

Material Concepts and Processing Methods for Electrical Insulation

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Abstract : Epoxy composites are broadly used as an electrical insulation for the high voltage applications since only such materials can fulfill particular mechanical, thermal, and dielectric requirements. However, properties of the final product are strongly dependent on proper manufacturing process with minimized material failures, as too large shrinkage, voids and cracks. Therefore, application of proper materials (epoxy, hardener, and filler) and process parameters (mold temperature, filling time, filling velocity, initial temperature of internal parts, gelation time), as well as design and geometric parameters are essential features for final quality of the produced components. In this paper, an approach for three-dimensional modeling of all molding stages, namely filling, curing and post-curing is presented. The reactive molding simulation tool is based on a commercial CFD package, and include dedicated models describing viscosity and reaction kinetics that have been successfully implemented to simulate the reactive nature of the system with exothermic effect. Also a dedicated simulation procedure for stress and shrinkage calculations, as well as simulation results are presented in the paper. Second part of the paper is dedicated to recent developments on formulations of functional composites for electrical insulation applications, focusing on thermally conductive materials. Concepts based on filler modifications for epoxy electrical composites have been presented, including the results of the obtained properties. Finally, having in mind tough environmental regulations, in addition to current process and design aspects, an approach for product re-design has been presented focusing on replacement of epoxy material with the thermoplastic one. Such "design-for-recycling" method is one of new directions associated with development of new material and processing concepts of electrical products and brings a lot of additional research challenges. For that, one of the successful products has been presented to illustrate the presented methodology.

Keywords : curing, epoxy insulation, numerical simulations, recycling

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