Proceedings of the 8th World Congress on Momentum, Heat and Mass Transfer (MHMT'23)
Lisbon, Portugal – March 26 – 28, 2023
Paper No. ICMFHT 116
DOI: 10.11159/icmfht23.116

A Python Based Approach for Drop Analysis in Micro-Fluidics Devices

Filippo Azzini [1], Lorenzo Mannucci[1], Massimiliano Rossi[1], Beatrice Pulvirenti[1], Gian Luca Morini[1]
[1] University of Bologna
Bologna, Italy
filippo.azzini2@unibo.it, massimiliano.rossi13@unibo.it, beatrice.pulvirenti@unibo.it, gianluca.morini@unibo.it

Extended Abstract

Micro-junctions are devices used for mixing and for micro-drop generation. This kind of technology can be used in different fields where precision in terms of drop volume plays a very important role (i.e. chemical reactor or DNA analysis). For this reason, it is important to know the behavior of a micro-junction in terms of variation of fluid volume and velocity during the drop generation. In this work, the generation of demineralized water drops in silicon oil in a micro-cross junction with stadium-shaped micro-channels is analyzed to study variations in terms of dimensions for fixed flow rates. The object of this study is to characterize a train of droplets formed in this micro-junction and their distributions in terms of velocity and dimensions. The evolution of the droplets is obtained for several ratios of the volume flow rates of the two fluids flowing inside the channel.

To achieve this goal a huge number of images taken from a high-speed camera need to be analyzed and then an in house software written in Python for drop identification and measurement it was realized.

This tool is based on a machine learning classification algorithm, and it is designed to work with different micro-fluidic devices and under different working conditions (i.e. different working fluids or different illumination intensities) and to reduce at minimum the user manual interventions.

The first step of the algorithm is to select from the initial ensemble of images obtained from the camera only the ones containing at most an entire drop, and then the code discards all the images that do not have a drop or the ones having a portion of a drop.

For this goal, the algorithm, based on the logistic function, needs to be trained, to reduce significantly the operation made manually by the user and to reduce the possibility of mistakes the training is made starting from synthetic data i.e. artifact drops created by the algorithm itself. Only an image that contains an entire drop need to be selected (seed image) by the user, then the algorithm creates, starting from the initial pool of images an image of the empty channel then starting from these two images two sets of images will be created: a set of good images that represent a prototype of the images that can be analyzed and a set of bad images that will be discharged.

Then the trained algorithm can be applied to the initial pool of images at the end of this process as results a ordered series of images that they represent an entire drop-train is obtained, therefore, is possible to analyze some oscillations that occur in the same drop and global oscillations of the entire set of drops.

Applying this technique to different cases with different dimensionless flow rates Q^* it is possible to observe some oscillations in terms of dimensions of droplets. Globally if Q^* increases the dimensions of the drop increase but analysing this result is possible to observe that for a fixed value of continuous and dispersed flow rates variation of the order of 6% are observed.

In this work also the velocity field inside the micro-channel is evaluated using μ-piv techniques, from this analysis is possible to observe similar oscillations occurring in the velocity field, possibly generated by the syringe pump used to move the two fluids.

These instabilities can influence the drop dimensions during the break-down phenomena .

This technique will be applied for different flow rates to better understand these phenomena and to correlate the oscillations in the velocity field with the ones in the drop dimensions.