Finite Element Analysis of the Interaction between a Crack and Micro-Inclusions in Aligned Carbon Nanofiber Composites

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Carbon nanofibers are usually dispersed randomly in nanocomposite materials as a reinforcement to enhance their mechanical, thermal, electrical and other properties due to a greater interfacial interaction with the matrix caused by higher ratio of their surface area to volume. Recently, there has been an increasing interest by different industries, including the aeronautic and aerospace and industry, in aligning nanofibers in nanocomposites for various applications. A special class of materials within this family is multidirectional carbon fiber reinforced composites toughened with aligned nanofibers or simply, aligned carbon nanofiber (ACFN) composites. Here, the matrix sensitive properties can be improved when aligned carbon nanofibers are utilized to pin through the carbon fiber laminae. During the manufacturing process, the new composite material has to be exposed in a strong electrical field to align carbon nanofibers.

In this study, finite element analysis is employed to compute the stress intensity factors during the interaction between a stationary crack and a single inclusion or a cluster of inclusions in single edge notch bend specimens made of ACNF composite material under both static and impact loading conditions. The primary objective of this research is to investigate the effects of different alignment angles of carbon nanofibers and crack-inclusion interaction on the fracture behavior of ACNF composites. The numerical results demonstrate a mechanism known as crack tip shielding which results in a better fracture toughness of the material. The results also show that the CNF alignment angle plays a certain role on the fracture behavior of this type of material.