Characterization of the dispersion of carbon nanotubes in nanocomposites by means of a non-destructive evaluation technique

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Abstract

An extensive use of CNTs enhanced polymer composites can be boosted by novel NDE techniques able to check the quality of the products made of these nanocomposites in order to guarantee that their specifications are met. It is well known in literature that the parameter that much more than others can affect the enhancing capabilities of the added nanoparticles is their dispersion. All the resulting physical properties of the CNTs based polymer composites depend strongly on level of dispersion of the CNTs throughout the matrix. Here we presented a novel NDE technique based on infrared thermography able to test the dispersion of the added nanoparticles in nanocomposites. Two different procedures were selected to prepare epoxy nanocomposites with dissimilar degree of nanoparticle dispersion. The novel NDE technique was then used to compare pairs of specimens whose only difference is represented by the dispersion level, which is much better in the samples manufactured by THINKY, a vacuum planetary mixer, compared to those produced with a less efficient approach. We found a significant difference in the thermal response to the heat transfer transients, i.e. the pairs of specimens, with dissimilar level of dispersion, have clearly distinguishable thermographic outcomes. The raising up of the temperature in samples exposed to the same heat flux, is faster for those with a better level of dispersion, compared to those with a poor dispersion. Thus, the NDE technique can be used to identify consistently the thermal response of a material with respect to another. A reference product, which has the expected dispersion level and achieves the desired design performance, can be used to test the thermal behaviour of other products coming out of the production process and those with poor dispersion can be identified. The mechanisms behind the effects of MWCNTs dispersion on the thermal response of the nanocomposites to the heat transfer transients were identified: homogeneous dispersion maximizes the interface area between MWCNTs and resin, the thermal conductivity of individual MWCNTs is at least four times higher than the thermal conductivity within MWCNTs bundles, the specific heat of individual MWCNTs is one third smaller than the specific heat of MWCNTs bundles.