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Topology optimization of membrane-type acoustic metamaterial for low frequency sound attenuation

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Abstract

In this paper, topology optimization for the design of membrane-type acoustic metamaterial (MAM) is conducted. The MAM featured membrane structure with rigid concentrated mass at the center, is a metamaterial for low frequency sound attenuation. The low frequency sound attenuation has been a very difficult problem because acoustic energy dissipation is very small at the low frequency range. Traditionally heavy and thick passive systems are required to attenuate the low frequency sound. Recently the MAM has been considered as a promising solution since it has good low frequency sound attenuation performance although it is thin and light. The principle of MAM is using anti-resonance of the sound transmission coefficient existed between in phase and out of phase mode of membrane and rigid mass. At the anti-resonance frequency, total reflection of incident sound pressure is occurred. Previously, the anti-resonance frequency of MAM is simply designed by changing area mass density and location of rigid mass. However for the design of MAM which has desired sound attenuation characteristics such as target anti-resonance frequency and high average sound transmission loss, more systematic method is required. Thus, this paper present a topology optimization procedure for the design of MAM to obtain the desired sound attenuation characteristics such as target anti-resonance frequency and high average transmission loss. The rigid mass distribution is considered as a design variable. For the purpose of controlling rigid mass distribution, the solid isotropic material with penalization (SIMP) model is used. Adjoint variable method (AVM) is used for sensitivity analysis. The result of topology optimization shows good low frequency sound attenuation performance.

References

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