Nonlinear Counterpropagating Waves in Inhomogeneous Materials

Arvi Ravasoo

Institute of Cybernetics at Tallinn University of Technology
Akadeemia tee 21, 12618 Tallinn
ESTONIA
e-mail: arvi@ioc.ee

ABSTRACT

Utilization of the data about complex phenomena of nonlinear wave-wave, wave-material and wave-prestress interaction is one of the very promising ways to enhance the methods for ultrasonic nondestructive characterization of different materials. This is illustrated by the analyses of model problems of nonlinear counter-propagation and interaction of two longitudinal waves in materials with complex properties.

The wave-wave interaction is in principle a nonlinear phenomenon. In linear case the superposition of waves occurs. Another nonlinear phenomenon is the wave-prestress interaction. Theoretically, deformation fields evoked in the material by the wave motion and prestress are bounded provided the geometrical nonlinearity of the problem is taken into account. The wave-material interaction is a fundamental phenomenon and this takes place by linear as well as by nonlinear propagation of waves in the material.

Peculiarities of these various interactions are addressed by elaboration of algorithms for ultrasonic nondestructive characterization of materials with prestress [1] and inhomogeneous properties [2]. Specimens (structural elements) with two parallel boundaries are considered. Counterpropagating waves are excited simultaneously on the boundaries of the specimens and the oscillations evoked by these waves are recorded on the same boundaries. The analyses of the profiles of recorded oscillations verify the fact that counter-propagation and interaction of waves enhances the amount of information in boundary oscillations about the properties of the specimen in comparison with the through-transmission technique.

Outcomes are the algorithms for ultrasonic nondestructive characterization of (i) two-parametric inhomogeneous prestress in the specimen (structural element) of the nonlinear elastic material and (ii) essentially changing properties of the functionally graded materials. Nonlinear wave-prestress interaction enables on the basis of boundary oscillations to determine qualitatively the presence and the nature of the prestress and to determine quantitatively the values of prestress parameters. Wave-wave and wave-material interactions are fundamentals for qualitative nondestructive characterization of the type of inhomogeneity (symmetric, asymmetric, etc.) of the properties of functionally graded materials and they enable to distinguish the most relevant property of the material responsible for inhomogeneity.

The research was supported by the Estonian Science Foundation through the Grant No. 7728.

REFERENCES

[1] A. Ravasoo. Non-linear interaction of waves in prestressed material. *Int. J. Non-Linear Mech.*, **42**, 1162-1169, 2007.

[2] A. Ravasoo. Nonlinear waves in Characterization of inhomogeneous elastic material. *Mech. Materials*, **31**, 205-213, 1999.