Numerical modeling of thermoelastic nanocomposites

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Abstract

Nanocomposites have drawn much attention due to their excellent properties for the same reinforcement volume fraction compared to classical composites. Moreover, they can integrate multi-physical properties for multifunctional applications. Such improvement in the material properties is usually explained by the important interface surface/bulk volume ratio in the case of nanocomposites. To study such a class of materials, imperfect interfaces are usually introduced. In the case of thermoelastic materials, such a hypothesis implies discontinuities of the different thermomechanical fields. Nevertheless, the analytical solutions hold only for simple boundary conditions and for spherical or cylindrical inclusions. Therefore, numerical tools are necessary to study nanocomposite materials behavior. Restricted to the linear elasticity and using the generalized Young-Laplace equation for the interface equilibrium, a numerical strategy for nanomaterials modeling is developed in [1] using three numerical methods: interface finite element method, extended finite element and embeded finite element methods.

Focusing on thermoelasticity, the formulation derived in [2], based on the introduction of interfacial energy, is considered here. In addition, the hypothesis of continuous displacement and temperature fields holds. Using the interface finite element method, we propose in the present study a numerical tool to deal with coupled time-dependent thermoelastic behavior in the presence of imperfect interfaces. Considering a unidirectional nanofibrous composite, we show that the interface has an important influence on the thermomechanical fields and then on the effective response of the REV. Besides, a numerical homogenization scheme is used with different boundary conditions as illustrated in [3]. Taking advantage of the proposed numerical tool, the effect of the reinforcement size on the effective thermoelastic parameters is studied for different fibers shapes. It is noteworthy that even if the interface behavior is restricted to linear elasticity, all the thermoelastic parameters are dependent on the fibers cross section radius. Moreover, the qualitative effect of the reinforcement size on the material parameters depends essentially on the different interface moduli.

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