TIR-LIF: A Validation Tool for Spray Impact Models

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Abstract

An experimental study of spray impact onto flat rigid surfaces is presented and discussed in this paper, which describes the use of Total Internal Reflection Laser Induced Fluorescence (TIR-LIF) as a tool for characterisation of fuel films, providing input data for validation of empirical models. In order to describe the spray/wall interaction process accurately, it is crucial to determine two interacting characteristics: i) the generation of secondary droplets, and ii) the accumulation of a liquid fuel film on the wall. Extensive research has been undertaken to characterise the post-impingement spray using Phase Doppler Anemometry (PDA). Although this technique offers considerable potential for quantification of post-impact droplet sizes and flowfield, a full understanding of the impingement process requires quantification of the mass and the spatial distribution of any residual fuel film. Hence, time-resolved spatial field measurements of droplet size need to be complemented by characterisation the resulting liquid fuel film on the wall.

This paper describes the use of the TIR-LIF technique, proposed by Alonso et al [1], for characterisation of transient liquid fuel films formed as a result of spray impingement of a gasoline DI spray on a flat surface under atmospheric and elevated ambient pressures. The TIR-LIF technique is an extension of LIF in which the propagation of a laser beam is carefully controlled so as to target the excitation of the liquid fuel film only and not the airborne droplets above the film. The technique is based on the principle that upon excitation by laser light, the intensity of the fluorescent signal from a tracer is proportional to the film thickness. A frequency quadrupled Nd:YAG laser at wavelength 266 nm is used as the excitation light source and an intensified CCD camera records the results as florescent images. A binary mixture of 10 % 3-Pentanone in Isooctane is used as a substitute of gasoline due to its similar thermofluid properties. Calibrated results presented in this paper demonstrate the ability of this technique for spatial and temporal characterisation of fuel films throughout the injection event. Quantitative results reported include time resolved distribution maps of fuel film thickness, transient average film thickness, aggregate mass deposits, and film footprint area. Observations of the transient development of the 3D liquid fuel films include details of fine surface waves. This information, in conjunction with post-impingement PDA characterisation, can be used for development of post-impingement empirical models and furthermore, for appraisal of integrated Computational Fluid Dynamics (CFD) predictions of spray impingement.

Key words: Spray/wall Interaction, Fuel films, Film Thickness, TIR-LIF