

PROCEEDINGS

A Shape Optimization Approach for 3D Doubly-Periodic Multi-Layered Systems

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ABSTRACT

Acoustic wave propagation has been the subject of many studies in engineering and physics. Researchers have shown an increased interest in recent years in the acoustic scattering of periodic systems, such as phononic crystals and metamaterials [1]. These artificial periodic systems possess some particular acoustic characteristics including noise control, waveguides and negative refraction, which manifest excellent potential applicability in acoustic engineering. Based on the isogeometric acoustic boundary element method (BEM) [2], an efficient shape optimization approach is proposed in this research for three-dimensional doubly-periodic multi-layered systems. The interfaces between different acoustic mediums are infinite doubly periodic surfaces, which can be constructed by open non-uniform rational B-splines (NURBS) surfaces. We develop a periodic isogeometric BEM for the sound field analysis of the doubly-periodic multi-layered system. The sound transmission and quasi-periodic boundary conditions are considered in the proposed method and the Ewald method is employed to accelerate the calculation of periodic green function. By imposing shape perturbation and using the adjoint variable method, the shape derivative formula is derived for the doubly-periodic multiple boundaries. The control points of the NURBS surfaces are selected as the shape design variables, and all shape sensitivities can be calculated by discretizing the shape derivative formula. Finally, the corresponding shape optimization problem is solved by the method of moving asymptotes. Numerical tests validate the accuracy and applicability of the proposed approach.

KEYWORDS

Doubly-periodic multi-layered system; shape optimization; isogeometric boundary element method; shape derivative; adjoint variable method

Funding Statement: This study was financially supported by the National Natural Science Foundation of China (NSFC) under Grant No. 12172350.

Conflicts of Interest: The authors declare that they have no conflicts of interest to report regarding the present study.

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