

Verification and application of fuel-air-ratio-LIF

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Keywords : Fuel-air-ratio laser induced fluorescence, FARLIF, LIF imaging, toluene, real fuel, gasoline

The FARLIF-concept for fuel-air-ratio measurements by laser-induced fluorescence is validated for the model-fuel isooctane with fluorescence tracer toluene for temperatures up to 433 K. Furthermore, the applicability of FARLIF is confirmed for a more realistic near-standard gasoline up to 500 K. Applications of calibrated planar FARLIF-imaging were successfully demonstrated for single-shot mixture analysis in transient flows.

1. Introduction

Controlled and well defined mixing of gases is essential in many technical applications. In particular, the formation of ignitable hydrocarbon-air mixtures in combustion engines is a central point of interest for process- and industrial engineering. The performance (e.g. emission and fuel economy) of new engine concepts like spark-ignition direct-injection (SIDI) engines or homogeneous-charge-compression-ignition (HCCI) engines depends on the mixture preparation and the in-cylinder fuel-air-ratio-distribution. Therefore, many optical diagnostic techniques have been developed during the past decades with the aim to get a better understanding of the processes governing the mixture formation.

In 1994, Reboux et al. (1994) introduced a diagnostic technique to measure the fuel air ratio by laser-induced fluorescence (FARLIF) with an excitation wavelength of 248 nm. They used toluene as a fluorescence tracer in the model-fuel isooctane and took advantage of the strong fluorescence quenching of oxygen. They could show that the fluorescence intensity grew linearly with the fuel-air-ratio and that the intensity was pressure-independent for a fixed fuel-air-ratio at higher pressures (FARLIF-concept).

Latest investigations, for example those of Koban et al. (2005) question the applicability of the FARLIF-concept with toluene at higher temperatures, but they give no temperature-limit at which the concept will fail. Results of Schulz and Sick (2005) predict, that the situation for FARLIF should be better at longer excitation wavelengths (e.g. 266 nm) but the concept should fail at elevated temperatures as well. Unfortunately they give no temperature limit either.

This work aims to survey the applicability and the constraints of FARLIF with the longer excitation wavelength (266 nm) at elevated temperatures.

2. Validation of FARLIF with toluene-isooctane

In preliminary investigations, the fundamental assumptions for FARLIF were verified for 5% to 10% toluene in isooctane in the temperature range from ambient temperature up to 433 K (upper limit of the apparatus). The

applicability of FARLIF was verified directly in terms of checking the pressure independence and the linearity of the FARLIF-signal with fuel-air ratio. The results validate the FARLIF-concept with 266 nm excitation for 5% to 10% toluene in isooctane in fuel-air mixtures with sufficient oxygen fraction ($\lambda \geq 0.2$) at pressures between 1.5 bar and 10 bar at temperatures at least up to 433 K. Investigation at higher temperatures are in progress.

3. Validation of FARLIF with gasoline

After these promising results the focus was set on FARLIF with more realistic self-fluorescing fuels. Barley modified standard gasoline, in which only the bitumen components are missing, was found as a good candidate. Here, the FARLIF-concept was validated for fuel-air mixtures with $\lambda \geq 0.1$, pressures above 1 bar and temperatures at least up to 500 K. To the authors' knowledge this is the first time that FARLIF is validated for an auto-fluorescing multi-component gasoline without any additional tracer.

Unfortunately, temperature effects arose for both, FARLIF with toluene-isooctane and FARLIF with gasoline. Therefore this technique is best suited for isothermal conditions. Else, the temperature has to be known for signal correction.

4. Planar FARLIF-imaging

The application of the FARLIF-concept was demonstrated in planar FARLIF-imaging experiments for the model fuel and the (almost) standard gasoline. In both cases, signal strength was sufficient for single-shot experiments in isothermal transient mixing flows, whereas the gasoline signal was the brighter one in comparison. For long excitation-paths through high fuel densities, the depletion of the excitation intensity influences FARLIF measurements. In these cases an absorption correction is needed for FARLIF-imaging.

Finally, the application of double-pulse FARLIF-imaging was demonstrated, giving insight into dynamic mixture processes. In general, the FARLIF-concept shows to be a powerful tool with multifunctional applications if used in its valid constraints and – if necessary – with appropriate corrections.

5. References

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