Comparison between signal attenuation correction methodology for LIF and scattered light intensity measurements in dense sprays

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The optical characterisation of sprays, such as the distribution of the droplet mass (Laser-induced Fluorescence (LIF) imaging) or the surface area (scattered light (Mie) imaging), is hindered when the sprays become dense. The measurement uncertainties are due to attenuation of the intensity of the illuminating light and of the intensity of the light emitted from the measured droplets, during interaction with the surrounding spray droplets. These uncertainties can affect both the qualitative description of the spatial spray characteristics and the estimation of quantitative information such as the Sauter Mean Diameter (SMD) when using the LIF/Mie intensity ratio technique for droplet sizing (Kamimoto, T. 1994), which is sensitive to the measured signal intensities (Charalampous, G. and Hardalupas, Y. 2011). The measurement uncertainties are compounded by multiple scattering noise. A scanning laser beam method has been proposed (Brown et al., 2002) to address these issues, by accounting for the illumination and signal intensity attenuation and by minimising multiple scattering noise.

Here, we focus on the application of the laser beam scanning and signal processing methodology, on the laser-induced fluorescent and scattered light intensities from the spray droplets. Both qualitative and quantitative spray characteristics are considered before and after the application of the attenuation correction procedure.

The investigation was conducted on a flat spray air assist atomiser. The atomising liquid was water doped with Rhodamine WT dye. Measurements were performed with a scanning laser beam along a plane normal to the direction of injection. At the measurement location, the spray density was sufficient for measurable attenuation of the illuminating beam and the collected signal. Imaging of the scattered and fluorescent light intensities from the spray was performed by a CCD camera fitted with an interference filter for the scattered light intensity measurements and a long pass filter for the fluorescent light intensity measurements. Monitoring the intensity of the laser beam before and after the spray was performed using a laser power meter.

The attenuation of the laser beam along the spray was as high as 10\% while the attenuation of the collected signal intensity could exceed 15\%. Corrections made to address the attenuation effects, especially at the further away regions of the spray relative to the camera position, where the attenuation is strongest, increased the measured intensity by about 20\%. This highlights the need for accounting for attenuation effects of the laser beam and scattered light intensity for quantitative spray measurements.

The corrected spray patterns from the scattered (Figure 1) and the fluorescent (Figure 2) intensities were found to be different. This demonstrates that the spray imaging wavelength needs to be carefully considered in order to characterise the desirable spray property. The attenuation correction procedure did not affect the evaluation of the spatial distribution of the droplet size using the LIF/Mie intensity ratio approach. The question of the contribution of the secondary scattering on the detected fluorescence and the scattering intensities and the associated uncertainty remains open.

![Corrected Mie](image1)

**Figure 1** Distribution of the corrected scattered light intensity signal from the droplets

![Corrected LIF](image2)

**Figure 2** Distribution of the corrected fluorescent intensity signal emitted from the droplets

References


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