1995116861

N95- 23281

Separation of Crack Extension Modes in Composite Delamination Problems

by

Jack Beuth
Assistant Professor
Department of Mechanical Engineering
Carnegie Mellon University
Pittsburgh, PA 15213

This work concerns fracture mechanics modeling of composite delamination problems. In order to predict delamination resistance, an applied stress intensity factor, K, or energy release rate, G, must be compared to a mode-dependent critical value of K or G from experiment. In the interfacial fracture analysis of most applications and some tests, the mode of crack extension is not uniquely defined. It is instead a function of distance from the crack tip due to the oscillating singularity existing at the tip. In this work, a consistent method is presented of extracting crack extension modes in such cases. In particular, use of the virtual crack closure technique (VCCT) to extract modes of crack extension is studied for cases of a crack along the interface between two in-plane orthotropic materials.

Modes of crack extension extracted from oscillatory analyses using VCCT are a function of the virtual crack extension length, Δ. Most existing efforts to obtain Δ-independent modes of crack extension involve changing the analysis in order to eliminate its oscillatory nature. One such method involves changing one or more properties of the layers to make the oscillatory exponent parameter, ε, equal zero. Standardized application of this method would require consistent criteria for identifying which properties can be altered without changing the physical aspects of the problem. Another method involves inserting a thin homogeneous layer (typically referred to as a resin interlayer) along the interface and placing the crack within it. The drawbacks of this method are that it requires increased modeling effort and introduces the thickness of the interlayer as an additional length parameter.

The approach presented here does not attempt to alter the interfacial fracture analysis to eliminate its oscillatory behavior. Instead, the argument is made that the oscillatory behavior is non-physical and that if its effects were separated from VCCT quantities, then consistent, Δ-independent modes of crack extension could be defined. Knowledge of the near-tip fields in a planar orthotropic material interfacial fracture analysis is used to determine the explicit Δ dependence of VCCT parameters. Once this Δ dependence is determined, energy release rates are defined with this Δ dependence factored out. This modified VCCT method is applied to results from two finite element test cases. It is shown that , as predicted, Δ-independent modes of crack extension result.

The modified VCCT approach shows potential as a consistent method of extracting crack extension modes. It uses the same information from a finite element analysis (i.e. nodal forces and displacements) as the traditional VCCT method does. The Δ-independent modes extracted using the modified VCCT approach can also be used as guides to test the convergence of finite element solutions.