STRUCTURAL HEALTH MONITORING USING MULTIPLE PIEZOELECTRIC SENSORS AND ACTUATORS

by

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ABSTRACT

A piezoelectric impedance-based structural health monitoring technique was developed at the Center for Intelligent Material Systems and Structures. It has been successfully implemented on several complex structures to detect incipient-type damage such as small cracks or loose connections. However, there are still some problems to be solved before full scale development and commercialization can take place. These include: i) the damage assessment is influenced by ambient temperature change; ii) the sensing area is small; and iii) the ability to identify the damage location is poor. The objective of this research is to solve these problems in order to apply the impedance-based structural health monitoring technique to real structures.

First, an empirical compensation technique to minimize the temperature effect on the damage assessment has been developed. The compensation technique utilizes the fact that the temperature change causes vertical and horizontal shifts of the signature pattern in the impedance versus frequency plot, while damage causes somewhat irregular changes.

Second, a new impedance-based technique that uses multiple piezoelectric sensor-actuators has been developed which extends the sensing area. The new technique relies on the measurement of electrical transfer admittance, which gives us mutual information between multiple piezoelectric sensor-actuators. We found that this technique increases the sensing region by at least an order of magnitude.

Third, a time domain technique to identify the damage location has been proposed. This technique also uses multiple piezoelectric sensors and actuators. The basic idea utilizes the pulse-echo method often used in ultrasonic testing, together with wavelet decomposition to extract traveling pulses from a noisy signal. The results for a one-dimensional structure show that we can determine the damage location to within a spatial resolution determined by the temporal resolution of the data acquisition.

The validity of all these techniques has been verified by proof-of-concept experiments. These techniques help bring conventional impedance-based structural health monitoring closer to full scale development and commercialization.

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