Unsteadiness in effervescent sprays – measurement and evaluation using combined PIV – PLIF technique

Jan Jedelsky, Miroslav Jicha

Faculty of Mechanical Engineering, Brno University of Technology, Brno, Czech Republic, jedelsky@fme.vutbr.cz

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Planar Laser-Induced-Fluorescence and stereoscopic Particle Image Velocimetry are simultaneously employed to study an effervescent atomizer generated spray. Light heating oil is continuously atomized using air as an atomizing medium. Double pulsed laser provides two pulses of 265 nm radiation. The pulses are converted to a light sheet illuminating the spray in a cross section perpendicular to the spray axis in the distance 152mm from the nozzle exit. Natural fluorescence of the light heating oil is used for instant liquid phase concentration distribution measurement. Simultaneous 3D velocity field is calculated using image pairs of the liquid concentration $c_i(x,y)$. Combination of the velocity component vertical to the laser light sheet and the concentration image leads to instant planar liquid mass flux:

$$\dot{m}_i(x,y) = w_i(x,y) \cdot c_i(x,y)$$

Set of 256 image pairs is used to calculate time averaged image of the liquid concentration and mass flux:

$$\overline{\dot{m}}(x,y) = \frac{1}{n}\sum_{i=1}^{n} \dot{m}_i(x,y).$$

Space-resolved fluctuations of both the values from average local value are evaluated. Root-mean-square of the liquid mass flux (liquid concentration) fluctuations normalized by the local time-average value is used to characterise space-resolved spray unsteadiness:

$$\overline{\dot{m}}'(x,y) = \frac{1}{\overline{\dot{m}}(x,y)}\sqrt{\frac{1}{n}\sum_{i=1}^{n}\left[\dot{m}_i(x,y) - \overline{\dot{m}}(x,y)\right]^2}$$

Results show similar spatial distribution of both the liquid concentration and mass flux. The spray is axially symmetrical with maximum of time-average mass flux (concentration) in spray axis. Radial profiles of the normalized RMS fluctuations of the mass flux (concentration) distribution show generally low value near the spray axis, increase with increasing radial distance and maximum close to the spray edge (Fig. 1). By reason of the symmetry only half profiles have been plotted.

Influence of atomizer operation conditions on the spray structure is investigated. The atomizer is operated in the range of air gauge pressure 0.1 – 0.5 MPa and Gas-to-Liquid-Ratio by mass (GLR) of 2 – 50%. Results document that radial profiles of the mean values and mainly of the fluctuations of the mass flux (concentration) vary with change of operation conditions. The spray unsteadiness is relatively low in case of high GLR with increasing tendency for decreasing GLR, see Fig. 1, up. This can be observed on the entire radial profile. Increase of the GLR also leads to a shift of the fluctuation maximum to higher radial distance from the spray axis. In addition at GLR = 2 % also growth of fluctuations near spray axis is seen. It could be caused by inferior atomization seen on some instant images of the liquid concentration. Influence of the air gauge pressure on the fluctuations of liquid mass concentration is not as significant with the exception of the results acquired at 0.1MPa (Fig. 1, bottom).

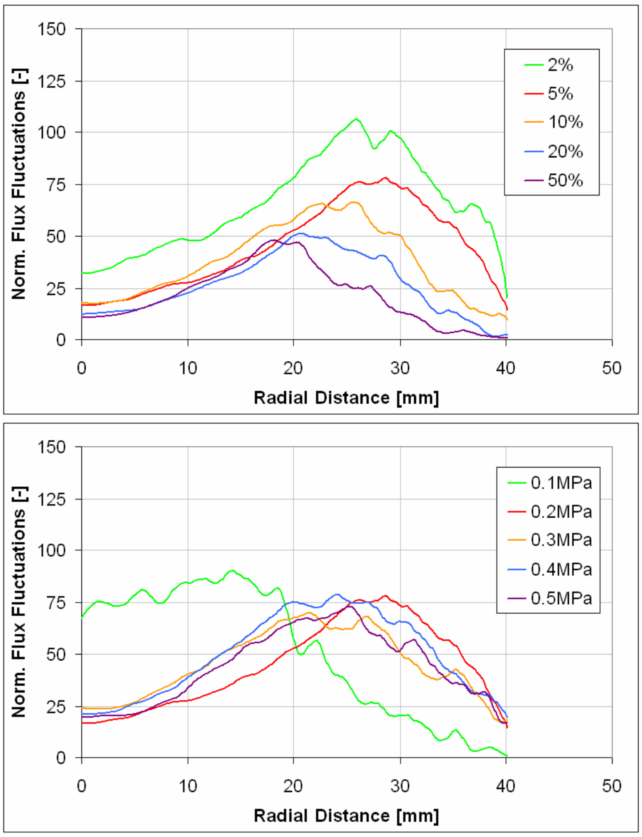

Fig. 1. Radial profiles of temporal fluctuations of the liquid mass flux, local RMS normalized by the local mean for different GLR at p_a=0.2MPa (up), for different air gauge pressure at GLR 5% (bottom)

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