Analysing droplets in a commercial inkjet printer with simulations

A digital inkjet printer shoots millions of microscopic droplets to create a single image. What effects this process and how can it be improved? A virtual model of this process might help to shed light on this process and give answers to these questions.

Digital printing methods, like inkjet printers, have revolutionized the printing industry. They allow the creation of images within seconds, without the need for any physical stamp. However, this immense flexibility does not come without drawbacks. Creating an image without a stamp requires the precise deposition of thousands of individual microscopic droplets, smaller than a human hair. Having a controlled formation of these drops is thereby essential. This is, however, not a trivial task, since many properties influence this process, like fluid properties, printhead dimensions, input signals, etc. It is not economical to investigate all these parameters with experiments since it would take a lot of time. For this reason, a virtual model of the droplet formation was created within this project. This model captures the formation of a single droplet, that is dispensed in air. A so-called Volume-of-Fluid method is used to simulate both air and liquid at the same time and how they influence each other. The final model can be used to investigate all kinds of different parameters and their effects on the droplet formation in a time efficient way.

The focus of the model is the correct prediction of so-called satellite droplets. These are small additional drops that appear next to the main droplet. They lead to blurry images and should be avoided. To test the ability of the simulation to predict the occurrence of these types of droplets, multiple experiments were conducted. They helped to calibrate the simulation method and to test the model's performance. By comparing the outcome of experiments and simulations under the same conditions, a good compliance between the two could be reached. This validation process is essential to build trust in the virtual model and its predicted results. After achieving the desired conformity between simulation and reality, a parameter study of different fluid types and properties was performed. The different effects of changes in density, surface tension, viscosity or contact angle could clearly be observed. Furthermore, the importance of the input signal to the printhead could be shown and different possible versions of this signal could be simulated.

The practical applications of the virtual model are vast and depend on the specific goals. With the current approach, we can investigate the influence of different Newtonian fluids, input signals, printhead dimensions, and more. The potential for further adaptations of the model opens even more possibilities, demonstrating the significant impact this research can have on the inkjet printing industry.