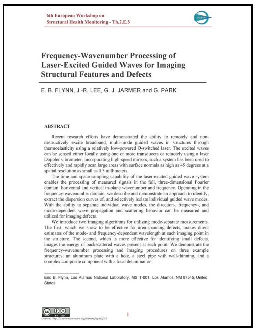

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Frequency-Wavenumber Processing of Laser-Excited Guided Waves for Imaging Structural Features and Defects

E. B. FLYNN, J.-R. LEE, G. J. JARMER and G. PARK

ABSTRACT

Recent research efforts have demonstrated the ability to remotely and non-destructively excite broadband, multi-mode guided waves in structures through thermoelasticity using a relatively low-powered Q-switched laser. The excited waves can be sensed either locally using one or more transducers or remotely using a laser Doppler vibrometer. Incorporating high-speed mirrors, such a system has been used to effectively and rapidly scan large areas with surface normals as high as 45 degrees at a spatial resolution as small as 0.5 millimeters.

The time and space sampling capability of the laser-excited guided wave system enables the processing of measured signals in the full, three-dimensional Fourier domain: horizontal and vertical in-plane wavenumber and frequency. Operating in the frequency-wavenumber domain, we describe and demonstrate an approach to identify, extract the dispersion curves of, and selectively isolate individual guided wave modes. With the ability to separate individual wave modes, the direction-, frequency-, and mode-dependent wave propagation and scattering behavior can be measured and utilized for imaging defects.

We introduce two imaging algorithms for utilizing mode-separate measurements. The first, which we show to be effective for area-spanning defects, makes direct estimates of the mode- and frequency-dependent wavelength at each imaging point in the structure. The second, which is more effective for identifying small defects, images the energy of backscattered waves present at each point. We demonstrate the frequency-wavenumber processing and imaging procedures on three example structures: an aluminum plate with a hole, a steel pipe with wall-thinning, and a complex composite component with a local delamination.

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Содержание