Vibration control with a magnetic tristable NES on a cantilever beam

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Abstract. The vibration suppression effect of novel magnetic tristable nonlinear energy sink (MTNES) on harmonically excited cantilever beam is studied. The performance is investigated through Hamilton's method, assumed mode method and fourth order Runge Kutta method. Taking the amplitude reduction of the end of the cantilever beam as the research objective, the method verified by the experiment is compared with the numerically calculated results. The results show that the MTNES has a good effect on the vibration suppression of cantilever beams and an increased robustness compared to the tuned-mass-damper (TMD).

Introduction

The nonlinear energy sink (NES) captures the vibration frequency of the host structure in a short time after the structure vibrates, and generate 1:1 resonance, realizing the dissipation and transfer of seismic energy. Because its nonlinear restoring force enables a wider frequency bandwidth and robustness than compared to the TMD, it has been studied by many scholars. Magnetic force can be used to obtain a nonlinear restoring force in the magnetic nonlinear energy sink (MNES). Al Shudeifat realized the MNES first by using asymmetric magnets. The MNES significantly improved the impact mitigation performance over broadband energy input compared to the conventional NES with cubic restoring force [1]. Chen proposed a magnetic bistable nonlinear energy sink for seismic control. By applying it to single-DOF and multi-DOF frame structures, he found an improved robustness[2]. Feudo proposed and built an MNES with adjustable restoring force, and used it for the vibration reduction of a three story frame structure[3]. In the current study, a novel tristable magnetical nonlinear energy sink is proposed, which consists of four outer magnets, two inner magnets and a linear spring (see Fig. 1a).

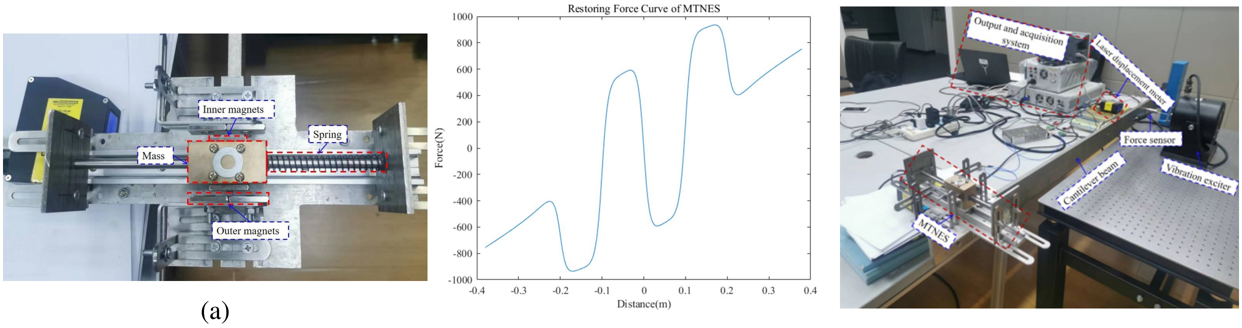

Figure 1: The MTNES (a), restoring force (b) and cantilever beam with MTNES (c).

Results and discussion

This particular configuration of magnets and springs yield the restoring force shown in Fig. 1b. The length, width and thickness of the magnet are 10cm, 10cm and 2cm respectively. The distance between the centers of the outer magnets and inner magnets along the length direction of the spring is 10cm, and the distance perpendicular to the direction of the spring is 3cm. The spring stiffness is 2000N/m. The first reonance frequency of the cantilever beam is 4.32Hz. When the excitation frequency is 4.4Hz, the maximum displacement of the uncontrolled cantilever beam end is 22.4mm, and the maximum displacement of the cantilever beam with MTNES structure is 7.2mm (66.7 % reduction). The setup is shown on Fig. 1c. Furthermore, numerical analysis will be used to study the influence different NES mass, magnetic force and spring stiffness on the performance of MTNES, compared to the MBNES and TMD.

References

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[3] Feudo S. L., Touzé C., Boisson J. and Cumunel G. (2019) Nonlinear magnetic vibration absorber for passive control of a multi-storey structure. *J. Sound Vib.* **438**:33-43