FINITE ELEMENT MODELLING AND SIMULATION OF MACRO FIBER COMPOSITE ACTUATED LAMINATED PLATES WITH APPLICATION TO STRUCTURAL HEALTH MONITORING

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ABSTRACT

Structural health monitoring (SHM) is a process that aims at detecting, locating and quantifying damage in structures at an early stage in order to avoid unexpected failure. SHM methods that are able to find changes in structural characteristics due to damage can be defined as damage identification methods. Throughout the literature, there is an immense range of techniques for detecting and identifying damage, strain-based SHM methods being of the most popular ones amongst them. As the name of the method suggest, the principal parameter employed for identification of damage in structure is the change in strain. In practical applications, the strain-based method can be performed in two ways. In one way, the strain distribution of the intact structure is measured as the baseline in advance. Damage can be then detected when the current strain measurement significantly diverges from the baseline. In the other way, a theoretical model for the structure is established and analyzed to acquire the strain data corresponding to various structural states. Comparing the data to the actually acquired ones directly or with criterions, the structural integrity is evaluated. The key issue lies in this methodology is how to make the model exact enough especially for the complex real-life structure. Accurate FE model that represents relevant physical processes of the actual structure may be used for simulation and prediction of structural behaviour under different loading conditions.

This paper presents development and validation of a linear electromechanically coupled finite element model for piezoelectric MFC actuation of the carbon fibre reinforced plastic (CFRP) composite plate. The FE model of the laminated plate with attached piezoelectric P1 patches was built based on linear piezoelectric constitutive equations by using the commercial FE software ANSYS. In the first stage, proposed concept is validated by deflection analysis of a simple aluminium cantilever beam with two bonded MFC patches where one is acting as an actuator and the other remaining passive. The obtained FE model prediction values of the beam tip deflection were compared to the numerical and experimental results reported by other authors. In the second stage, numerical model was extended for the cross-ply laminated composite plate with bonded MFC actuator and a harmonic analysis of were performed. A good agreement between the predicted dynamic strain values and the experimental measurements was observed.