FLOW-3D

3D Printing: Multi-Material, Single Printhead Simulation

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Abstract

The study aims at simulating the microfluidic printhead for multi-material 3D printing (2 materials in this case) and compares the results with the experiments. The actual inks used in the experiment are polydimethylsiloxane (PDMS) inks. For the simulation properties similar to the PDMS inks have been used. *FLOW-3D*® is used for the simulation while its postprocessor FlowSight is used for visualizing the results.

Introduction

Viscoelastic ink printing is the future of 3D printing. It does not require added heat, relying instead on a pump to eject any number of materials with thick consistencies onto a build platform. However, like any other 3D printing method there is an issue when multiple inks are used for the same product. The use of multiple extruders - as it is currently done - comes with inherent inaccuracy associated with the transitioning of extruders. For products at the scale of microns, inaccuracy could lead to misalignment and hence a bad product.

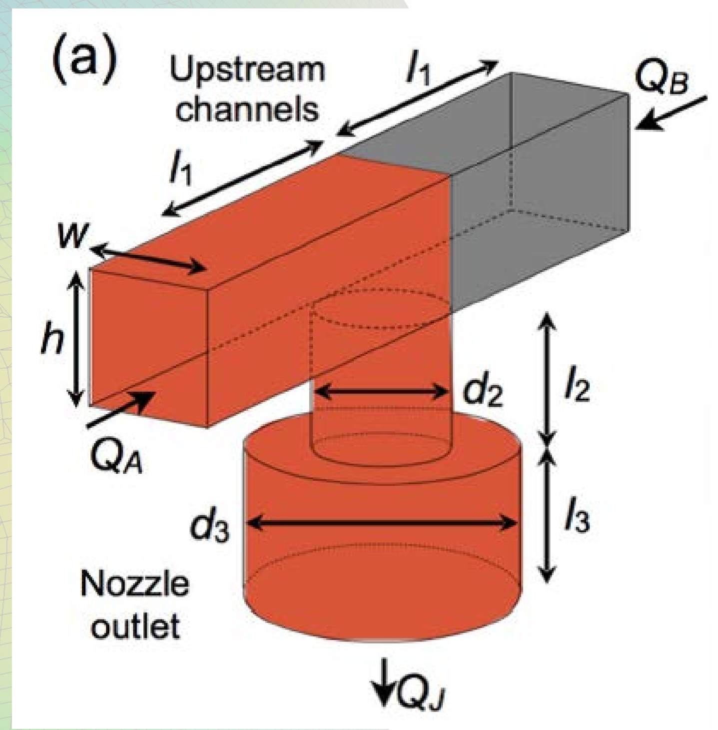

Figure (a): Two-material T-junction microfluidic printhead

However, researchers at the Harvard School of Engineering and Applied Sciences have come up with a solution to precisely transition from one material to another. The solution is straightforward; use a single printhead/nozzle but control the inflow of multiple inks through the same nozzle in a programmable manner. To be more specific, the transition between the two inks should be as abrupt as possible.

Methods

In this case, *FLOW-3D*, a highly-accurate multi-physics CFD package, is used to simulate a two-ink microfluidic printhead for printing viscoelastic inks.

The setup of the printhead is shown in Figure (a). The dimensions are only a few hundred micro-meters in length which requires a very fine mesh to capture the dynamics at the micron scale.

Since the viscosity of inks is strain rate dependent, *FLOW-3D* allows the user to specify the fluid property in a tabular form representing the strain rate-viscosity curve. Figure (b) shows the programmable control of the incoming discharge rates of inks from the two ends of the printhead. In *FLOW-3D*, the exact boundary condition has been specified. *FLOW-3D*'s Moving Object model simulates the movement of the printing platform at a designated speed. In this case it is 2.65 mm/sec.

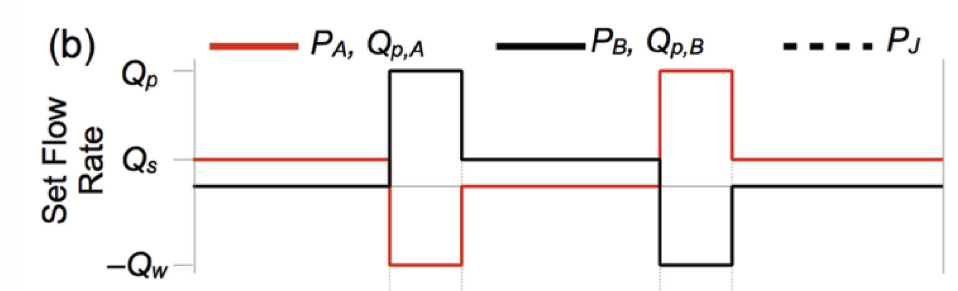

Figure (b): Plots of volumetric flow rates set in the printhead and corresponding pressures in nozzle

Results

Using *FLOW-3D* this approach is validated and the results can be seen in the image, as in Figure (c). *FLOW-3D*'s post-processor FlowSight™ can create line probes to plot variables over a defined distance. In this study, a line probe was used across the transition length of ejected inks and a distance-fluid fraction plot was made. It is observed that a complete transition happens around 0.5 mm of printed ink streak. This matches with experimental results.

