10th OpenFOAM Conference
Improvement of a solver to model the formation of Polyurethane foams

Sahrish B. Naqvi[1], Mohsen Karimi[2], Ricardo Costa[1], João Miguel Nobrega[1]
[1] Institute for Polymers and Composites/Department of Polymer Engineering, University of Minho, Guimarães, Portugal
[2] Alfa Laval Technology AB, Stockholm, Sweden

Keywords: Polyurethane, CFD, Parallelization, Meter model, Shoe sole.

Polyurethane (PU) foams are widely used in several applications, for instance, furniture, composite fabrics, clothing, shoes, car cushions, sports equipment, refrigerators, and refrigerated containers, among several others. The project in which this work is integrated is geared toward extending PUFoam (Karimi M. et al., 2017), an OpenFOAM-based solver developed to model the formation of PU foams, to industrial applications, more precisely the mold-filling stage of shoe soles. The typical soles employed in shoes present complex geometries (see Figure 1), and an accurate simulation of the physical phenomena involved in the problem requires refined computational meshes. Moreover, the calculation of PU foams formation comprises a complex framework, where the evolution of different chemical species is coupled with flow and heat-transfer. The base version of PUFoam comprises a three-dimensional solver that is not parallelized, which significantly limits its applicability, especially in computationally demanding simulations, such as those for the shoe sole mold-filling. Based on the above, the present work aims at appropriately parallelizing the PUFoam solver and extend the available viscosity models to include the Meter model (Meter and Bird, 1964), which is more flexible than the previously available ones. The expansion of the PU foam region predicted by the parallelized PUFoam solver for a unit cell of a complex shoe sole is illustrated in Figure 1. With this updated solver, the results obtained in serial and parallel calculations are superimposed, and a good scalability, near to linear, was achieved in all the tests performed.

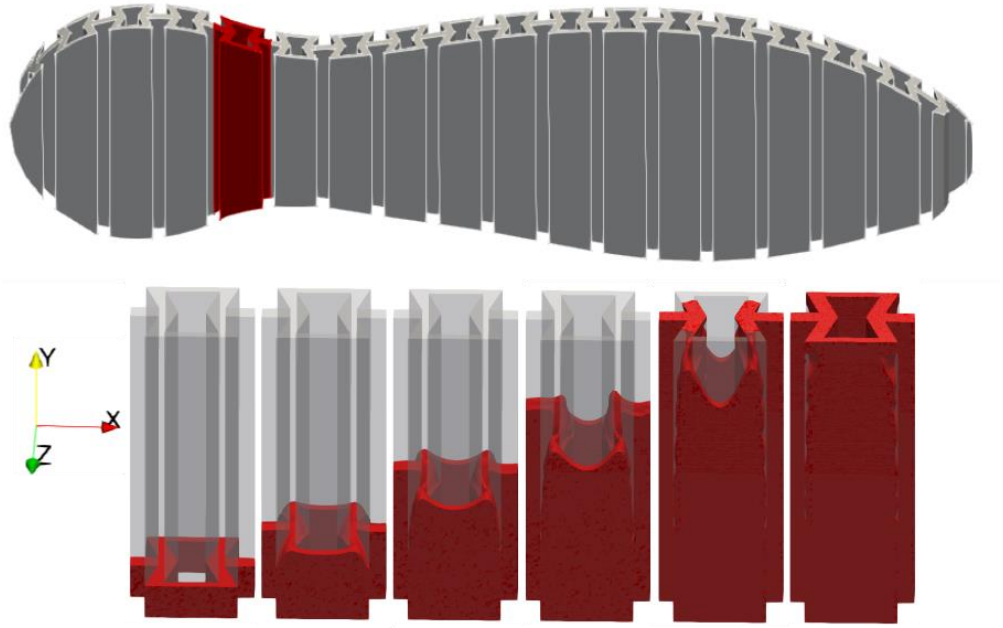

Figure 1: Top: Schematic of shoe sole geometry (in grey) together with a representative unit cell (in red). Bottom: Evolution of the PU foam region in the domain.

Acknowledgments
This work was funded by National Funds through FCT – Portuguese Foundation for Science and Technology, Reference UID/CTM/50025/2019 and UIDB/04436/2020, and project GreensShoes 4.0 (POCI-01-0247-FEDER-046082).

References
Karimi M., Droghetti H., and Marchisio D.L., PUFoam: A novel open-source CFD solver for the simulation of polyurethane foams. *Comput. Phys*. Commun. 2017. Doi: 10.1016/j.cpc.2017.03.010
Meter D.M., and Bird R.B., Tube flow of non-Newtonian polymer solutions: Part I. Laminar flow and rheological models. 1964. Doi: 10.1002/aic.690100619