Computational study of fuel property effects on the breakup of a liquid ligament

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Abstract
In the present work, fuel property effects on the process of droplet creation are investigated using simulations based on an algebraic Volume-of-Fluid (VoF) method. Several experimental and computational studies on atomization reveal ligament dynamics as a key feature leading to droplet creation. In the present work, we idealize ligaments as cylindrical column and the mechanism of its breakup due to surface tension [Eggers and Villermaux, Rep. Prog. Phys, 2008] as the well investigated Rayleigh-Plateau mechanism. While this idealization does not reflect the processes leading to ligament creation, it does describe approximately the local flow corresponding to growth of a capillary instability and ligament pinch-off. The solver is first validated by comparing the instability growth rates with the linear theory of Chandrasekhar [Hydrodynamic and hydromagnetic stability, Oxford University press, 1961] and droplet sizes with experiments of Lafrance [Phys. Fluids, 1975], leading to an adequate agreement. The effects of fuel properties on Rayleigh-Plateau breakup of ligament are then studied for five fuels corresponding to conventional and alternative fuels in the aviation and Diesel fuels category. Additionally, two single species fuels, hexene and octadecene, are also simulated. The results show that over the range of Reynolds numbers studied (4 < Re < 60), fuel properties do have a significant influence on droplet sizes as well as breakup times. With increase in Re, satellite droplet size increases while time required for breakup of the ligament decreases. The effects are expected to be stronger for more viscous fluids (lower Re).

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