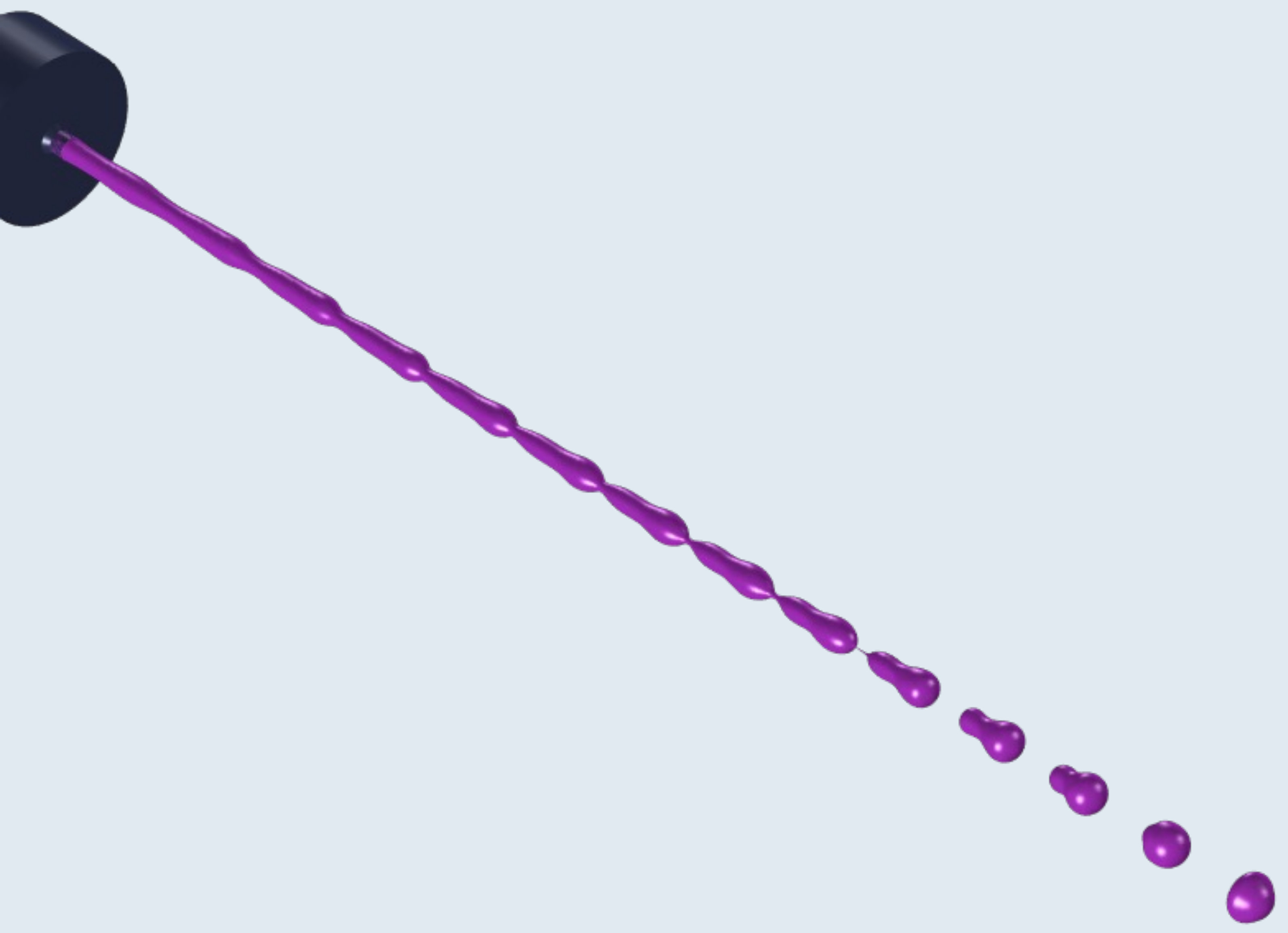

Modelling of Ink Jet Breakup using COMSOL Multiphysics®

This work proposes a new numerical model to predict the ink jet breakup process occurring in the Continuous Ink Jet (CIJ) technology.

