Dissertation title:

Dynamics of coherent structures of pressure-swirl atomization: Influence of internal nozzle flow on the sheet breakup

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Due to the favorable operating characteristics, pressure-swirl atomizers are usually operated in the domain of wavy-sheet disintegration. The droplet formation process is typically modelled using comprehensive atomization models. However, the hitherto unknown initial disturbance of the liquid lamella is decisive for the break-up process and is not taken into account in design methods so far. The aim is to derive an initial condition from the internal nozzle flow and thus enable the development of new models.

The break-up of the liquid is characterized through high-speed imaging at a specifically designed test stand. The numerical flow simulation allows the investigation of the experimentally inaccessible three-dimensional, transient and two-phase internal nozzle flow. The link between experiment and simulation is provided by the method of Proper Orthogonal Decomposition. This enables the characterization of the wave movement responsible for disintegration of the liquid lamella. The wavelength of the disturbance can be determined on the basis of the calculated spatial basis functions. Spectral analysis of the time signals provides the corresponding dominant frequency. Coherent flow structures occurring in the nozzle and their corresponding dominant frequencies can also be identified by means of this methodology. Experiments with transparent nozzles made of Plexiglas allow an additional comparison to the numerical flow simulation.

The results from simulation and experiment identify the instability of the air-filled hollow core within the nozzle as the break-up cause. This instability deforms the hollow core and causes a disturbance in the liquid film emitted by the nozzle. The disturbance grows over the length of the lamella and induces the break-up. It is shown that several superimposed disturbances of the lamella and the internal nozzle flow can be extracted by means of the applied method. These interact with each other. Presumed resonance effects cause an irregular disintegration of the lamella. With the known initial disturbance, a new atomization model can be formulated in a next step.