

Drops distributions and flux measurements in sprays using the phase Doppler technique

by

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ABSTRACT

The subject of the present investigation is the measurement of the flux and concentration of drops in sprays using the phase Doppler technique. One important issue is the difference between the illuminated volume and the detection volume, the detection volume being a function of particle size, photodetector location and specifications, signal detection criteria, etc. A further consideration is the count error due to multiple particles in the volume. A statistical correction for this effect is introduced and shown to be already significant in relatively sparse sprays. Comparisons between various estimators and a simple patternator confirm the improvements of the new estimators.

As an illustration of the improvements achieved, measurements downstream of a simple pressure atomizer are considered. In Fig. 1 the mass flux in the main spray direction (x) calculated by commercial software and by the present model, including the multiple drop consideration and the reference area expression, are compared with the results of measurements by a patternator at different downstream distances l from the nozzle. The agreement of the present model with the data obtained by the collector is good, even at points where the flux and the relative signal presence are high. The model used in the commercial software does not take into account the presence of multiple drop signals and as a result underestimates the mass flux at small distances from the nozzle, where the drop concentration is high.

The model is based on the assumption that the drops in the spray are distributed randomly and thus the probability of two or more drops in the probe volume can be described by the Poisson distribution. Once this probability is estimated from the measured data resident times, the total drop counts can be adjusted accordingly, assuming no correlation between occurrence probability in the volume and particle size. As an example of the significance of this consideration, if the measured residence times amount to 30% of the total measurement duration, already 50% more droplets are present than are registered as signals. This greatly influences the derived fluxes.

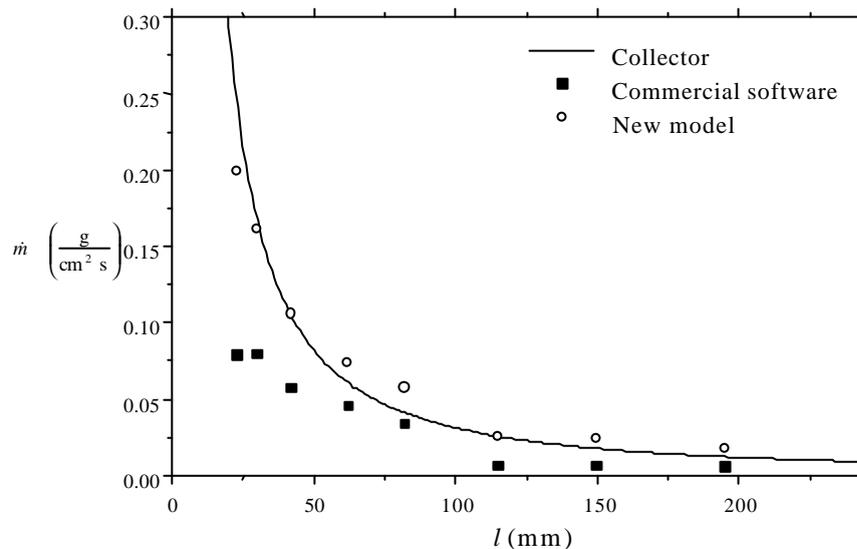


Fig. 1: Comparison of the mass flux calculated by commercial software and by the present model with the results of measurements by the patternator.

The present model also allows computation of fluxes in arbitrary directions, even when the main flow direction of the spray is not aligned with the x -axis of the phase Doppler system. The phase Doppler measurements are in good agreement with the measurements using the tube collector, both for inclined impinging sprays and for an inclined collector plane. This allows investigations in regions of the spray, where strong variations of the velocity directions can be expected, for example near the wall or in the region of interaction of two sprays.