On Analytical and Numerical Solutions of the Folgar–Tucker Equation and Model Refinements

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The contribution aims to provide a theoretical investigation of the orientation of rigid fibers in flowing fiber suspensions. The influence of flow on fiber orientation is not only of fundamental scientific interest but also of considerable technical relevance. For instance, fiber-reinforced polymers are commonly produced from the melt by injection molding, and steel fiber-reinforced concrete is cast in flowing states; in both cases, the mechanical properties of the resulting material strongly depend on the fiber orientation.

The theoretical modeling of such processes is typically based on the Folgar–Tucker equation (FTE) for the second-order orientation tensor, combined with various closure relations.

In the first part, analytical solutions of the quadratically closed FTE in a planar flow are presented. Both the analytical and the corresponding numerical solutions demonstrate that a planar flow problem in three dimensions cannot be regarded as purely two-dimensional.

In the second part, extensions of the Folgar–Tucker model are discussed. In particular, the classical FTE does not account for the geometric hindrance of fiber rotations in dense suspensions arising from the fact that fibers cannot penetrate each other. This effect is incorporated in an extended model through a hardcore potential. Numerical solutions of this modified FTE are compared with those of the classical model for the case of a planar flow.