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DAMAGE DETECTION METHOD FOR LAMINA COMPOSITES

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Introductions. The advantage of using Lamb waves in damage detection is that they are highly sensitive to disturbances in the propagation path, such as a fault or boundary. In addition, Lamb waves can propagate over long distances even in highly attenuating materials such as carbon fiber-reinforced composites [1, 2]. As a result, a wide area can be quickly investigated in experimental studies of, for example, laminated composites. The entire thickness of the laminate can also be related to different Lamb modes. This makes it possible to detect both internal and surface damage. The range of potential damage types that Lamb wave analysis can detect is quite wide. In general, the Lamb wave approach to damage detection is characterized by (the ability to inspect large structures while preserving coating and insulation. In addition, the ability to inspect the entire cross-sectional area of the structure is preserved. The Lamb wave packet-based technique has high sensitivity to multiple defects with high identification accuracy. The analysis of Lamb wave propagation in anisotropic viscoelastic media is quite a challenging task. With very high speed, waves reflected from boundaries can easily hide components scattered by damage in signals. To ensure accuracy, the structure to be tested can be relatively large and with a relatively small detection area. Lamb waves are usually characterized by several wave modes [3]. The dispersion properties of such wave formations are not identical throughout the thickness of the composite, even for the same mode, but in different frequency ranges. Existing methods of both experimental and theoretical studies provide the possibility of identifying damage using Lamb waves for fiber-reinforced composite structures. Lamb waves propagating in composite structures have unique characteristics of dispersion processes.

Aim. Lamb waves, consisting of a superposition of longitudinal and shear modes, are observed in relatively thin laminated composite plates. Their propagation characteristics vary with the angle of entry, excitation, and structural geometry. Lamb waves, consisting of a superposition of longitudinal and shear modes, are observed in relatively thin laminated composite plates. Their propagation characteristics vary with the angle of entry, excitation, and structural geometry [4]. A slightly different approach to structural damage detection is based on the combination of independent component analysis in the time domain. This technique allows the detection of key features from the measured vibration signals. However, with the exception of a few successful applications in fault localization, direct time series analysis is usually unable to isolate information scattered across defects properly from noise in different frequency ranges. In addition, a reference signal is needed for comparison. This paper analyzes a method for detecting mechanical defects in laminated composites using Lamb wave packets.

Materials and methods. The deficiencies of dynamic Lamb wave analysis in the time or frequency domain can be addressed by introducing a packet that combines time information with frequency data. The Lamb wave signal applied with the basic orthogonal function, obtained from the sensor can be transformed into a quadratic expression using the scale of the coordinate and time parameters. Due to the fact that the composite material is generally inhomogeneous, the scattered Lamb waves measured by different actuator-sensor paths can be time-reversed, which is realized by replacing the actuator and sensor and vice versa. In this case, the Lamb wave should propagate from the sensor to the actuator. All these time-reversed wave signals, each of which exhibits a time delay due to the presence of the fault, will converge simultaneously at one point, namely the scattering point (of the fault). The results of applying the equivalent time reversal technique to localize mechanical damage in a composite plate are examined in this work.

Results and discussion. Three-dimensional finite element modeling as well as experimental studies have demonstrated SH modes using models that allow particle motion in all directions. As a characteristic mode, we can mention the propagation of the Lamb SH wave in a medium that is covered with a layer of another material, as in polymer composite laminates. Lamb waves move with the same speed in all directions when propagating in isotropic plates. The Lamb wave front forms a locus of points equivalent to a circle. For non-isotropic materials, in particular for fiber-reinforced composites, the wave speed depends on the direction of propagation. This fact is the reason why the shape of the wave front differs significantly from a circle and is described by the equation of a generalized ellipse with a fixed slope to the axes of the reference system.

Conclusions. The difference in the directions of Lamb wave propagation is described by the retardation profile, which is a function of the reciprocal of the direction-dependent propagation velocity. The lowest order modes (S0, A0 and SH0) behave quite differently in different directions of propagation relative to the 0° fiber, but they all become almost directionally independent in a laminate of quasi-isotropic configuration (e.g., [±45/0/90]s). This variation model based on mechanical stress testing is the most developed model for predicting matrix crack density.

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