Quantifying Statistical Measures of Diesel Spray Soot Characteristics using Laser-Induced Incandescence

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Abstract

Increased understanding is needed with respect to soot formation from high pressure diesel sprays as emissions standards become increasingly stringent and require complex methods for its reduction. Understanding soot formation and its spatial distributions is necessary to advance fundamental spray combustion knowledge. Given that the underlying nature of high pressure combusting diesel sprays results in turbulent mixing and combustion, significant variation in the location of soot and its structure is observed even when the conditions of the test are closely controlled. In this work, diesel spray soot characteristics are studied in a constant volume optically accessible combustion vessel through the application of laser-induced incandescence (LII). Studies are performed using a piezoelectric high pressure common rail injector with a high cetane (CN=56.5) diesel fuel at an injection pressure of 620 bar. Combusting sprays are examined at a part load charge-gas condition of 11.6 kg/m^3 density, 1300 K temperature, and in 21% oxygen and 15% oxygen (simulating 38% exhaust gas recirculation) environments. Images are acquired at 1.0 ms after start of injection in 21% oxygen and 1.5 ms after start of injection in 15% oxygen. Tests are repeated 14 times at each condition to provide a statistically significant sample. Images are compared, with average images and images of the ratio of the local standard deviation to the average, or local coefficient of variation, also considered to understand structure variations test to test. The results are quantified for total soot intensity and location of first soot. From this the required number of samples for a 95% confidence interval and 5% allowed error are determined.

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