Theoretical evaluation of droplet concentration limits for interferometric droplet sizing measurements

K. Zarogoulidis, Y. Hardalupas*, A.M.K.P. Taylor

Dept. of Mechanical Engineering, Imperial College London, United Kingdom
* Correspondent author: y.hardalupas@imperial.ac.uk

Keywords: sprays, ILIDS, GPD, concentration limits, interferometry, image generation

This study reports the development of a simulation process, which involves the generation of artificial fringe pattern images that are obtained when planar droplet sizing measurements with interferometric imaging are taking place. This procedure evaluates the droplet concentration limits of interferometric droplet sizing techniques (such as standard, compressed ILIDS and Global Phase Doppler) and allows the design and optimisation of the optical arrangement. The droplets arrive in the images with a rate defined by the Poisson distribution, are randomly distributed spatially with a uniform probability distribution and have their sizes defined by the Rosin-Rammler distribution. The fringe patterns created during the interferometric imaging of the constructed droplet distributions are then evaluated, so that the probability of overlapping between fringe patterns of different droplets can be quantified for different system parameters. These parameters include the size of the fringe pattern as defined by $\beta$, the ratio of the fringe pattern area over the overall image area, the mean droplet arrival rate at the image and the allowed pattern overlapping that is allowed by the image processing software. The droplet number, volume and mass concentration can be therefore estimated from the droplets whose fringe patterns are not overlapping and due to the nature of the calculation, the results provided can be applied to any optical arrangement. It is found from our simulations that the compressed ILIDS technique is 2—5 times more efficient for real-world measurements compared to standard ILIDS and GPD. Finally, the concentration limits of such interferometric imaging sizing techniques are discussed, and it is shown that there is an optimal concentration limit that can be achieved via a combination of the aforementioned parameters and the characteristics of the spray under investigation.

References


