Correlating Results from Numerical Simulation to SLIPI-based Measurements for a non-combusting Diesel Spray

H. Grosshans* [1], E. Berrocal [2], E. Kristensson [2], Robert-Zoltán Szász [1] and Laszlo Fuchs [1]
1: Division of Fluid Mechanics, Lund University, Sweden
2: Division of Combustion Physics, Lund University, Sweden

Abstract

The validation of numerical methods for the study of highly atomizing transient sprays (e.g. Diesel sprays) is a nontrivial task. One important issue concerns the fact that such sprays are optically dense making the measurement particularly difficult, especially when high accuracy is required (which is the case for model validation purposes). It has recently been demonstrated that SLIPI-based (Structured Laser Illumination Planar Imaging) techniques are able to provide either two or three-dimensional quantitative results of the extinction coefficient even in challenging situations. More specifically, the extinction coefficient of a non-combusting Diesel sprays injected at 1100 bar in a chamber pressurized at 18.6 bar could be extracted in two-dimension at late time (2000 μs) after injection start. In this article, these experimental results are correlated with numerical data. The numerical calculations are based on Large-Eddy Simulation (LES) combined with Lagrangian Particle Tracking (LPT). The simulation includes secondary droplet break-up models, gas-liquid two-way coupling and an evaporation model. The main purpose of the work presented here is, then, to numerically deduce the extinction coefficient field which can can be directly compared to the one obtained experimentally. The extinction coefficient is related to the droplet number density times the extinction cross-section which is calculated, for each droplet size, based on the Lorenz-Mie theory. We show, that by extracting the extinction coefficient from numerical simulation, comparisons between simulated and SLIPI-based experimental results are becoming possible even in optically dense sprays. Thus, the presented approach is a step towards in providing strong evidence of similar or different structures between the experimental and simulated description of atomizing spray systems. The experimental results used in this paper have been published in [1]. The extinction coefficient field obtained numerically is shown for three instances in time in Fig. 1, where $t = 0$ corresponds to the beginning of injection of the liquid spray. The shown planes are also cuts through the spray including the injection nozzle, which is located at the bottom of the figures.

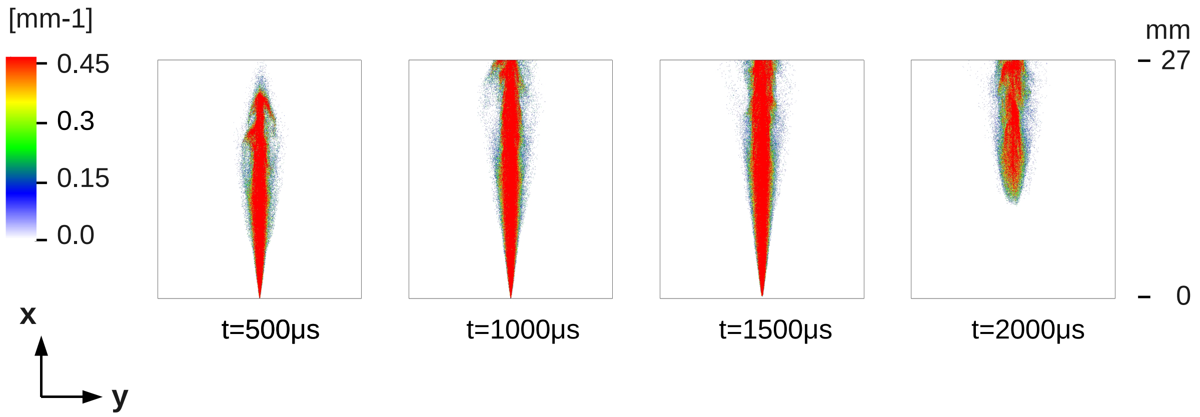

Figure 1. Extinction coefficient fields numerically simulated for $t = 500\ \mu s$, $1000\ \mu s$, $1500\ \mu s$ and $2000\ \mu s$ (from left to right).

References

[1] E. Berrocal, E. Kristensson, P. Hottenbach, M. Alden, and G. Gruenefeld. Quantitative imaging of a non-combusting diesel spray using structured laser illumination planar imaging. *Appl. Phys. B*, to be published.

*Corresponding author: holger.grosshans@energy.lth.se