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High Sensitivity Crack Detection and Locating with Optimized Spatial Wavelet Analysis

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Abstract : In this study, a spatial wavelet-based crack localization technique for a thick beam is presented. Wavelet scale in spatial wavelet transformation is optimized to enhance crack detection sensitivity. A windowing function is also employed to erase the edge effect of the wavelet transformation, which enables the method to detect and localize cracks near the beam/measurement boundaries. Theoretical model and vibration analysis considering the crack effect are first proposed and performed in MATLAB based on the Timoshenko beam model. Gabor wavelet family is applied to the beam vibration mode shapes derived from the theoretical beam model to magnify the crack effect so as to locate the crack. Relative wavelet coefficient is obtained for sensitivity analysis by comparing the coefficient values at different positions of the beam with the lowest value in the intact area of the beam. Afterward, the optimal wavelet scale corresponding to the highest relative wavelet coefficient at the crack position is obtained for each vibration mode, through numerical simulations. The same procedure is performed for cracks with different sizes and positions in order to find the optimal scale range for the Gabor wavelet family. Finally, Hanning window is applied to different vibration mode shapes in order to overcome the edge effect problem of wavelet transformation and its effect on the localization of crack close to the measurement boundaries. Comparison of the wavelet coefficients distribution of windowed and initial mode shapes demonstrates that window function eases the identification of the cracks close to the boundaries.

Keywords : edge effect, scale optimization, small crack locating, spatial wavelet
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