11th World Congress on Structural and Multidisciplinary Optimisation
07th -12th, June 2015, Sydney Australia

Topology Optimization of Underwater Acoustic Lenses

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Abstract

In this paper, topology optimization of two-dimensional acoustic lenses for an acoustic camera which is used for underwater acoustic imaging is presented by using the phase field method [1]. The resolution of an acoustic image is increased by maximizing sound pressure at the focal region, which makes the beam pattern larger and narrower on the focal plane. The objective for topology optimization is to maximize the acoustic pressure at a specified point inside the acoustic domain for a given frequency, and the constraint is imposed on the material amount of acoustic lenses. Topology optimization of acoustic lenses are obtained as the steady state of the phase transition described by the Allen-Cahn equation. The finite element method is used to solve the Helmholtz equation modelling the wave propagation in the acoustic domain. The advantage of topology optimization compared to other existing optimization methods when it comes to the lens design problem is that creative lens layouts such as multiple lenses or small lens groups can be obtained through the optimization without carefully selecting the initial layout. The effectiveness of the proposed method is verified by applying it for several two-dimensional acoustic lens system design problems.

Reference:
[1] B. Bourdin, A, Chambolle, The phase field method in optimal design, IUTAM Symposium on Topology Design Optimization of Structures, Machines and Materials, 207-215, 2006.