experimental runs and cannot be predicted accurately from just the initial drop diameter before it enters the air stream. Also, before the rim shatters it is corrugated and not perfectly toroidal (Zhao, 2011) which is an important consideration in the analysis and is taken into account. Typically, the bag fragments comprise of smaller drops, large in number and the rim consists of large drops smaller in number and form after the bag has completed ruptured (Dai, 2001). This expected bi-modal distribution is not observed in the experimental runs because the probability of larger drops was insignificant for these tests. Thus, the preliminary analysis and experiments have helped extend current understanding and confirm existing notions about the bag breakup in secondary atomization.

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* Corresponding author: sojka@ecn.purdue.edu
† Presently at Sandia National Laboratories, Albuquerque, NM, U.S.A.