Application of laser-induced fluorescence for imaging sprays of model fuels emulating gasoline and gasoline/ethanol blends

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Abstract

The performance at cold start of spark-ignited car engines is still a challenge since slow and incomplete vaporization of the fuel causes high emissions of unburned hydrocarbons and may even cause difficulties to start at very low temperatures, in particular with alternative fuels such as ethanol. One approach to improve fuel evaporation is by direct injection into the cylinder late during the compression stroke. In this study the evaporation of fuel, including selective evaporation of fuel components of different volatility, has been studied, in sprays injected into air with a controlled pressure and temperature.

Planar laser-induced fluorescence (PLIF) and Mie scattering were used to image the fuel distribution in vapor and liquid phase in a cross-section of sprays. A model fuel of non-fluorescent molecules was used and a fluorescent tracer molecule was added. To simulate a fuel with a distillation curve similar to gasoline a multi-component model fuel was selected. The fuel was composed of five iso- or cyclo-alkenes with boiling points that span the 30-190°C range. As fluorescence tracers ketones: acetone, 3-pentanone and methylcyclohexanone, were used to trace light, medium-heavy and heavy fuel fractions. Besides investigating the gasoline-like model fuel, ethanol and an ethanol/multi-components fuel blend were investigated.

Spray imaging was carried out in a pressurized chamber. The injector was an outward-opening piezo-actuated injector generating a hollow-cone spray. A cross-section of the spray was illuminated by laser light at a wavelength of 266 nm formed into a thin sheet. Two intensified CCD-cameras were used to detect fluorescence and scattered light. The presence and penetration of liquid was determined by detecting Mie-scattered light. The PLIF-images provided the total distribution of fuel in liquid and vapor phase, and by comparing with the Mie-images it could be determined when the vapor started to appear in areas with little or no drops present indicating the presence of fuel vapor. It was found that at 90°C the light fuel components evaporated quickly, the medium-heavy components slowly while the heavy ones remained in liquid phase. At 140°C also the medium-heavy components evaporate relatively rapidly.

Key words: laser-induced fluorescence, imaging, model fuels, gasoline, ethanol, piezo injector

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