Formation, growth and detachment of multiple droplets at the free flow–porous medium interface

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Formation of droplets at the interface of a coupled free-flow–porous medium system occurs in many engineering applications such as: fuel cells, cooling systems, thermal insulation and air conditioning of buildings [4, 1, 5]. Emerging of a droplet at the interface significantly alters mass, momentum and energy exchange between the two domains. An interface including droplet not only handles exchange between free flow and porous medium, but also stores mass and energy [2]. Such an interface also experiences the droplet dynamics such as the droplet formation, growth and detachment.

We developed a new model to takes the droplet impact at the interface of a free-flow–porous medium system into account. In this model, we extend the pore-network model developed by [7] to describe the porous medium to include the droplet formation at the interface. The Navier-Stocks equations describe the free-flow domain. Including the droplet dynamics, we developed new coupling conditions between the free-flow and the porous medium [6]. To predict the droplet detachment, we distinguished between the forces acting on the droplet in favor of the detachment, i.e. free-flow forces, and the forces acting on the droplet triple contact line, which keep the droplet at the interface. Comparison of these forces gives us a criterion to predict the droplet detachment. The model implementations have been done in DuMu^{x}, an open-source simulation toolbox for transport in porous media [3].

In addition to helping us to gain a better understanding of the droplet formation at the interface between a free-flow and a porous medium, our model could provide a basis for further scale-bridging developments.

References

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