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Anisotropic Shrinkage in Injection Moldings of Amorphous and Semicrystalline Polymers: Simulation and Experiment

A.I. Isayev, K. Kwon and K.H. Kim
Institute of Polymer Engineering, The University of Akron, Akron, OH 44325-0301, USA

A novel approach is proposed to simulate anisotropic shrinkage based on material properties and processing conditions. It uses the frozen-in molecular orientation, elastic recovery and PVT equation for amorphous thermoplastics along with the flow-induced crystallization for semicrystalline thermoplastics to predict anisotropic shrinkage in injection moldings. The in-plane anisotropic shrinkages are determined through the unfrozen portion of the elastic recovery and the anisotropic thermal expansion coefficients affected by the frozen-in orientation function. The amorphous and crystalline frozen-in orientation functions are calculated via the frozen-in and intrinsic birefringence and the elastic recovery. The flow-induced crystallization was modelled by Nakamura and Hoffman-Lauritzen equations with the rate constant affected by the elevated melting temperature determined via entropy change during flow. The frozen-in birefringence, elastic recovery and entropy change are calculated by means of a non-linear constitutive equation with an inclusion of the temperature and crystallinity dependence of relaxation times and viscosities. The proposed approach for prediction of anisotropic shrinkage is verified by measuring the thickness, length and width shrinkages in injection moldings of polystyrene and polypropylenes of various molecular weights prepared by varying packing time, flow rate, melt and mold temperatures.