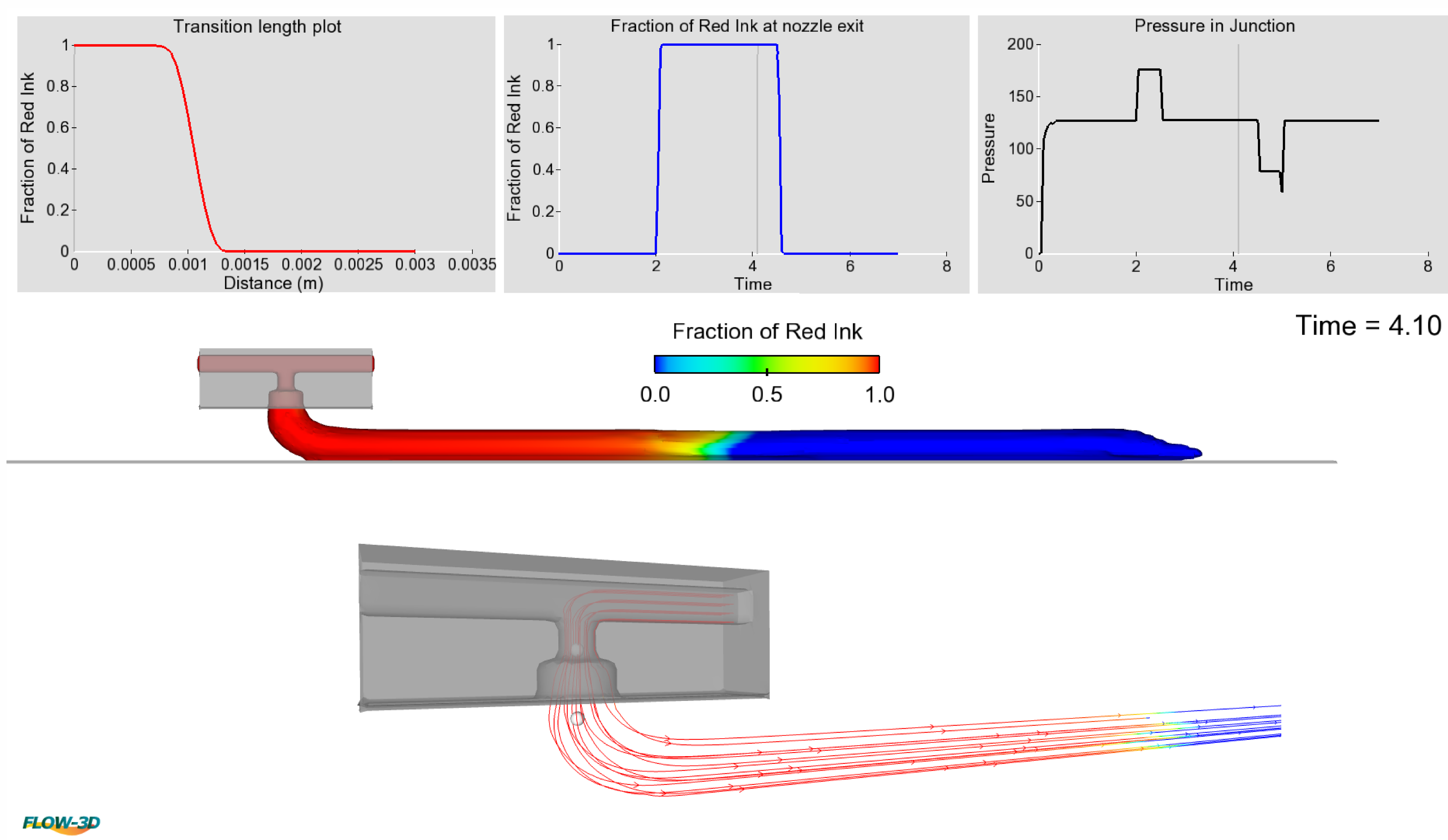

Figure (c): Simulation of a multi-material T-junction microfluidic printhead using *FLOW-3D*

Conclusion

The use of single printheads for multiple visco-elactic inks can be controlled in a programmable manner and put to use with greater accuracy than currently available multiple printhead setups. The use of computational fluid dynamics to study the physics of the processes involved can be useful for production at larger scales. *FLOW-3D* used as a CFD model to simulate the process gives satisfactory results when compared to experimental results. Further detailed simulations are in progress to capture more physics of the process.

References

James O. Hardin, Thomas J. Ober, Alexander D. Valentine, Jennifer A. Lewis. *Microfluidic Printheads for Multimaterial 3D Printing of Viscoelastic Inks*, 2015.

About Flow Science

- Founded in 1980, by Dr. Tony Hirt, one of the developers of the Volume of Fluid (VOF) method for free-surface tracking at the Los Alamos National Laboratory
- Commercial software *FLOW-3D* released in 1985
- Develops and sells *FLOW-3D*, a highly-accurate computational fluid dynamics (CFD) software capable of solving many types of complex flows
- Provides expert CFD engineering services and custom software solutions
- Offers high performance computing with parallel processing capabilities

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