Theoretical and Experimental Study of Generation Mechanisms

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Abstract

The aerospace industry is beginning to use advanced composite materials for primary load bearing structures and their failure mechanisms must be better understood to predict their behavior in service. The Combined Loads Tests (COLTS) facility is being constructed at the NASA Langley Research Center to characterize these failure mechanisms. Laser-based ultrasonic NDE can monitor the samples *during* dynamic loading without interfering with the structural tests. However, the constraints of implementing laser ultrasound in a structures laboratory reduce the efficiency of the technique. The system has to be "eye safe" because many people will be present during the structural tests. Consequently, laser light has to be delivered through fiber optics and a significant amount of light is lost. Also, the nature of the composite materials makes laser ultrasonic inspection difficult. The composites of interest are formed from woven layers that are stitched through the laminate thickness and bound in a resin matrix. These materials attenuate ultrasound strongly and exhibit a high degree of scattering.

Generation mechanisms in laser-based ultrasound must be better understood to improve generation efficiency and consequently improve the signal-to-noise ratio. Although some experimental and theoretical studies have been conducted to characterize generation mechanisms, more extensive work is needed for composite materials. Specifically, we are concerned with generation mechanisms in thick, stitched composite structures. We describe a theoretical and experimental investigation of laser-generated ultrasound in complex composite materials. We first develop a mathematical model describing the thermoelastic generation of ultrasound in a general anisotropic material. We then present a wide range of experimental data investigating the effects of laser and material parameters on the generated ultrasound. We specifically consider the relationship between laser pulse width, laser wavelength, and material composition. Finally, we compare this data to our mathematical model.