Chair: Physics of Fluids group

Dirt particle motion in an ink channel: Altering the dynamics through a multi-component pulse

Description

Inkjet printing is a successful industrial application of micro-fluidics allowing for highly controlled material deposition of droplets at picoliter volumes (Wijshoff, 2010) (see Fig. 1a). This technique has wide-ranging applications such as, in graphics printing, 3D printing, biomaterials, pharmaceuticals and chip technology. Hence, understanding the processes involved in droplet formation holds immense importance, in addition to its scientific relevance.

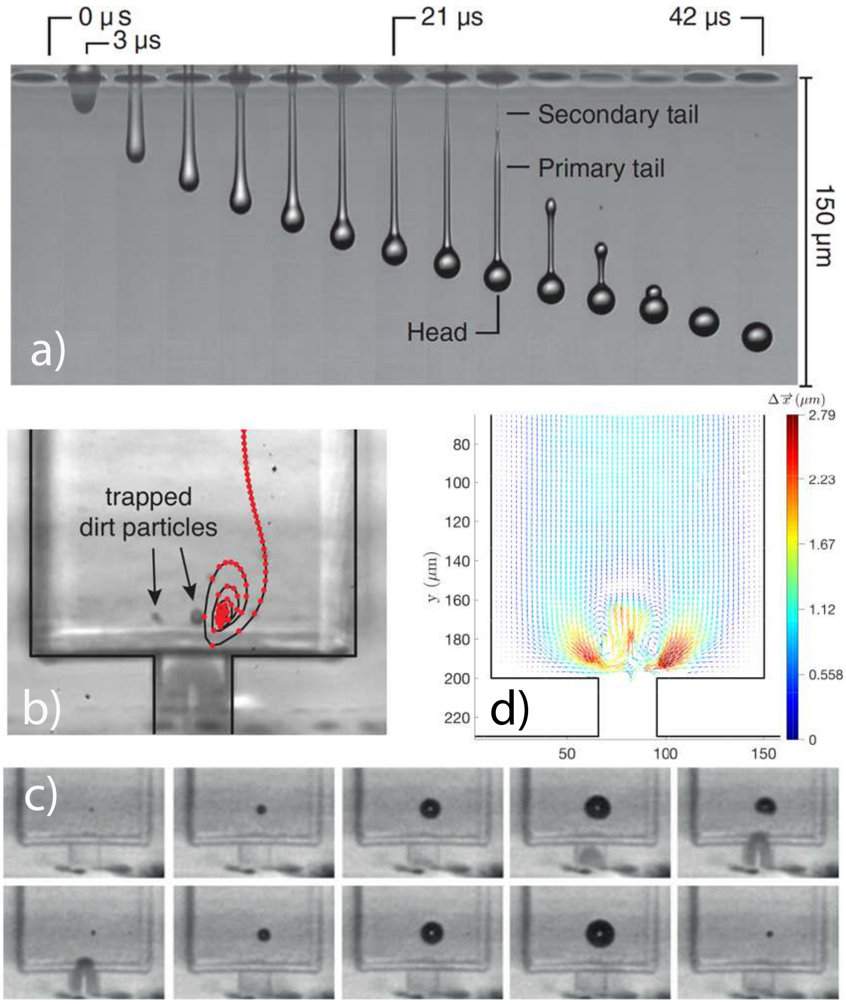

Figure 1: (a) Jetted droplets captured through high-speed imaging. (b) Trapping of dirt particles in the vortex ring in the channel. (c) Bubble oscillations driven by the printhead acoustics. Bubble entrainment leads to acute nozzle failure. (d) Flow structure inside the channel revealed by particle tracking velocimetry (PTV).

It is important to understand which designs lead to desirable jetting behaviour. It is also equally important to understand unstable jetting conditions, such as bubble entrainment inside the channel. Entrainment of a bubble, which leads to complete failure of the nozzle, has been observed to occur in conjunction with trapping of dirt particles inside the vortex ring above the nozzle (Fraters et al.,

2019) (see Fig. 1b & c). In this project, we aim to investigate the possibility to maneuver the particle motion inside the channel. Specifically, the goal is to drift the particle away from the vortex ring thereby reducing the probability of nozzle failure via bubble entrainment. Multicomponent actuation pulse has been shown to alter the jetting dynamics and droplet shape by controlling the acoustics within the ink channel (Fraters et al., 2020). So, a particle that has been observed to be trapped within a vortex ring, could potentially be made to move centrifugally by switching to a multicomponent actuation pulse.

In this numerical and experimental study, the main goal is to explore the switching of particle motion from centrifugal (from center to outwards) to centripetal (from outside towards center) or vice versa. We have numerically modeled the flow inside the channel with a coupled Navier-Stokes and Helmholtz oscillator model, which is shown to be in good agreement with the experimental measurements obtained with fluorescent particle tracking velocimetry. The particle trajectory for a given flow is then computed by solving the Maxey-Riley equation. The flow inside the channel can be studied using the printer with optically transparent channels that was developed in our group in collaboration with our industrial partner (Canon Production Printing) (see Fig. 1d). Both, high-speed imaging and PTV can be employed for this purpose.

Assignment

The most important aspect of the project is to investigate the dirt particle motion inside an inkjet channel. The particle dynamics are studied for particles with varying sizes and ink channels of varying nozzle shapes. The potential of a switching behavior for a given particle and nozzle shape is then explored. Based on the interest of the student, the problem could be approached either numerically or experimentally.

Thus, this assignment includes experimental aspects such as printhead operation, high-speed imaging, particle tracking velocimetry, and image analysis techniques. Furthermore, the possibility to employ the in-house developed tools for numerical validation.

Supervision	**E-mail**	**Tel.**	**Office**	**Lab**
Yogesh Jethani	y.j.jethani@utwente.nl	+31 (0) 53 489 5898	Meander 246A	Meander 113C
Tim Segers	t.segers@utwente.nl	+31 (0) 53 489 7477	Meander 214A	Meander 113C
Michel Versluis	m.versluis@utwente.nl	+31 (0) 53 489 6824	Meander 260	

References

Arjan Fraters, Marc van den Berg, Youri de Loore, Hans Reinten, Herman Wijshoff, Detlef Lohse, Michel Versluis, and Tim Segers. Inkjet nozzle failure by heterogeneous nucleation: Bubble entrainment, cavitation, and diffusive growth. *Physical review applied*, 12(6):064019, 2019.

Arjan Fraters, Roger Jeurissen, Marc van den Berg, Hans Reinten, Herman Wijshoff, Detlef Lohse, Michel Versluis, and Tim Segers. Secondary tail formation and breakup in piezoacoustic inkjet printing: Femtoliter droplets captured in flight. *Physical Review Applied*, 13(2):024075, 2020.

Herman Wijshoff. The dynamics of the piezo inkjet printhead operation. *Physics reports*, 491(4-5): 77–177, 2010.