ME PhD Thesis Defense

Vibration Mitigation in Spacecraft Components Using Stewart Platform and Particle Impact Damping

Mr. Nazeer Ahmad, PhD Scholar, Mechanical Engineering, IISc

ABSTRACT

A spacecraft encounters two regimes of vibrations: launch loads and on orbit loads. Both these loads propagate through the spacecraft structure, made up of honeycomb sandwich, and they can affect the performance of sensitive devices on the spacecraft, especially when in orbit. To reduce vibration level, the damping behavior of the honeycomb panels can be improved by inserting damping particles in the empty cells of the honeycomb core. Another way of reducing the vibration level is to use a multi-axis isolator between source and target. In this work, both the approaches are addressed.

First, a design of a multi-axis vibration isolator based on a Stewart-Gough platform (SGP) and a modified Stewart-Gough Platform (MSGP) is considered. The SGP need to have its first six modal frequencies close to each other, thus enabling development of effective vibration isolation for all six primary modes. The proposed design has the ratio of the maximum to the minimum natural frequency (also termed as dynamic isotropy index) as 1.70 and 1.31 when torsional mode was excluded, respectively. A prototype SGP showed a dynamic isotropy index of 1.50. To obtain a better dynamic isotropy index a modified SGP with connection points in two circles is considered. It is shown that with this modification, all six frequencies are same even after incorporating a cross-blade flexural joint and metallic bellow to provide the required stiffness to legs. The detailed finite element model used for modal analysis and steady state dynamic analysis is performed and the transfer functions show that an isolation of 33dB/oct is achievable.

For the second approach to improve the damping characteristics of honeycomb panel, damping particles (DPs) are filled in the core of honeycomb sandwich at strategically selected locations. The coupled dynamics of damping particle and honeycomb plate/beam is modeled using discrete element method (DEM) combined with finite element method (FEM). In the DEM, the dynamics of the DPs is based on the Newton's Laws and the particle-particle and particle-cell walls interaction are modelled using modified nonlinear dissipative Hertz contact theory in conjunction with Coulomb friction. The coupled equations of motion of DP, cell walls and host structure is solved using numerical method and the interactions of damping particles with the walls of the cells and its overall effect on the frequency response function (FRF) and the damping of the structure are obtained. Two cases: a beam and a plate are considered for numerical and experimental studies. The experimental results from the beam and the plates agree very well with the damping and transfer functions obtained from the mathematical model. Significant improvement in damping ratios and attenuation of vibration level has been observed in the experiments.

ABOUT THE SPEAKER

Nazeer Ahmad, scientist at the UR Rao Satellite Centre of ISRO, Bangalore, is a PhD scholar in the Department of Mechanical Engineering, IISc, under the ERP programme. For his PhD, he has been working with Prof. Ashitava Ghosal and Dr. R. Ranganath (ISRO) in the field of vibration isolation and mitigation in spacecraft. He graduated in Mechanical Engineering from Aligarh Muslim University. He did his post-graduation in Machine Design, from AMU, India. His research focuses on vibration analysis and design of spacecraft.

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