Near-Field Dynamics of Diesel and Biodiesel Sprays at 200 MPa Injection Pressure

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Abstract

High-pressure, high-speed diesel fuel sprays are complex multiphase flow phenomena. Great efforts have been devoted to understand their dynamics that is essential to the breakup, especially, in this near-nozzle region. However, conventional optical techniques are not effective to probe the dynamics in the first several millimeters of the optically dense region, where liquid is fast and in a complex morphology. By taking advantage of high-intensity and high-brilliance x-ray beams available at the Advanced Photon Source (APS), the morphology of the sprays can be imaged with ultrafast x-ray micro-imaging techniques and with sub-ns temporal resolution.

Furthermore, two short x-ray pulses (sub-nanosecond to a few nanoseconds) with a variety of intervals can be used to visualize the high-speed sprays. By tracking the movement of features in the double-exposure images without the need of seed particles, it becomes well possible to derive velocity fields of the sprays in the near-nozzle region. To understand near-field flow dynamics of diesel and biodiesel sprays injected at 200 MPa and travelling at a velocity exceeding 600 m/s, double-exposed images were taken using x-ray pulses with time interval of 68 ns. By using auto-correlation analysis, the near-field spray velocity can be obtained quantitatively.

We recorded the double-exposed x-ray images and derived auto-correlation functions of diesel and biodiesel sprays under various injection pressures up to 200 MPa. We note that 200 MPa injection pressure is not the maximum limit for the x-ray method rather it was limited by the specification of the fuel-injection system. The theoretical velocity was calculated using Bernoulli equation, which was compared against measurement. The results showed that the axial velocity increased with increase in injection pressure and reached over 600 m/s at 200 MPa injection pressure. We also made comparison between diesel and biodiesel sprays under various injection pressures. To probe the interaction between the sprays and surrounding gas, the local flow velocities were measured at different axial and radial locations. The results will prove valuable in providing validation of internal-flow and spray modeling.

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