Interlaminar Properties Improvement of Polymeric Nanocomposites Using Helical Carbon Nanotubes

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Polymer based composite materials are widely used in industries like aerospace, automobile, ship building, renewable energy, spaceships, recreational industry etc. One of the largest consumers of polymeric composite materials is aerospace industry, which extensively uses composite materials to fabricate primary airframe structures such as skin, stringer, and frames of an aircraft. Polymer based composite consists of micro-fibers as reinforcements and polymeric resins that act like a glue, holding the fibers together and gives shape to the part. Micro-fibers can be either carbon, glass, or Kevlar. The use of fibers and resin systems is based on their application. Fibers are known to have excellent mechanical properties and sometimes, high thermal and electrical conductivities. Therefore, when they are put together with the resin system, the resulting composites will have superior mechanical, thermal and electrical properties, mostly with the plane of continuous fiber reinforcements (i.e., in-plane properties), such as the wood laminates. One of the main disadvantages of composite laminates is poor out-of-plane strength through the thickness direction (i.e., interlaminar strength) of the laminate. This could lead to delamination of laminates which is a very common problem in aerospace industry. There are several ways to solve this problem, one unique solution is to use carbon nanotubes in between the laminae and micro-fiber filaments. Carbon nanotubes are nano scaled materials with very high aspect ratio and very high mechanical, thermal, and electrical properties. From our previous research investigations, it was found that helical carbon nanotubes performs better than the straight carbon nanotubes, due to the interlocking mechanism of Heli-coil geometry nanotubes. The interlaminar strength of a composite laminate can be found by conducting flexural test (ASTM D790) and short-beam strength test (ASTM D2344). In this research three different types of glass fiber reinforced epoxy laminates were made per ASTM standard. One without helical carbon nanotubes, the other two with two different load weight percentages of helical carbon nanotubes mixed in epoxy resin system. Test coupons were cut and tested per ASTM D2344. The results showed considerable improvements in short-beam strength of samples with helical carbon nanotubes when compared against samples without helical carbon nanotubes. All the failure modes were interlaminar shear per ASTM D2344 which indicates that the helical carbon nanotubes strongly hold the laminae together and thereby delaying the failure of the composite laminates.