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Numerical simulation of fibre orientation in simple injection molding processes

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Abstract

The study of the flow of fiber-filled polymers in such cavities is quite complex due to the fact that the flow of fiber filled thermoplastics in the molten state is modified by the presence of fibers. Since the filling stage of injection molding process has important effects on the determination of the orientation of the fiber, accurate analysis of the flow field for the mold filling stage becomes a necessity. The aim of the paper is to develop a Computational Fluid Dynamics (CFD) model to simulate and characterise the fiber suspension flow in two dimensional mold cavities. The model is intended to describe the velocity profile and to predict the fiber orientation. The flow was considered to be incompressible, non-isothermal, transient and behave as non-Newtonian fluid containing suspensions of short-fibers. The numerical model for determination of velocity profile and fiber orientation during mold-filling stage of injection molding process was solved using finite difference method. The orientations of the fibers are represented by a second-order orientation tensor. The governing equations, in addition to the continuity, momentum, energy and second order orientation, contain a fourth order orientation tensor which is approximated in terms of second order tensor through the use of appropriate closure rules. To check the numerical method, test cases were modelled for different fiber-polymer matrices using both power law and cross models. The numerical results were compared with available experimental findings. A good agreement between the numerical results and the experimental data was achieved.

Key words:*Computational Fluid Dynamics (CFD), Fiber suspension, Fiber orientation, Non-Newtonian fluid*

1. Introduction

Recently, injection molded short-fiber reinforced composites are widely used for their high strength to weight ratios and remarkably enhanced physical properties compared to pure polymer products. The injection molding process of such products involves flow of fiber suspensions in cavities with various sizes and shapes. For example, the final product of injection molded composites often depends on the flow characteristics, such as the velocity profile and the wall shear stress. By definition, fiber suspensions in

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