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Finite Element Modeling of Crack Sensing in Polymers Using Conductive Carbon Nanotube Networks

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ABSTRACT

Crack sensing in polymers using carbon nanotube (CNT) conductive networks is modelled using the finite element method. Modeling is performed in two scales, the micro-scale and the macro-scale. In the micro-scale, a polymeric plate electrically reinforced by a superimposed CNT network is modelled. The effective conductivity of the nanocomposite is computed by considering the CNT conduction paths and the tunnelling effect. The proposed model of electrical network is validated against an analytical micromechanical model from the literature. It is found that the presence of a crack in the micro-model significantly reduces the effective conductivity of the nanocomposite. The decrease is larger for larger nanotube volume fractions. In the macro-model, isotropic conductivity is assumed expect from the cracked area. In this area, the conductivity of the cracked polymer, derived from the micro-model, is used. The conductivity of the macro-model is computed through a two-dimensional scan of the difference of electric potential. The numerical results show that the presence of the crack decreases the conductivity of the nanocomposite sufficiently enough in order for the crack to be detectable in the macro-scale. The decrease in the conductivity is affected by the crack orientation. The results demonstrate that the present model can be used to identify the parameters influencing crack detection in polymers by conductive CNT networks and could serve as a basis for modeling crack detection in fiber composites.