Aerospace Engineering Doctoral Defense

Multiscale Analysis of Nanocomposites and their use in Structural Level Applications

School for Engineering of Matter, Transport and Energy

Zeaid Hasan

Advisor: Dr. Aditi Chattopadhyay

abstract

This research focuses on the benefits of using nanocomposites in aerospace structural components to prevent or delay the occurrence of unique composite failure modes such as delamination. Analytical, numerical and experimental analyses are conducted in order to provide a comprehensive understanding of how carbon nanotubes (CNTs) will provide the additional structural integrity when using them in specific hot spots within the structure. A multiscale approach is implemented to determine the mechanical and thermal properties of the nanocomposites which are used in detailed finite element models to analyze T and Hat section stringers against interlaminar failures. The delamination that initiates between the tow filler and the bondline between the stringer and skin is the locations of interest. Both locations are considered to be hot spots in such structural components, and failure tends to initiate from those locations. In this research the use of nanocomposites is investigated as an alternative to traditional methods of suppressing delamination. The stringer is analyzed under different loading conditions and assuming different defects in the structure. Initial damage is detected via the virtual crack closure technique implemented in the finite element analysis and is considered to be the characteristic variable to compare the different behaviors in this study.

Experiments are conducted in support of this research. Initially an experiment is conducted to test T section skin/stringer specimens under pull-off loading, replicating those used in composite panels as stiffeners. Two types of designs are considered: one using pure epoxy to fill the tow region and another that used nanocomposite with 5 wt. % CNTs. The response variable in the tests was the initial damage defined as the first drop in the load displacement curve. Detailed analysis is conducted using finite element models to correlate to the experimental data. The correlation between both the experiment and model was satisfactory. Finally, the effect of thermal cure and temperature variation on the behavior of the nanocomposite structure is also studied. It was found that both effects influence the performance of the nanocomposite structure.

July 18, 2014; 10:00 AM; ENGRC 593