Effect of Curing Conditions on Mechanical Properties and Chemical Shrinkage in Polymers

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Abstract

The effect that different curing time/temperature conditions bring to the final properties of a polymeric resin, along with measurements of their chemical shrinkage have been investigated in the present study.

Polymers and polymer composites have been extensively used on a great variety of applications. However, the increasing interest on composite materials raises the level of understanding that one must have in their mechanics. During the manufacturing, all composites are subjected to curing, consisting of certain time/temperature/pressure conditions, usually suggested by the supplier. These curing profiles, despite being different, aim to achieve the same degree of curing and ultimately produce the same final material with the same properties. This assumption is taken into investigation in the current work, in which two epoxy resins; Araldite LY5052 and HexFlow® RTM6 have been cured with different profiles, all theoretically reaching the same degree of curing. The degree of cure has been estimated for each case and the mechanical properties have also been studied experimentally as an attempt to draw a connection between the duration of curing-degree of curing-mechanical performance.

The second part of this investigation is related to chemical shrinkage strain. The chemical shrinkage occurs during the curing process, at constant temperature and it is related to the re-arrangement of the polymer chains. The polymer chains are given the necessary energy to increase their mobility, which ultimately leads to a closer packing. Macroscopically, this phenomenon is observed as a volumetric decrease. When fibres are introduced in the uncured polymer, they act as a restriction to the free volumetric shrinkage during the curing, eventually causing internal stresses. In this work, the existence of such stresses has been proven by studying the curvature of unsymmetric CF/RTM6 samples when reheated to their curing temperature.

Two different methods of measuring the chemical shrinkage of RTM6 resin have been used; one by measuring in situ the volume of the resin while curing in a

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cylindrical glass testing tube and a second method that utilizes the Archimedes principle in which resin has been cured in a capsule immersed in an oil bath at curing temperature. In both cases, the chemical shrinkage has been measured and the contribution to the internal stresses has been calculated.

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