Volumetric locking issue with uncertainty in the design of locally resonant acoustic metamaterials

[*]ZC He[1,2], Eric Li[1,2]

[1]State Key Laboratory of Advanced Design and Manufacturing for Vehicle Body, Hunan University, Changsha, 410082 PR China

[2] The State Key Laboratory of Fluid Power and Mechatronic Systems, Zhejiang University, Hangzhou, 310027, China

*Presenting and corresponding author: hezhicheng815@hnu.edu.cn

Abstract

In the design of locally resonant acoustic metamaterials (LRAMs), the incompressible rubber is widely used. However, the physical behavior of LRAMs with a ternary structure is very sensitive to the Poisson's ratio of incompressible rubber. The slight variance of Poisson's ratio could lead a significant change of physical response of LRAMs. On the other hand, the manufacturing error is unavoidable in the application of LRAMs. Therefore, it is important to predict the upper and lower bounds of physical response of LRAMs with uncertainty parameters. For the first time, the mathematical model to predict the upper and lower bounds of mechanical response of LRAMs with uncertainty parameters such as Young's modulus, Poisson's ratio and density, is established by the nonlinear interval perturbation hybrid node-based smoothed finite element method (NIPH-NS/FEM). One of the main features of NIPH-NS/FEM with a softened effect in the discretize model is capable to overcome the volumetric locking issue of incompressible rubber in the standard finite element method (FEM). The accuracy and effectiveness of NIPH-NS/FEM have been validated by two numerical examples including LRAMs with binary and ternary structures.

Keywords: Volumetric locking; locally resonant acoustic metamaterials; Uncertainty effect; Softened stiffness; Interval model