Abstract

Autoclave molding of prepregs is an established fabrication method to produce high performance composite components to be used in the aerospace industry and elsewhere. The process parameters for autoclave molding process such as the application pressure and temperature, resin flow and the variation of laminate thickness due to resin flow during cure, are determined by trial & error due to the lack of a reliable process model. To reduce these trial & error processes, robust control systems employing a suitable process model including all the challenging factors are required to adopt all the changes that happen during the molding process. A suitable process model not only will enable the fabricator to determine the process parameters but also to optimize the process parameters.

Prepreg based composite products manufactured using autoclave molding process undergo a severe shrinkage/warpage and deformation due to the thermal history during the molding process as well as the extraction process. The prediction and minimization of the shrinkage/warpage and deformation of the composite parts are critical for manufacturing the composite components without defects for various applications such as in aerospace, defense and satellite industry.

Automated composite forming processes are depended upon various characterizing properties of prepregs and these characterizing properties are different in different areas of the composite part at a given time-temperature profile. To predict the behaviour of the composite parts accurately, the data and the sub-model/empirical correlations for the several characterizing properties of the prepreg and cured composites are critical. These characterizing properties include cure kinetics and chemorheological properties and compressibility of prepregs, permeability of the mats used for prepreg, thermal transport and other thermal and mechanical properties of prepregs and cured composites.

In the current work, the model has been developed for the prediction of the resin cures and resin flow under the pressure and temperature during the autoclave molding of prepregs as well as to predict the shrinkage/warpage and the deformation of composite parts of various geometry viz. Flat, L-shaped and C-shaped taking account the thermal history of the parts during the molding process as well as the cooling process during extraction. The developed model not only helps to predict the warpage/shrinkage and deformation, but also predicts the shape of the final warped geometry. The developed model can be utilized to determine the most effective process parameters for molding and extraction to minimize the shrinkage/warpage and deformation of the composite parts. Methodologies for experimental determination and development of sub-model/correlations for predicting these critical characterizing properties, which are not readily available, are also being developed and used for the simulation of the model by using the generated computer code being developed for simulating the model.

Keywords: Autoclave molding process, Prepreg, Process induced deformation, Tool-part interaction, Warpage and Spring-in angle