Advanced Suspension Technologies for Vibration Control

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Abstract

This study investigates the design and validation of innovative stiffness control systems for vibration control, focusing on two distinct approaches: thermo-driven Shape Memory Polymers (SMPs) and mechanically tunable stiffness devices. The objective is to develop adaptive suspension systems capable of changing stiffness to address diverse operational challenges, such as in-flight stabilization and payload protection under extreme vibration loads.

For SMP-based systems, a comprehensive numerical framework has been established to model the temperature-dependent stiffness variation. Experimental validations have demonstrated the significant potential of SMPs, showing eigenfrequency shifts and a notable capacity to transition between soft and rigid states. This adaptability enables these systems to provide high-static and low-dynamic stiffness properties, ensuring effective vibration attenuation across a wide range of operational conditions.

In parallel, mechanically tunable stiffness devices have been explored as an alternative approach for precise control of vibration isolation. Numerical studies have identified critical design parameters and operational thresholds for efficient stiffness adjustment. Ongoing experimental efforts aim to validate these findings and assess the performance of such devices under varying loads and excitation scenarios.

This research highlights the potential of these two approaches to address critical vibration control requirements. By leveraging their distinct capabilities, SMPs and mechanical tunable stiffness devices present promising solutions for optimizing suspension behavior while ensuring reliability and protection for sensitive payloads.

The integration of numerical and experimental results underscores significant progress toward achieving a technology readiness level suitable for industrial applications. These findings pave the way for deploying advanced vibration control systems in aeronautical, automotive, and industrial sectors, addressing key challenges in dynamic and high-performance environments.

Keywords
Vibration control, Adaptive suspension system, Shape Memory Polymer.