Public Abstract
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Title:ELASTIC WAVE ABSORPTION IN LASER-CUT ACOUSTIC METAMATERIAL PLATES

This dissertation presents modeling techniques for design and analysis of laser-cut acoustic metamaterial plates (LCMPs) capable of acoustic/elastic vibration suppression. The conventional acoustic metamaterial plate (CMP) consists of a uniform isotropic plate with many small spring-mass-damper subsystems integrated at different locations acting as vibration absorbers. Both the single-stopband laser-cut acoustic metamaterial plate (SLCMP) and the multi-stopband laser-cut acoustic metamaterial plate (MLCMP) are proposed in this dissertation, with cutting periodic vibration absorbers consisting of one center mass and four surrounding beams into an isotropic plate for an SLCMP or two center masses and eight surrounding beams for an MLCMP. The concepts of negative effective mass density and negative effective stiffness as well as acoustic and optical modes are well explained. This work shows that local resonance of the CMP unit cells can generate inertia forces against the external load and prevent elastic wave from propagating forward within designed excitation frequency bands, which are called stopbands. For infinite CMPs, dispersion analysis is conducted to find their stopbands. For unit cells of finite CMPs, governing equations are derived based on extended Hamilton principle and their stopbands are obtained and explained in detail. For unit cells of LCMPs, modal analysis is used to calculate their resonant frequencies. Dispersion analysis in infinite LCMPs is conducted, where stopbands are clearly illustrated. Finite LCMP designs are also modeled numerically, where the stopbands characteristics are investigated with frequency response analysis and transient analysis. Factors that influence the stopbands characteristics such as the unit cells' resonant frequencies, damping coefficient and plate boundary conditions are also analyzed and discussed. Based on the fundamental acoustic metamaterial concept, dynamic disturbances with frequencies near the local resonance of the LCMP microstructure will be attenuated, thus inhibiting the propagation of acoustic/elastic waves. For an LCMP with unit cells designed with one specific resonant frequency, a single stopband will occur at the unit cells' locally resonant frequency. Moreover, if each unit cell has two locally resonant frequencies, there are two stopbands. In addition, we demonstrate that increasing the damping coefficients of the SLCMP vibration absorbers will increase the stopband's width to a small degree as well as lower the overall response of the base plate. For an MLCMP, two stopbands can be combined into one wider stopband by using a greater damping coefficient for the inside vibration absorbers when unit cells' two resonant frequencies are designed to be close to each other. Finally, it is found that boundary conditions applied to the LCMPs will not significantly affect the stopbands characteristics.