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Coupling Stokes and *level-set* equations for capillary driven flows in fibrous media

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Numerical simulation is a crucial asset for high performance composite manufacturing. When a liquid resin infuses reinforcements made of carbon fibres, voids may be created due to the competition between capillary effects and viscous effects. This study focuses on capillary effects investigated at the fibre scale.

The computation of capillary effects relies on the geometry of the interface and the contact angle. In our case, the weak enforcement of the mechanical equilibrium along the contact line between liquid, air and fibers, results naturally in the associated static contact angle [1]. The two-fluid (air-resin) Stokes problem is solved using a stabilised finite element method based on a linear approximations for both velocity and pressure. Since such an approximation does not satisfy the Ladyzhenskaya-Babuškha-Brezzi stability condition, an *Algebraic SubGrid Scale* method [2] is used to ensure the existence and uniqueness of the solution. Furthermore, the front of resin is captured by a *level-set* function convected with the flow velocity. Due to capillary effects and jump of material properties at the air-resin interface, pressure and pressure gradient are discontinuous. This is taken into account by enriching the pressure space locally, with two discontinuous shape functions. As in any bi-fluid problem, the equations describing the flow depend, in a non-linearly way, on the interface position, and therefore on the level-set function. The specificity of capillary flows is the strong dependence of Stokes' equations on the interface geometry, through the curvature, the normal vector, and the contact angle. In this work, the relevancy of an iterative coupling between Stokes' equations and transport equation (updating the interface) is evaluated. In particular, the effects of the strong coupling on the contact angle and the dynamic of the contact line when going back to the static contact angle is discussed.

The method is tested first against validation cases of a static bubble and a fluid wicking against a wall. Next, more complex applications are investigated.

REFERENCES

[1] J. Bruchon, N. Moulin and Y. Liu. *New variational formulation of the triple junction equilibrium with applications to wetting problems*, ECCOMAS Congress 2016, Crete

[2] R. Codina *A stabilized finite element method for generalized stationary incompressible flows*, Computer Methods in Applied Mechanics and Engineering, 2681-2706, 2001.