Characteristics of Lamb Wave Dispersion in Carbon Fiber Reinforced Polymer Laminates with Arbitrary Layup Configurations

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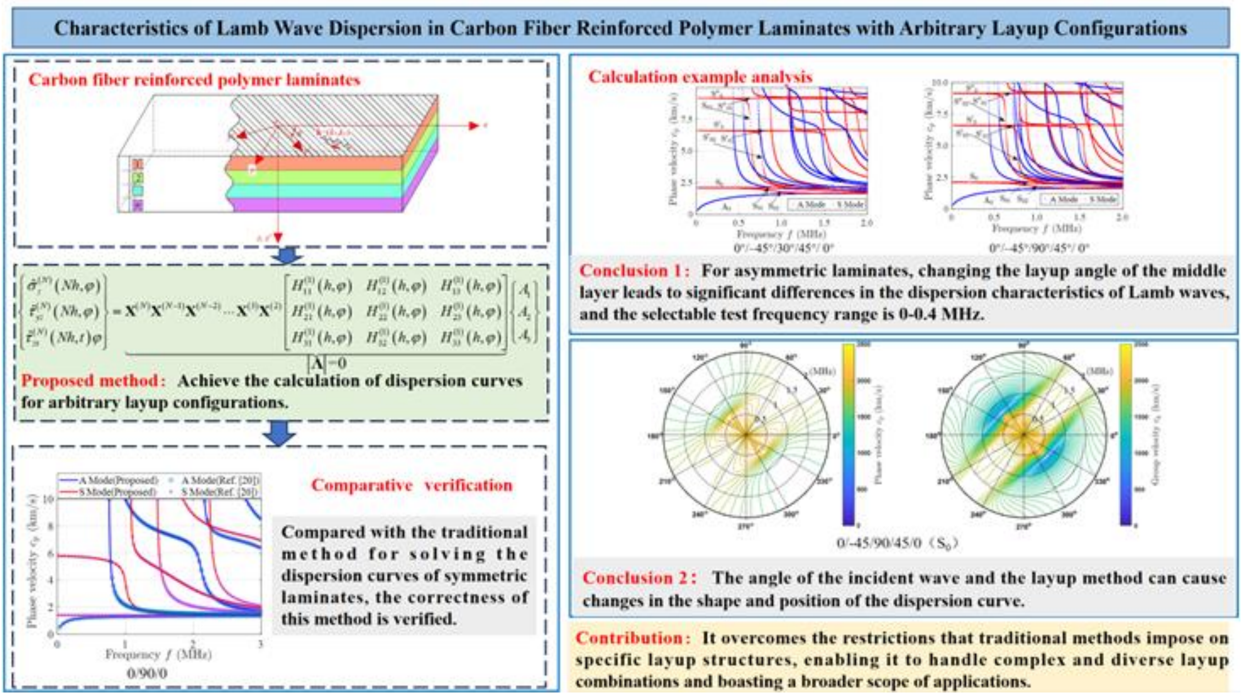
Abstract

This paper proposes a method for analyzing the dispersion characteristics of Lamb waves in carbon fiber reinforced polymer (CFRP) with arbitrary layup configurations, providing theoretical support for structural health monitoring of composite materials. Based on the three-dimensional elasticity theory and transfer matrix method, a dispersion characteristic model suitable for arbitrary layup form is constructed. The dispersion curves are solved by a semi-analytical method, revealing the influence of layup angles and fiber directions on the propagation characteristics of Lamb waves. The research results show that the non-uniform distribution of the material stiffness matrix caused by asymmetric layup significantly alters the dispersion characteristics, specifically manifested as enhanced directional dependence of phase velocity, increased complexity of mode conversion, and nonlinear distortion of the group velocity-frequency curve. The low-frequency S0 mode is suitable for long-distance monitoring due to its attenuation characteristics, while the high-frequency A0 mode and higher-order modes are difficult to separate and extract due to significant dispersion effects. The method proposed in this paper provides a theoretical framework for the analysis of Lamb wave dispersion characteristics in carbon fiber reinforced polymer with arbitrary layup configurations, which is of great significance for promoting the development of structural health monitoring technology for composite materials.

Table of Contents



Innovative Description: An analysis method applicable to any layer configuration has been proposed, revealing the unique law of Lamb wave dispersion characteristics under asymmetric layers.