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Band gap tuning based on adjustable stiffness of local resonators

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Abstract: This research explores the feasibility of using a cantilever-type resonator beam to achieve tunable and real-time control of vibration suppression. By varying the center of mass of the attached masses, the bandgap and transmittance response can be significantly impacted. The results suggest potential for improving resonator performance and optimizing metamaterial beams for vibration suppression applications.

Summary:

The method involves analyzing the propagation of acoustic waves through a phononic structure with one, two, and four beams connected to a non-uniform beam-type resonator. The frequency response of the tip of the Euler-Bernoulli beam is monitored to verify the outcomes found in the dispersion curves. The equation of motion is solved using a harmonic input force, with periodic boundary conditions and Floquet periodicity taken into account for accurate results. The study demonstrates the feasibility of using a cantilever-type resonator instead of a lumped mass spring for examining other modes of the resonator and tuning and controlling the bandgap characteristics of the beam in real-time experiments. A simulation is performed using finite element software.

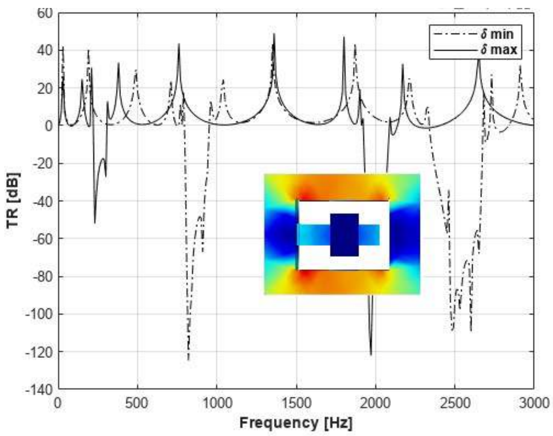

Fig.1. Transmittance responses of the first and second mode of resonator with μ=0.9 for different δ.

By using a cantilever-type resonator instead of a lumped mass spring, it becomes feasible to examine other modes of the resonator. Fig.1 shows the transmittance responses of the first and second mode of the resonator with a high mass ratio of μ=0.9 for different values of resonator center of mass (δ). The second mode is observed in the transverse vibration of the beam, and the attached mass on the resonator material is replaced from PLA to steel to decrease the natural frequency of the resonator to the desired frequency range. The result shows the same behaviour in the second mode as well, and the variation of δ changes the bandwidth and edge of bandgap similar to first mode.

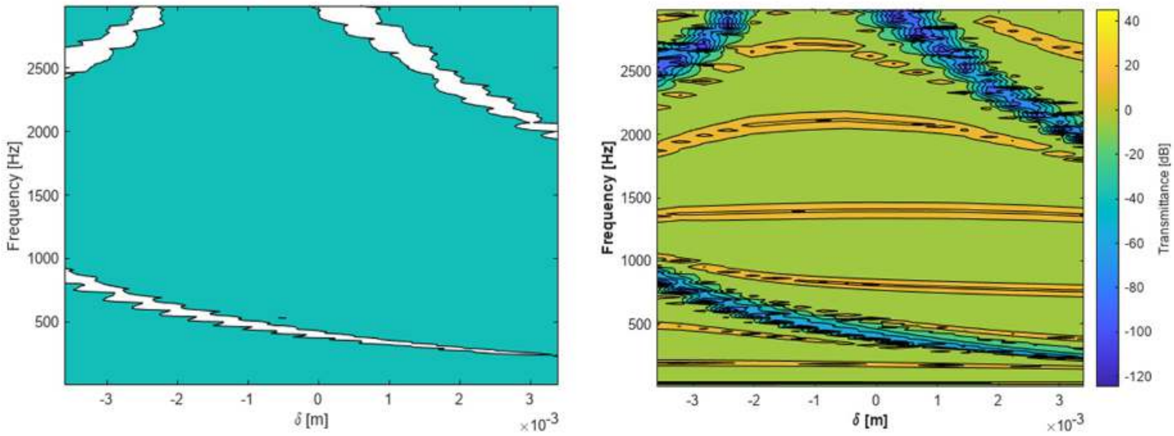

Fig.2. Contour and Image binarization of the transmittance using -40 dB as reference in response to the variation of δ, and μ=0.9.

Fig.2 shows the binary representation of the transmittance contour pattern evolution with changes in δ for a high mass ratio of μ=0.9. The image binary contour of the transmittance for μ=0.9 and -40 dB as reference is shown in Fig.2. The second mode of resonator creates an additional gap in higher frequencies, as shown in the top part of Fig.2. This result suggests that using a cantilever-type resonator instead of a lumped mass spring allows the study of other modes of the resonator. Moreover, the change in attached mass and mass ratio allows for tuning and controlling the bandgap characteristics of the beam in real-time experiments.

In conclusion, this research has examined the possibility of tuning the band gap of beam-type resonators based on adjustable stiffness to achieve broadband vibration suppression. Through the analysis of dispersion relations and the binary representation of transmittance contour patterns, it has been demonstrated that the center of masses of attached masses does not significantly affect the vibration suppression performance of the metamaterial beam. However, by using a cantilever-type resonator instead of a lumped mass spring, it has become possible to examine other modes of the resonator and to tune and control the bandgap characteristics of the beam in real-time experiments. This study has provided valuable insights into the design and optimization of graded metamaterial beams for vibration suppression applications.

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