Injection Molding Simulation: Aspects Related To The Crystallization Behavior And Micro-morphology

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Abstract

Injection molding is one of the most diffused processes for mass production of polymeric components. It is adopted in many fields, from the automotive one to the biomedical field. The aspects related to environmental pollution make mandatory the reduction of plastic wastes, especially during polymer processing. For this reason, the prediction of the properties of the injection molded manufact before the starting of the production of a new part is crucial. The properties of a molded manufact, in the case of semi-crystalline polymers, mainly depend on the micro-morphology developed during the process. It is well known, for instance, that the processing of polyolefins gives rise to the formation of fibrillar structure close to the sample wall and isotropic structures, namely spherulites, in the inner core. The anisotropic distribution of the morphological structures induces an anisotropic distribution of the mechanical properties. The commercial software available for the simulation of the process is not able to predict the kind of morphological structure developed during the process, even if some model for crystallization, also in processing conditions, have been already implemented. The aim of this work is to overcome this limitation introducing models for the prediction of micro-morphology in the cases in which small thickness components have been produced. To this purpose, a Phase Field model has been coupled with the Laminar Flow to predict the final filling length in a cavity having 0.50 mm thickness. This model is very useful when the presence of the air inside the cavity slowdowns the melt entering inside the cavity. The Heat Transfer Model in Fluids has been coupled with the above-mentioned multiphase models to describe the distribution of temperatures and the heat transfer inside the cavity. The models for the prediction of crystallization of both structures, fibrillar-like and spherulites have been implemented into the model. The Kolmogorov-Avrami model is adopted in order to take into account the impingement and to describe the degree of space-filling. A simplified Maxwell model for the description of the stretch undergone by the polymer chains during the process has been also implemented. The results of simulations have been compared with experimental results, finding consistency between the simulation and the experimental results in terms of micro-morphology prediction. In the following, it is shown an example of prediction of fibrillar structures developed in a specimen made on isotactic polypropylene, the micrograph of the sample (obtained by optical polarized microscope) is also reported for comparison. The region characterized by fibrils extends up to 0.052 mm in the molded sample; this result is similar to the one obtained with COMSOL Multiphysics®.

Figures used in the abstract

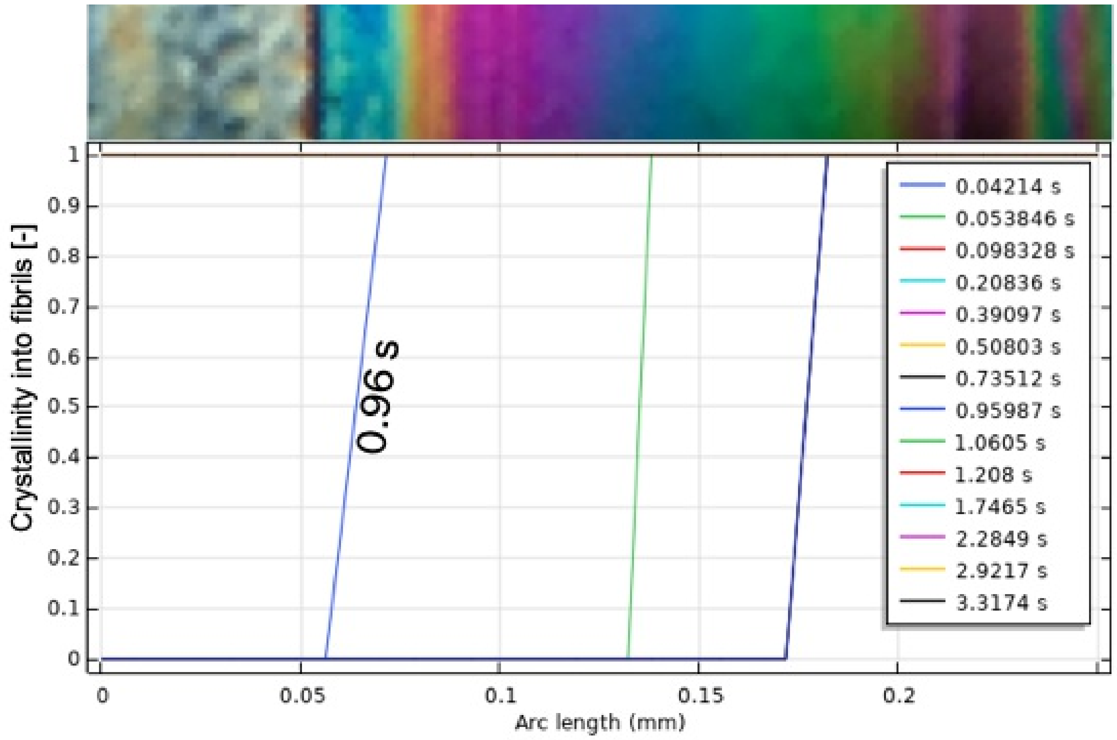

Figure 1 : Extension of the region characterized by fibrillar structures predicted by Comsol. The micrograph of the sample half-thickness is also reported for comparison.