FUNDAMENTAL LAMB WAVE MODE DISPERSION CHARACTERISTICS IN COMPOSITES

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The propagation of elastic waves in fiber composites has been the subject of much research in recent years. It should be noted that the non-isotropic properties of fiber-reinforced composites can seriously complicate the calculation of the wave propagation kinetics [1]. Typically, these materials consist of brittle, highly rigid fibers embedded in a matrix of more ductile material that binds the fibers together and acts as a load-transfer medium [2]. The methodology for describing the general problem of elastic waves consists of using various approximations. An example of such methods is the theory of "effective modulus", in which the approximate constants of a composite material are a geometrically weighted average of the component properties. A disadvantage of such a methodology is the limited applicability of effective modulus theories to dynamic loading [3]. A model developed to account for dynamic effects must reflect the influence of microstructure and anisotropy.

The second example of a fairly successful method is the theory of "effective stiffness". In this theory, a real composite is transformed into a homogeneous continuum of higher order with a fixed microstructure. The basic postulates of the composite elastic dynamics model are the provisions of the theory of mixtures [4]. The composite components are distributed non-isotropically in space and are subject to individual deformations. The method of weakly interacting continua offers an alternative procedure for modeling the response of composites, where, in particular, a rational construction of the momentum of the mixture and the term of the constitutive relation is specified. This theory leads to simple equations of wave propagation, which contain the full influence of the microstructure. The study of the acoustic properties of heterogeneous and anisotropic materials is driven by their increasing use in applications requiring high stiffness-to-weight ratios. Ultrasonic non-destructive evaluation is one of the useful tools to ensure the structural integrity of fiber composites. The most complete theoretical description of the wave propagation characteristics in a composite material allows, in turn, to optimize ultrasonic testing experiments on laminar composites.

The objective of this study was to describe the kinetics of plate (Lamb) waves in loaded unidirectional, fiber composite materials, where the direction of wave propagation coincides with the fiber axis. In addition, the ultrasonic reflectivity properties of the composite plate are derived, from the behavior of which it is possible to draw The propagation characteristics of Lamb waves are due to the ultrasonic reflectivity properties of the composite.

The basic model for the calculation in this method was the case of an acoustic wave incident on a fiber-reinforced composite plate. It was assumed that the laminated composite plate consisted of small, almost parallel, circular fibers arranged in an approximately hexagonal lattice. The coordinate system was chosen so that the abscissa axis coincided with the mean direction of the fibers, and the applicate axis was perpendicular to the lateral planes of the sample. The basic assumption was also that the plate had a sufficiently large extension in the direction of the ordinate axis. The plan of the calculation method was to approximate the highly structured composite by a continuum, preserving the corresponding elastic anisotropy, and to analyze the ultrasonic reflection from such a plate to study the behavior of Lamb waves in these materials.

The first step in solving the field equations at the lateral surfaces of the specimen was to impose mechanical continuity conditions. Due to the complex microstructure of the composite sections, continuity conditions exist at both the macroscopic and microscopic scales. The boundary conditions at the macroscale must be satisfied first, while at the microscale there are additional conditions at the matrix-fiber interfaces. An alternative to obtaining exact solutions of the field equations was to formulate an approximate analysis in which the composite plate is replaced by a homogeneous, transversely isotropic medium. In performing this approximation, micro continuity conditions will be used.

The basic mathematical model of the kinetics of Lamb wave propagation in laminated composites was the wavelet transform model. The main group velocities of Lamb waves were calculated for a sound wave whose particle motion is limited by a plane perpendicular to the main cross-section of the sample. It was found that the average values of longitudinal wave velocities critically depended on the volume fraction of the fiber. The calculation results indicate the closeness of the phase velocities of the mode attenuation for symmetric and antisymmetric modes of the lowest order.

References:

1. Yamamoto, N., de Villoria, R. G., & Wardle, B. L. (2012). Electrical and thermal property enhancement of fiber-reinforced polymer laminate composites through controlled implementation of multi-walled carbon nanotubes. Composites Science and Technology,72(16), 2009-2015. https://doi.org/ 10.1016/j.compscitech.2012.09.006
2. Sharma, H., Kumar, A., Rana, S., Sahoo, N. G., Jamil, M., Kumar, R., ... & Abbas, M. (2023). Critical review on advancements on the fiber-reinforced composites: role of fiber/matrix modification on the performance of the fibrous composites. Journal of Materials Research and Technology, 26, 2975-3002. https://doi.org/ 10.1016/j.jmrt.2023.08.036

3. Akbas, S. D., Numanoglu, H. M., Akgöz, B., & Civalek, Ö. (2022). Application of Newmark Average Acceleration and Ritz Methods on Dynamical Analysis of Composite Beams under a Moving Load. Journal of Applied and Computational Mechanics, 8(2), 764-773. https://doi.org/ 10.22055/jacm.2022.39345.3393
4. Gao, S. L., & Mäder, E. (2006). Jute/polypropylene composites I. Effect of matrix modification. Composites science and technology, 66 (7-8), 952-963. https://doi.org/10.1016/j.compscitech.2005.08.009

USING PARAMETRIC RESONANCE TO CREATE EFFICIENT POWER SUPPLIES FOR UNMANNED VEHICLES

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Unmanned aerial, ground and marine vehicles are widely used around the world. The movement of these vehicles is provided by engines: internal combustion, electric and their combination. The use of electric engines for unmanned vehicles allows to reduce their cost, eliminate heat signature, reduce sound trace, eliminate exhaust gases, etc. For unmanned aerial vehicles (UAV) like multicopters there is practically no alternative to electric propulsion because of the ease of their control. Ease of operation, high reliability and low cost have become a decisive factor for manufacturers of electrically powered UAVs [1, p. 13]. Today, the bottleneck for all types of unmanned vehicles is their poor power capability [2, p. 677]. This problem is most acute for unmanned aerial vehicles, where the mass of the structure is one of the main indicators [3, p. 67]. This trend directs specialists to search for efficient UAV power supplies. In UAV design, batteries and secondary power supplies (SPUs) are the most massive. However, the power source, as well as the type of propulsion system that provides flight performance, is in direct dependence on the entire power system of the unmanned vehicle. Consequently, adding batteries to the system does not increase flight time or payload. The only way to increase time is to increase the quality of energy conversion, in other words, to increase the specific mass (W/kg) and volumetric specific energy (W/dm3) of the unmanned vehicle. One of the solutions to this problem can be the use of parametric generators, which will allow to provide efficient energy