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Abstract

Continuous inkjet technology, widely used for marking and coding, relies on emitting charged droplets at high velocity and frequency. Key factors in printhead design include droplet shape and jet breakup length, which affect the apparatus size and print quality. Understand how the droplet generator geometry, ink properties, and operating conditions influence these factors is crucial.

This article introduces a novel approach to model the ink jet breakup process using COMSOL Multiphysics®. It employs a diphasic flow model using the Laminar Flow interface with the Level-Set method. The novelty consists in incorporating a Navier-Slip boundary condition at walls, which once adjusted, allows for accurate predictions of the ink jet breakup for various configurations.

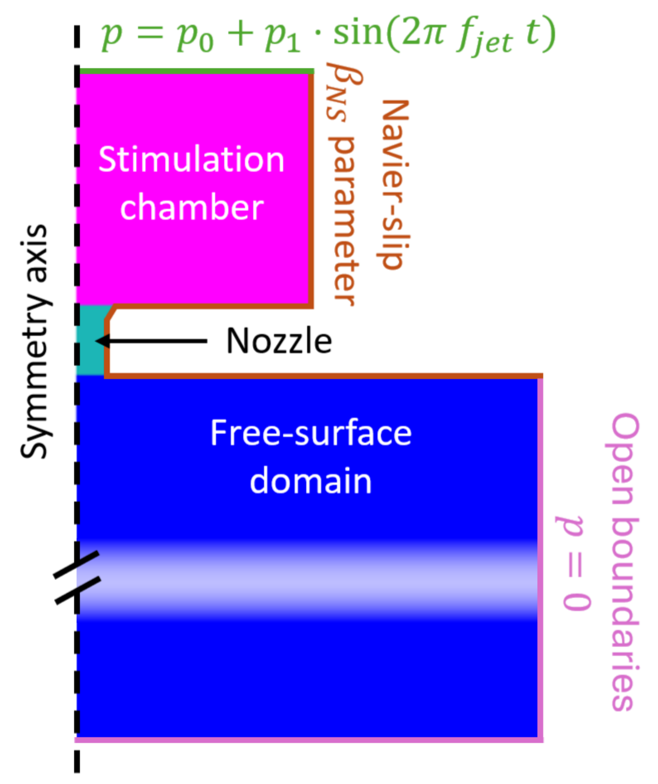

FIGURE 1. Simulation domain and boundary conditions.

Methodology

A diphasic flow is simulation over the simulation domain pictured in FIGURE 1. An oscillating pressure difference simulates a continuous flow of ink, perturbed by an oscillating piezoelectric membrane. The perturbation is chosen to amplify along the formed jet to obtain at a certain point droplet formation, thanks to the Rayleigh-Plateau instability. The novelty is using a Navier-slip boundary condition at walls, parameterized by a coefficient β_{NS} controlling the degree of slip. The free-surface domain is long enough to simulate the generated droplets.

Experimentally, the ink, the droplet generator, the frequency f_{jet}, the mean volumetric flow and the amplitude of the signal applied on the piezoelectric membrane define the operating point. The measured jet velocity is used with the volumetric flow as criteria to adjust the model: upstream average pressure p_0 and slip coefficient β_{NS}. Since the piezoelectric membrane is not physically modelled, simulations are performed with multiple values of perturbation pressure amplitude p_1.

Results

Once calibrated, the model is able to predict the droplet generation across on a wide range of perturbation amplitudes. Indeed, in FIGURE 2.a, a linear relationship between the amplitude of the signal applied on the piezo-membrane and the amplitude of the pressure perturbation is found by fitting the breakup length curves. It allows for comparing numerical and experimental jet shapes at breakup (FIGURE 2.b): all experimental shapes has been found. This work highlights the existence of wall slip, the origin of which remains to be determined.

