

A study of frequency dependence in level set-based topology optimization for the design of wave motion converter in an acoustic-elastic coupled system

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Abstract

We present a topology optimization method for the design of a wave motion converter consisting of an elastic medium and air, based on a level set-based boundary expression and the Finite Element Method (FEM), and examine the frequency dependence of the optimal designs. Both acoustic and elastic waves exist in an acoustic-elastic coupled system. Acoustic waves propagate only as longitudinal waves, whereas elastic waves propagate as both longitudinal and transverse waves. A wave motion converter can convert between these types of wave, for example, from longitudinal to transverse waves, and *vice versa*. In general, a displacement oscillation in an elastic medium can be decomposed into longitudinal and transverse components, and obtaining an optimal configuration for a wave converter requires that one of these be maximized. We introduce a unified multiphase (UMP) modeling technique in which Biot's equations, governing equations originally proposed for poroelastic media, are used to represent the acoustic-elastic coupled system [J. Lee et al. (2012)]. In this UMP modeling, expressions of the air and elastic medium regions are implemented by adjusting parameters in the weak form of Biot's equations. Therefore, the interface of the acoustic-elastic coupled system need not be traced during the optimization process, unlike the procedure required in conventional methods. First, the level set-based topology optimization method is discussed [T. Yamada et al. (2010)]. Next, an optimal design problem for a wave motion converter is formulated and an optimization algorithm is constructed using the adjoint variable method, with the FEM used for solving the wave propagation problem and updating the level set function. Finally, two-dimensional design examples in which different frequencies of incident waves impinge upon the wave converter configuration are provided to demonstrate the validity of the proposed method.

Keywords: Topology optimization, Level set method, Acoustic-elastic coupled system, Unified multiphase modeling technique, Wave motion converter

References

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