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Multi-scale Computational Modeling of Flow of Hybrid Composites

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Overmolding, or in other words the injection of long fiber thermoplastics (LFT) over a continuous fiber reinforced thermoplastic composite insert, is gaining in popularity. This technology can be applied to both simple and complex parts and is of interest to many of industries and fields of applications such as: automotive, aeronautics and electronics. During the injection step, the fluid pressure may displace or deform the fiber reinforced composite insert. The development of this process is hindered by a lack of numerical simulation solutions of the insert position and fiber orientation. This process involves multiphysics coupling (fluid flow, fluid/fluid interaction and heat transfer).

A numerical study is carried out to focus on the predictions of the fiber orientation patterns in 2D/3D geometrical features. The numerical modeling of short fiber suspensions flows requires a description of the micro-structural evolution that can be related to fiber orientation which affects the flow kinematics and that is itself governed by this kinematics. Several approaches have been proposed in the literature to describe the micro-structural state including the use of orientation tensors which requires closure approximation techniques. In this work, the novelty of the proposed approach, that is depicted as the direct solver technique, is based on describe the fiber orientation state from its probability density whose evolution is described by the Fokker–Planck equation. It is worth to note that the orientation probability density $\varphi(\mathbf{x},\mathbf{p})$ depends on the fiber position $\mathbf{x}$ in a Cartesian coordinate system and the angle of orientation $\mathbf{p}$. As result two kinds of discretization can be looked at separately: angular discretization and spatial discretization. The technique adopted here is to discretize first the variation of fiber angles over an unit circle (2D) or a sphere (3D) S and capture all possible fiber orientations in each spatial node, then to solve another advection equation using the finite element method to descretize the fokker-planck equation spatially.