Turbulent flow investigations in a micro-channel

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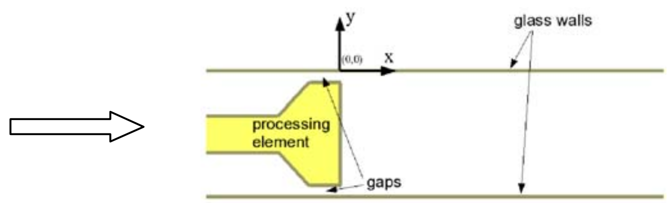
Turbulent flow of water in a narrow gap of an emulsifier is investigated experimentally using micro-PIV technique and compared with numerical predictions performed using the commercial code Fluent. The purpose of the investigations is to develop procedure for well-controlled generation of mono-dispersed suspension of micro droplets. These droplets will form a matrix for collection of nano-particles into well-structured configuration.

The micro-flow measurements are based on epi-fluorescence illumination and high speed imaging. The experimental set-up consists of the experimental emulsifier cell, epi-fluorescence microscope, high resolution PIV camera, double pulse Nd:YAG laser (5ns pulse) and pressure system for flow acceleration. The micro-PIV velocity measurements are performed in a 0.4mm high and 1mm long channel formed between two glass plates. The Reynolds number in the gap is 8000. Fluorescent polystyrene spheres, 2μm in diameter (Duke Scientific Inc.) are used for the flow seeding. The flow is observed through the upper window. By traversing the field of observation in the horizontal and vertical direction, the position of the interrogated flow plane is selected. The vertical resolution depends on the depth of field of the objective. In the micro-PIV experiments performed the vertical resolution is estimated to be 10μm and the horizontal resolution of the velocity field measurements is about 0.5μm. The accuracy of the velocity measurement depends on several experimental factors (quality of images, seeding concentration, particle displacement), as well as on the vector evaluation procedure. Using in house developed software the error of velocity measurement is estimated to be below 5%. The full field flow data are used to evaluate local velocity gradients, necessary to estimate conditions for the droplet break-up.

The experimental data are compared with the numerical results obtained using both turbulent and laminar flow models. It was found that due to small channel dimensions and very short flow development length the turbulent energy dissipation takes place mainly in the gap and shortly behind it. The estimated value of mean energy dissipation is used to predict mean droplets diameter. These predictions are validated using experimental data for the emulsion.



Schematic view of the investigated emulsifier.

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