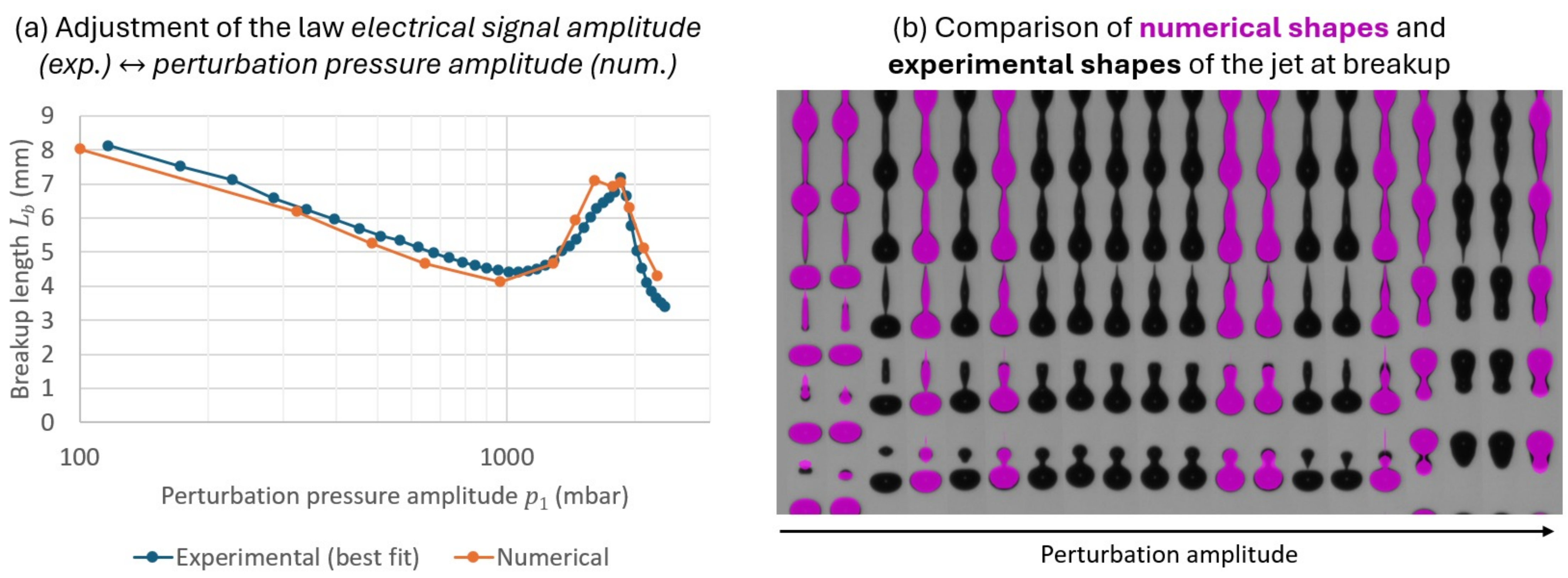

FIGURE 2. Model-experiment comparison in function of the perturbation amplitude.

REFERENCES

1. M. Rosello, Etudes numérique et expérimentale de l'instabilité de Rayleigh-Plateau : Application aux jets d'encres, PhD Thesis, Université Grenoble Alpes, 2017.
2. Z. Zhao and W. Li, "Numerical study of continuous liquid tin jet breakup and satellite droplet formation," AIP Advances, vol. 12, no. 125216, pp. 1-11, 2022.
3. M. Sturma, A. Monlon, P. Namy, F. Viry and B. Barbet, "Modelling of Droplet Charge Dynamics during an Ink Jet Breakup using COMSOL Multiphysics®," in COMSOL Conference, Munich, 2023.
4. T. Otowa, S. Tsubouchi and Y. Suwa, "Analysic of the Ink-Stream Break-up Phenomenon in Continuous Inkjet Printing," ACS Omega, vol. 8, no. 38, pp. 34442-34447, 2023.

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This work has been founded by MARKEM-Imaje and made in a fruitful collaboration between MARKEM-Imaje and SIMTEC.