Enhanced performance of nonlinear energy sink under harmonic excitation using acoustic black hole effect

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Abstract. To avoid failure of nonlinear energy sink (NES) under large excitation, a novel design is proposed by attaching ABH beam with damping layer at its tip to the mass block of NES. The introduction of the ABH beam has two main influences: first, it raises the excitation threshold of NES's failure by increasing the energy dissipation pathway. Second, it reduces the main structure's amplitude after NES's failure by utilizing the highly damped modes of ABH structure. This novel NES is called ABH-NES. Its theoretical model is established using the Rayleigh-Ritz method and modal approach. Then the influence of various parameters on the ABH-NES's performance is analyzed. After that, the responses of ABH-NES, NES, and Uniform Beam-NES (UB-NES, using uniform beams to replace ABH beams) are compared. The results show that ABH-NES with the same parameters as the NES has a better and more robust damping effect.

Introduction

Although nonlinear energy sink (NES) solves the frequency dependence of linear tuned-mass-damper (TMD), its damping performance is influenced by the excitation amplitude. Especially for large excitation, the coupled system of the NES may generate an additional high periodic or quasi-periodic solution branch in the frequency band where the excitation frequency is slightly smaller than the main structure's frequency. The high solution branch is also called closed detached response (CDR) [1]. The appearance of CDR means that the damping effect of NES has seriously deteriorated, and continuing to increase the excitation amplitude, the absorber may fail completely. To fix this NES's disadvantage, scholars have done much work [1-5]. References [2, 3] found that nonlinear damping can eliminate CDR while preserving strongly modulated response (SMR). Zang et al. [1] found that increasing the absorber's mass can also improve the performance of the NES under large excitation. Chen et al. [4] utilized piecewise nonlinear stiffness to enhance the performance of the NES under small and large excitations. Zhang et al. [5] found that the increase in the absorber's degrees of freedom can delay the appearance of the CDR.

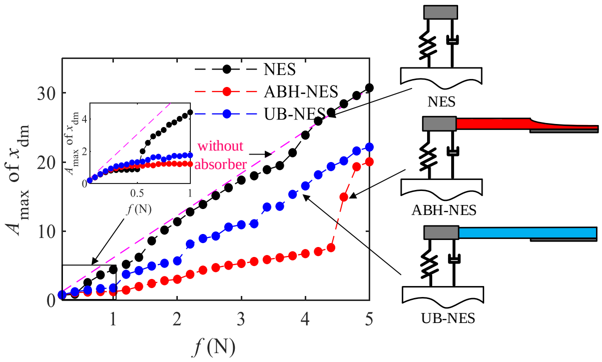

Figure 1: Comparison of NES, ABH-NES, and UB-NES on vibration damping under different excitation amplitude *f*.

Results and discussion

This research proposes a new NES, ABH-NES, to solve the problem that the conventional NES may fail under large excitation. And through numerical simulation, the following conclusions are obtained: 1. The introduction of the ABH beam has two effects: to delay the CDR's excitation threshold and to reduce the CDR's maximum amplitude. 2. When the second-order frequency of the ABH-NES is close to the main structure frequency, the performance of the ABH-NES may be worse than that of the NES. 3. When the parameters are chosen reasonably, ABH-NES can achieve better and more robust damping performance than NES by using a lighter mass.

References

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