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Extreme Impact Events for Glycerin Provide new Insights for Splash Dynamics

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Abstract

In the wake of terrorist attacks on civil and governmental structures with transportation vehicles, Sandia National Labs has been actively working to better understand the complex dynamics of large, high-speed liquid impact as it relates to the subsequent thermal insult. This necessitates knowledge of the break-up and transport of the fluid as this relates directly to the fate of the fluid. Such fate varies from rapid consumption in a fireball, to later consumption in a longer-term surface fire. Accurate predictive capabilities allows for improved vulnerability assessments and critical safety design. We find that the size of the body of evidence tends to be inversely proportional to the scale of droplet impact, which means that there are few reports for large-scale impacts. We have therefore focused on experimental testing of fluid dynamics in this large-scale test regime. Single large-scale impacts rapidly disintegrate into many smaller-scale drop problems. The continuum capability to model a wide range of scales is therefore important to the accuracy of a generic impact model.

Motivated by the need for data, we have performed many tests with a variety of fluids and scales into dry, rigid surfaces. In particular, a few tests at large scale with a high viscosity fluid, glycerin, have produced remarkable results. The results of our testing were very different than any theory or empirical relationships heretofore presented would suggest. The subsequent analysis of the existing theoretical models in light of these findings expose shortcomings in the most current models. Many models using non-dimensional parameters such as Weber number and/or Reynolds number appear to be insufficient for the broad range of regimes of interest. Further, this new data and analysis helps define methods for subsequent research that should help improve the applicability of subsequent model development to a broader range of drop conditions.

Key words: Viscosity, Large-scale, drop impact, impact models, splashing, spreading, fingers

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