Structural Damage Detection Method Based on Decomposition of the Operating Deflection Shapes

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Abstract: Full-field measurement techniques such as the scanning laser Doppler vibrometer (LDV) and the electronic speckle pattern interferometry systems can provide a dense and accurate vibration measurement on structural operating deflection shape (ODS) on a relatively short period of time. The possibility of structural damage detection and localization using the ODS looks likely more attractive than when using traditional measurement techniques which address only a small number of discrete points. This paper discusses the decomposition method of the structural ODSs in the time history using principal component analysis to provide a novel approach to the structural health monitoring and damage detection. The damage indicator is proposed through comparison of structural singular vectors of the ODS variation matrixes between the healthy and damaged stages. A plate piece with a fix-free configuration is used as an example to demonstrate the effectiveness of the damage detection and localization using the proposed method. The simulation results show that: (1) the dominated principal components and the corresponding singular vectors obtained from the decomposition of the structural ODSs maintain most of all vibration information of the plate, especially in the case of harmonic force excitations that the 1st principal component and its vectors mostly dominated in the system; (2) the damage indicator can apparently flag out the damage localization in the case of the different sinusoidal excitation frequencies that may not be close to any of structural natural frequencies. The successful simulation indicates that the proposed method for structural damage detection is novel and robust. It also indicates the potentially practical applications in industries.

Key words: damage detection, decomposition, operating deflection shape (ODS), principal component

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