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Design and Performance Analysis of a Quasi-Zero Stiffness Isolator with Tunable Positive Stiffness Using Magnetorheological Elastomer

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Quasi-zero stiffness (QZS) isolators have emerged as an effective solution for low-frequency vibration isolation in fields such as precision machining platforms and optical communication systems, owing to their nonlinear stiffness characteristics featuring high static stiffness and low dynamic stiffness. However, conventional QZS isolators face challenges including difficulty in achieving precise matching between positive and negative stiffness, a narrow quasi-zero stiffness region, and poor load adaptability. To address these issues, this paper designs a positive stiffness-tunable QZS isolator based on Magnetorheological Elastomer (MRE)—a novel smart material composed of a polymer elastomer, magnetic particles, and auxiliary additives—and analyzes its vibration isolation performance through structural optimization, theoretical analysis of static and dynamic characteristics, and experimental verification. Experimental results show that under current regulation of -3 A, 0 A, and +3 A, the composite stiffness of the quasi-zero stiffness isolator varies in the negative direction from 7.2 N/mm to 18.2 N/mm, and in the positive direction from 18.2 N/mm to 52.9 N/mm. Corresponding dynamic frequency response characteristics are as follows: under negative current, the natural frequency decreases from 9.1 Hz to 5.8 Hz (a leftward shift of 3.3 Hz, with dynamic stiffness reduced by 60.4%); under positive current, the frequency shifts rightward by 6.0 Hz.

Type:

Oral