Modeling Chemically Blown Foam Expansion Using the Finite Element Method

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We are developing production-level foam processing models for polyurethanes and other chemically blown foams. These foams have at least two simultaneous, competing reactions including polymerization of the reactive resins and carbon dioxide gas formation that creates the foamed material. The kinetics of the resin cure were evaluated on the dry polyurethane precursor, as water is critical to carbon dioxide formation, in order to separate out the polymerization and blowing reactions, which both consume primary isocyanate groups. The kinetics of the foaming reaction was measured by tracking gas evolution with time. Rheology was performed on the dry polyurethane precursor in order to quantify the effects of cure on the continuous phase viscosity. Rheology of the foam was carried out to understand the effect of gas fraction on the flow of polymer. A finite element model was developed combining the equations of motion, an energy balance, and rate equations for the two reactions, combined with a level set method to track the location of the free surface as it evolves in time. The viscosity of the foam is dependent on degree of cure, temperature and gas fraction as the foam evolves from a bubbly liquid to a jammed system of bubbles. The three-dimensional model is compared to experimental flow visualization data in two complex geometries including flow through an aluminum mold with serpentine features and around obstacles in an acrylic box. * Sandia is a multiprogram laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000.