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Damage identification in composite plates using two-dimensional B-spline wavelets

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ABSTRACT

In this paper the construction of general order two-dimensional B-spline wavelets was presented and applied for damage identification in polymeric composite plates. At the very beginning the algorithm of one- and two-dimensional discrete wavelet transform and formulation of one- and two-dimensional B-spline wavelets with examples were presented. The fully clamped square layered composite plate was modeled using finite element-based software. Estimated natural modes of vibration with various damage configurations were analyzed using the two-dimensional sixth-order B-spline wavelet, and the method of damage identification was presented. The effective damage identification is based on the evaluation of the singularities in horizontal, vertical and diagonal details coefficients. Results obtained based on the numerical data were verified experimentally. Research results show the effectiveness of B-spline wavelets in application to the diagnostics and structural health monitoring.

1. Introduction

Wavelet analysis is a comparatively new methodology which has found wide applications in numerous theoretical and engineering problems. The popularity of wavelet analysis is reasoned by some nice properties of wavelets and the possibility of multiresolution analysis. The multiresolution analysis is possible using discrete wavelet transform (DWT), and therefore the main interest in practical means is in the investigation of compactly supported wavelets. The development of compactly supported wavelets was started by Daubechie's [1], Cohen and Feauveau [2]. The investigation on spline and B-spline wavelets was introduced by Chui and Wang [3]. When the B-spline wavelets were formulated many applications of them were rightly appeared.

Uppermost B-spline wavelets found an application in numerical methods thanks to their adaptivity and other properties, such as compact support and semi-orthogonality. They were used for numerical solving of partial differential [4], integral [5,6] and integro-differential [7] equations, where the wavelet scaling function was used as the differential operator. Using Lakestani's method, the solution of the above-mentioned equations is reduced to the solution of algebraic equations. B-spline wavelets also found an application in many other branches. They were used in mammography [8], finite element method for the construction of new types of elements [9], image compression and filtering [10] etc.

Wavelets and wavelet analysis are found to be useful in signal processing. Many authors apply wavelet analysis for detecting singularities of the signal, but such an analysis also allows the detection of abnormalities in regular signals. It is very useful for the analysis of transient signals, e.g. machine run-up. Research of the application of DWT to rotating machinery condition diagnostics was presented by Timofiejczuk [11]. Wavelet analysis is also applicable in structural

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