# A topology optimization framework of damping layer design for minimizing acoustic radiation in unbounded domain

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## Abstract

Optimal design for reducing the sound radiation of vibrating structures is important in many engineering applications. An effective way to reduce the noise and vibration of flexible shell structures is to attach damping materials to the structures. In practical applications, however, it is usually not possible to apply a full-coverage damping layer treatment. The problem of topology optimization of the damping layer thus arises.

Many studies have been devoted to the optimization of structural-acoustical properties of vibrating structures by using different acoustic characteristics as the objective function, including the sound power of interior/exterior sound radiation [1-2] and the sound pressure level [3]. However, the studies on topology optimization of structural-acoustical properties have been mainly devoted to the optimal stiffness and mass properties, while the layout optimization of damping layers attached to the structures has been rarely treated.

In this paper, we present a topology optimization formulation and numerical techniques for the layout optimization of the damping material layer attached to a thin-shell base structure for minimizing the sound pressure at given locations. Here, the structure is assumed to be placed in an acoustic medium with an open boundary. In the topology optimization formulation, an artificial damping model with penalization [4] is employed for suppressing intermediate density values. The damping property of the overall structure is not proportional and thus the real-mode superposition method cannot be applied. Therefore we employ the complex mode superposition method in the state space in the structural vibration analysis. The boundary element method (BEM) is used to predict the sound pressure on the basis of the normal velocity results on the structural surfaces. In this context, the adjoint-variable sensitivity analysis is derived. The optimization problem is then solved with a gradient-based mathematical programming method. Several numerical examples are given to illustrate the validity and efficiency of this approach. The influences of the excitation frequency, the damping coefficients and the reference point positions on the optimal topologies are also studied.

**Keywords**: Topology optimization, damping material, acoustic radiation, boundary element method, sensitivity analysis.

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