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SIMULATION OF ACOUSTIC EMISSION WAVE PROPAGATION IN THERMAL PROTECTION SYSTEM WITH PLAIN WEAVE C/SIC COMPOSITE

Abstract

Carbon fiber rein-forced silicon carbide (C/SiC) composites have made it into several high-temperature aerospace applications, like nozzle extensions, combustion chamber components and thermal protection system (TPS) for re-entry. With the considerable applications of C/SiC damage characterization and non-destructive testing (NDT) has become the focus of great concern to researchers. Acoustic Emission (AE) is defined as the class of phenomena whereby transient elastic wave is generated by the rapid release of energy from a localized source of damage. Since most of the damage information including cracking time, location and severity is contained in AE signal, AE is probably the most sensitive NDT. However, when the AE wave propagates in C/SiC composite structures, the signals may be significantly affected by multi-mode, dispersion, energy attenuation and other factors caused by the complex propagation path. An objective of this study is to reveal pattern of AE wave propagation in plain weave C/SiC composite by finite element analysis. The simulation of AE waveforms resulting from failure during mechanical loading of C/SiC structures is investigated using a finite element simulation approach. For this investigation we focus on the dominant failure mechanisms in fiber reinforced structures consisting of matrix cracking, fiber breakage and fiber-matrix interface failure. To simulate the failure process accurately, firstly this paper proposed a novel AE source model that is based on the microscopic source geometry and micromechanical properties of fiber and resin, where the stepped load and a dipole force is applied to generate the release of power loss. Secondly, the propagation of the AE wave is described using this macroscopic three-dimensional model geometry which includes contributions of reflections from the specimen boundaries. To enhance the understanding of correlation between macroscopically detectable acoustic emission signals

and microscopic failure mechanisms different source excitation times, crack surface displacements and displacement directions are considered in the simulation. Finally, the wavelet transform is adopted to process the AE signals and extract the time-frequency characteristics. It is showed that the microscopic elastic properties of the AE source have significant influence on the excitation of distinct AE wave modes. This can be used to distinguish between failure mechanisms like fiber breakage or resin fracture in fiber reinforced materials. The results demonstrate that the application of these methods help support in-flight as well as post-flight impact analysis by identifying failure modes and cracking of fibers from flexural and/or extensional mode acoustic signals in TPS.