A macroscopic model for the impregnation process of composite material by a concentrated suspension

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In order to improve thermal, mechanical behavior and weight of our turbine blades, we need to use a new composite material. The manufacturing process to obtain this composite is intricate and requires a fluid densification process consisted of two parts. Firstly, particles are introduced in the reinforcement thanks to a pressure-driven flow, where they are retained by a filtration membrane. By reducing porosity, we improve the capillarity infiltration of a melted metal which can react with particles (second part). In this present study, we carry out a model that can describe physics of particles' introduction in our material.

Given that we wanted to simulate flow at fibers scale and considering average particles' size is about a micrometer, we decided to use the volume fraction of particles Φ to describe our colloidal suspension. Thus, suspension flow can be resolved with the Navier-Stokes equations of mass and momentum conservation. To evaluate the particles concentration field, a diffusion equation is introduced. Originally developed by Leighton *et al* [1], then improved by Phillips *et al* [2] this equation describes the migration of particles in a sheared flow. At last, the viscosity dependence of volume fraction is given by Krieger [3]: $\mu(\Phi) = (1 - \Phi/\Phi_{max})^{\eta \Phi_{max}}$

Due to the filtration membrane presence, our process is similar to the dead-end filtration developed in microfiltration process [4]. Thus, we easily observe the sieving mechanism with formation of a growing cake that can be seen as a porous media. In the cake, our model describes a macroscopic flow of aqueous fluid in a porous media composed of rigid spheres. Microfiltration process can also provide theoretical law over temporal evolution of the cake-layer thickness. Before testing our model over realistic geometries, it was evaluated with experiments [5]. Then, our work consisted of two parts: 2D parametric studies and strong 3D simulations over RVE.

References

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