A model-based optimization approach for ultrasonic transducers for selective guided wave generation in complex media

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Abstract

Guided ultrasonic waves are widely employed in Structural Health Monitoring and Non-Destructive Testing techniques for evaluation of structural state, damage detection and localization. Although potentially attractive due to multiple features that can be possibly used for damage detection, multimodal and dispersive nature of propagation results in substantial complexity of data analysis. In SHM/NDT systems elastic waves are typically excited and acquired by piezoelectric transducers. Apart from signal processing techniques, actuators and sensors play a significant role in damage detection, evaluation and localization problems. Transducers enabling selective wave generation and/or acquisition can significantly facilitate the inspection and diagnostic process.

The presented work is devoted to a semi-analytical optimization strategy for piezoelectric transducers. The method utilizes analytically or semi-analytically calculated spectral characteristics, i.e. dispersion and excitability curves, and a numerical model of a transducer. Assuming a target excitation signal, containing desired frequency components, the resulting displacement field – excited by the transducer - can be calculated effectively. Also, given a goal function, e.g. a selective excitation of a guided wave mode, the stress field exerted by the transducer can be calculated through an inverse problem solution. Also, the transducer shape can be explicitly modeled and its spatial arrangement adjusted in the inverse procedure. The approach makes use of an analytical technique combined with a numerical integration approaches, hence can be effectively used in identification problems. The method formulation, implementation and test cases will be shown.

Keywords: guided waves, transducers design, dispersion curves, optimization, numerical modeling