IFPRI Project Abstract

High-Fidelity Numerical Modeling of Spray Droplet Formation

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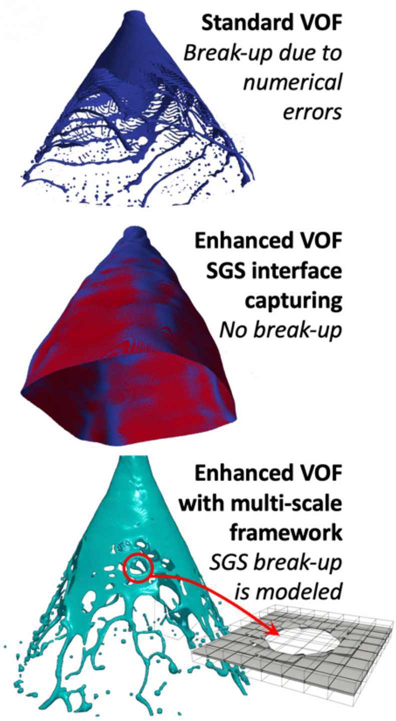
Project Objective:

The objective of this project is to assess and enhance the ability of a novel multi-scale, high-fidelity computational modeling framework for spray formation to predict drop size and velocity distributions in high-viscosity and non-Newtonian liquid atomization systems, such as found in spray drying applications.



Approach:

This project employs a novel multi-scale computational modeling framework for predicting sprays within the open-source NGA2 code based on:

- Sub-grid scale tracking of thin interfacial structures such as ligaments and films,
- Explicit physics-based modeling of the surface tension-dominated dynamics of these thin structures and their break-up into Lagrangian droplets.

Recent Results:

Since May 2023, three main tasks were accomplished:

1- A modeling strategy for non-Newtonian liquids has been implemented & validated against experiments.
2- A volume-filtered multi-scale modeling framework for two-phase flows with break-up was formalized. This framework exploits recent innovations in Eulerian interface capturing at the sub-grid scale that enable the accurate and efficient tracking of films & ligaments below the mesh size.
3- The critical sub-grid scale terms that need closure models were identified. For films, these include surface tension, hole formation, rim retraction, and droplet shedding from retracting rims. We have provided a closure for the surface tension force in sub-grid scale films, have introduced a simple strategy for hole formation, and have proposed an algebraic closure for capturing rim retraction.

We demonstrate these closures in a simulation of pressure swirl atomization, where for the first time, break-up is induced from physical models and not numerical errors.

Next Steps:

Further validations, with our goal being to deploy our computing strategy in a flow for which experimental data for drop size is available for direct comparison.