Transition from droplet evaporation to miscible mixing at diesel engine conditions

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Abstract

Whilst the physics of both classical evaporation and miscible fluid mixing are reasonably well characterized and understood in isolation, little is known about the transition from one to the other in the context of liquid fuel systems. To address these issues we performed systematic measurements using a high-speed camera fitted with a long-distance microscope, for three single-component fuels (*n*-heptane, *n*-dodecane, *n*-hexadecane), into gas at temperatures from 700 to 1200 K and pressures from 2 to 11 MPa. We describe these high-speed visualizations and the time evolution of the transition from liquid droplet to fuel vapor at the microscopic level. The measurements show that the classical atomization and vaporization processes do shift to one where surface tension forces diminish with increasing pressure and temperature, but the transition to miscible mixing does not occur instantaneously when the fuel enters the chamber. Rather, the large, cool liquid structure that was just injected exhibits surface tension at first, and then, after time surrounded by the hot ambient and other fuel vapor, undergoes a transition to a dense miscible fluid. We find clear evidence of surface tension and primary atomization for a period of time at all the above conditions for *n*-dodecane and *n*-hexadecane, but not at the most elevated conditions (1200 K, 10 MPa) for *n*-heptane. The time taken by a droplet to transition to miscible mixing depends on the fuel properties, the pressure and temperature of the gas surrounding the droplet. We summarize these transitions as pressure-temperature diagrams for each fuel we have tested, revealing the conditions where transcritical mixing is relevant to diesel fuel sprays.

Keywords: Spray, atomization, measurement, drop size, imaging diagnostics

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