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A Crystallization Kinetic Model for Long Fiber-Based Composite with Thermoplastic Semicrystalline Polymer Matrix

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Abstract : Composite materials with polymer matrices are widely used in most industrial areas, particularly in aeronautical and automotive ones. Thanks to the development of a high-performance thermoplastic semicrystalline polymer matrix, those materials exhibit more and more efficient properties. The polymer matrix in composite materials can manifest a specific crystalline structure characteristic of crystallization in a fibrous medium. In order to guarantee a good mechanical behavior of structures and to optimize their performances, it is necessary to define realistic mechanical constitutive laws of such materials considering their physical structure. The interaction between fibers and matrix is a key factor in the mechanical behavior of composite materials. Transcrystallization phenomena which develops in the matrix around the fibers constitute the interphase which greatly affects and governs the nature of the fiber-matrix interaction. Hence, it becomes fundamental to quantify its impact on the thermo-mechanical behavior of composites material in relationship with processing conditions. In this work, we propose a numerical model coupling the thermal and crystallization kinetics in long fiber-based composite materials, considering both the spherulitic and transcrystalline types of the induced structures. After validation of the model with comparison to results from the literature and noticing a good correlation, a parametric study has been led on the effects of the thermal kinetics, the fibers volume fractions, the deformation, and the pressure on the crystallization rate in the material, under processing conditions. The ratio of the transcrystallinity is highlighted and analyzed with regard to the thermal kinetics and gradients in the material. Experimental results on the process are foreseen and pave the way to establish a mechanical constitutive law describing, with the introduction of the role on the crystallization rates and types on the thermo-mechanical behavior of composites materials.

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