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Analysis of Individual Attenuation Components of Ultrasonic Waves in Composite Material Considering Frequency Dependence

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Abstract

In light of the rapid increasing demand for high-precision ultrasonic technologies for damage detection in composite structures, it is necessary to give a further study on the ultrasonic attenuation characteristics, with consideration of the combined effects of material anisotropy and viscoelasticity, and the frequency characteristics of the individual attenuation component. In the present paper, based on the time-domain finite element analysis of ultrasonic wave propagation in a two-layered fiber/matrix composite material, a new method is presented. In the method, by means of extracting the individual attenuation components (viscoelastic attenuation, scattering attenuation due to interface defects, and energy dissipation at the interface) from the overall attenuation respectively, the variation behavior of them with material anisotropy and viscoelasticity, and incident wave frequency, are quantitatively evaluated. The change of proportion of individual attenuation components in overall attenuation under different conditions are also investigated. From the results, the energy loss at the interface is always a major part in ultrasonic attenuation characteristics. Each attenuation component shows frequency dependence, especially the viscoelastic attenuation and energy dissipation at the interface. The simulation results also clarified the detailed effect mechanism of material viscoelasticity and anisotropy on the attenuation characteristics, which will encourage the further development of attenuation measurements for damage detection in composite structures.

Keywords

A, Layered structures; B, Anisotropy; C, Finite element analysis (FEA); D, Ultrasonics

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