Simulating Nozzle Flow and Sprays Using An Eulerian Two-Phase Flow Model with a Realistic Equation of State

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Abstract

The internal flow in a fuel injector nozzle and the external spray atomization are closely related. As a result, CFD modeling of sprays must properly take into account the influence of the nozzle flow. Before its complete atomization into droplets, the fuel is in the form of continuous liquid column in the near-nozzle region. An Eulerian CFD approach assumes a continuum two-phase fluid both inside and outside of the nozzle, and hence provides a natural coupling between the two flows. Most previous studies using the Eulerian approach assume incompressibility. However, considering the fact that the sound speed is greatly reduced in the two-phase regime, this assumption limits the model's application to high-speed fuel injection cases.

The current study presents an equilibrium Eulerian approach for compressible flows. For single-component flows, the thermodynamic states and phase transition are modeled with the Stiffened Gas Equations [1, 2] implemented in the KIVA-3V code. The model is then extended to two-component flows under the assumption of ideal mixing, with one component being inert air. The methodology of the model and its validation against classical two-phase flow problems are presented.