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AN IMPROVED HEALTH MONITORING SYSTEM FOR THE DETECTION OF IMPACT DAMAGE IN COMPOSITE STRUCTURES

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1 Introduction

The paper is concerned with the detection and characterization of impact damage in a stiffened woven composite panel using both high frequency Lamb waves and low frequency vibrations.

The complexity of modern aircraft structural systems combined with their high operational reliability and safety needs, have brought to an increasing interest in new approach for structural health monitoring and damage analysis. Composite materials are finding increasing use as primary structural components in many aerospace applications due to their high strength-to-weight ratio and other properties that make them preferable to more conventional engineering materials. Laminated composite materials often contain a variety of hidden internal flaws [1]. They occur during manufacturing and processing of the materials or while the structure is subjected to service loads. A major concern in these structures is the growth of undetected hidden damage, caused by fatigue and foreign object's impact, that can reach a critical size during service. A continuous health monitoring system, sensitive to quite small changes of the structural integrity and able to perform an early detection of such damages is a key element to foresee the remaining operative life and recommend maintenance strategies.

Although the geometric and material complexities of the structure present practical difficulties in the direct analysis of both wave propagation and modal vibration data using theoretical constructs, the proposed method can be applied to any structure regardless its geometric and material complexities [2].

2 Structural Health Monitoring Approaches

For both Lamb waves and low frequency vibrations, an array of sensors (broadband and narrowband) located in critical areas is used to record and evaluate changes in certain characteristics of the Lamb waves and the structure's global dynamical properties with the appearance of new damage or the growth of existing flaws. A damage index, calculated from the signals recorded under different damage states, is used as an estimator of the location and severity of the damage [3]. Since the measurements can be affected by errors or environmental noise that could affect damage detection, a statistical analysis has also been carried out in order to detect damage with some degree of confidence. An improved ultrasonic and vibration test setup, consisting of high fidelity sensor arrays, laser scanner vibrometer, data acquisition boards, signal conditioning and dedicated software has been implemented. The health monitoring system presented is characterized by a low computational effort and high reliability level, able to treat, in real time, the acquired data and to identify the presence of a damaged structural area. The main advantage of the method is that it is relatively insensitive to environmental noise and structural complexities as it is based on the comparison between two adjacent dynamical states of the structure and the baseline for comparison is continuously updated to the previous state.

References

[1] Abrate S. "*Impact on Composite Structures*". Cambridge University Press, New York, 1988.

[2] Mal A.K., Ricci F., Banerjee S. "A Conceptual Structural Health Monitoring System Based on Wave Propagation and Modal Data". *Structural Health Monitoring – an International Journal* – SAGE Publications, September 2005 4(3), 283-293

[3] Banerjee S., Ricci F., Monaco E., Lecce L., Mal A.K. "Autonomous Impact Damage Monitoring in a Stiffened Composite Panel". *Journal of Intelligent material Systems and Structures* – Sage Publications, in press.