Finite Element Model Calibration of Sandwich Structure Based on Mixed Numerical Experimental Technique

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ABSTRACT

In this paper, a new finite element (FE) model calibration method for sandwich structure based on the Mixed Numerical Experimental Technique (MNET) is proposed. The general idea of the MNET is that instead of measuring the property of interest, indirect procedures measure a number of related quantities and derive the unknown property from the experimental values of these quantities. In the MNET, a numerical model is built to relate the physical property of interest to the measured quantities. Then the inverse problem is used to derive a number of model parameters from the response of system to a particular input. The inverse problem is solved by minimizing the error function that expresses the difference between the numerical model response and the experimentally measured one. In this study, instead of the direct minimisation of the response discrepancy, the experiment design and the response surface method is proposed to solve the inverse problem.

The structure considered in this study is a sandwich panel composed of two laminated carbon fibre reinforced plastic (CFRP) face sheets and aluminium alloy pyramidal truss core. Finite element model of the sandwich panel is built by using the commercial FE software ABAQUS. Four independent engineering constants of a single transversally isotropic layer of CFRP face sheets and two engineering constants of the aluminium core are unknown parameters in finite element model and need to be identified for model calibration purposes. The modal frequencies of the sandwich panel is considered the response of the system to be compared between measured and simulated data. Experimental eigenfrequencies and corresponding mode shapes of the sandwich panel are measured by using a POLYTEC PSV-400-B Scanning Laser Vibrometer. Numerical eigenfrequencies are obtained by performing finite element calculations in sample points derived by Latin Hypercube experiment design. Each sample point represents a unique engineering constant configuration in the FE model of the sandwich panel. By taking the unknown parameters as inputs and the calculated eigenfrequencies as outputs, response functions in the mathematical form describing the relationship between them are obtained by means of response surface method. The genetic algorithm (GA) is employed to solve the minimisation of the response discrepancy where the response functions instead of FE calculations are used to obtain the numerical modal frequencies. Robustness and efficiency of the proposed FE model calibration method is assessed by comparing the experimental eigenfrequencies with the numerically ones calculated in the point of optima (using the calibrated engineering constants). A good agreement between them is observed indicating a successful FE model calibration.

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