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GROUND SIMULATION SYSTEM FOR ACTIVE VIBRATION CONTROL BASED ON THE BIO-INSPIRED X-SHAPE STRUCTURE FOR FREE-FLOATING SPACECRAFT

Abstract

With the rapid development of space technologies, the requirements of on-orbit servicing increase a lot. Some sensitive payloads of spacecraft are always mounted on the satellite platform, which requires a relative stable environment for working precisely. Especially, when the robotic manipulator of spacecraft performs the capturing missions for space targets including space debris and useless satellites, there always exists an inevitable impact between them, which leads to some undesirable vibration and drifting motion for the satellite platform. That, how to suppress the post-capture vibrations efficiently, is still a challenging issue in aerospace engineering.

A kind of novel bio-inspired X-shape vibration isolation structure has been proposed and designed to install between the robotic arm and the capture mechanism of the free-floating spacecraft. Theoretical analyses and numerical simulations demonstrated the bio-inspired X-shape structure has a relative better performance compared with the traditional spring-mass-damper isolator. To get much better isolation performance, active control strategy has been put forward before to assist the passive system in suppressing post-capture vibrations. It has been verified to be valid by numerical simulations but needs to be validated by ground experimental results.

This paper aims to design a ground experimental system based on the bio-inspired X-shape structure to simulate the vibration responses of the satellite platform and the capture mechanism when the end-effector of the free-floating spacecraft is subjected to the impulsive force or the external periodic excitation. The gas ejecting system is constructed to provide the active control force for the simulation system to suppress the vibrations of system or stabilize it, where the pulse-width-pulse-frequency (PWPF) modulator is introduced to tune the continuous control signals into a series of pulse signals. Moreover, an efficient control method is employed in the control system in order to get the better performance. The results of the ground simulation system are in agreement with that of the numerical simulations in MATLAB on the whole. The designed ground experimental system shows the validity and feasibility of the bio-

inspired X-shape vibration isolation structure in combination with active control strategy in suppressing the post-capture vibrations of a free-floating spacecraft.