A Fitted Closure of the Sixth-Order Orientation Tensor for Short-Fiber Reinforced Polymer Composite Modeling

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ABSTRACT

Orientation tensors are widely used to describe fiber distributions of short fiber reinforced polymer composite systems. These tensors capture the stochastic nature of concentrated fiber suspensions in a compact form suitable for numerical computation. Unfortunately, the evolution equations for the components of an even-ordered orientation tensor require that the next higher even-ordered orientation tensor be known a priori. For example, information about the fourth-order orientation tensor is needed to evaluate the second-order orientation tensor during polymer flow simulations. Similarly, computing the evolution of a fourth-order orientation tensor requires sixth-order information, and so on. It is, therefore, common to introduce a closure which approximates an even-ordered orientation tensor as a function of lower-order tensors. Closures of the fourth-order orientation tensor have been extensively investigated in the literature, whereas sixth-order closures have received much less attention. Fourth-order closures have been shown to accurately represent lower ordered information of the distribution function, but fail to represent the higher order information required to accurately represent orientation distribution functions. This paper presents a sixth-order fitted closure which is derived by assuming that the principal planes of the fourth-order orientation tensor correspond to the planes of material symmetry of the approximate sixth-order orientation tensor, and that the principal components of the sixth-order orientation tensor are related to the principal components of the fourth-order orientation tensor. The fitted closure of the sixth-order orientation tensor is shown to represent the higher order information of the distribution function better than existing closures for concentrated suspensions of fibers.