

On the Peculiarities of Lamb Wave Dispersion in Multilayer Structures

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Abstract

Analyzing different approaches to structural monitoring of composite materials, the use of Lamb waves is an interesting method due to its low cost, online monitoring and high sensitivity. Structural analysis based on Lamb waves in heterogeneous materials requires fundamental knowledge of the behavior of waves in such materials. Recently, Lamb wave methods have been used for simultaneous examination of a large area of composite structures. However, such methods are more complicated than traditional ultrasonic testing, since the waves have dispersion characteristics. Experimentally measured group velocities of waves in composite materials with anisotropic characteristics do not coincide with the theoretical group velocities calculated using the Lamb wave dispersion equation. This discrepancy arises from the fact that in anisotropic materials there is an angle between the direction of the group velocity and the direction of the phase velocity. The author investigated the propagation characteristics of Lamb waves in composites with emphasis on group velocity and characteristic wave curves. A method was proposed for symmetric laminates, which consists in imposing boundary conditions on the midplane and the top surface to separate symmetric and antisymmetric wave modes. The dispersion and anisotropic behavior of Lamb waves in two different types of symmetric laminates was theoretically investigated in more detail. It is also shown that only the fundamental modes are not characterized by a cutoff frequency, which indicates the interaction of the fundamental modes with the composite layers in the low-frequency range. A high level of dispersion of the group velocity of the SH₀ and S₀ modes is revealed. The author concluded that in isotropic laminates, the dispersion during the propagation of the wave process is characteristic of symmetric modes. It is shown that the frequency dependence of the group velocity of Lamb waves of laminar composites can be represented in polynomial form.

Keywords: Lamb wave; Group velocity dispersion; Laminar composites