Paper ID: 69096
oral
student

IAF MATERIALS AND STRUCTURES SYMPOSIUM (C2)
Space Structures - Dynamics and Microdynamics (3)

Author: Mr. Mattia Marcello Longato
University of Auckland, New Zealand

Mr. Thomas Hughes
University of Auckland, New Zealand
Dr. Vladimir Yotov
University of Auckland, New Zealand
Prof. Guglielmo S Aglietti
University of Auckland, New Zealand

FEM MODELLING OF REACTION WHEEL MICROVIBRATION

Abstract

Microvibrations onboard satellites are a common phenomenon that excite the satellite structure with low-level accelerations (microg μg). These vibrations need to be controlled to avoid critical perturbations of the payload stability. Such a significant subject has been investigated for the past decades because microvibrations caused relevant degradation of highly sensitive payload performances leading to their relative mission failure. Rotating devices such as reaction and momentum wheels are considered the most consistent source of microvibration disturbances for the many sensitive devices in space. Misalignments and little unbalances on the high-speed rotating flywheels that act simultaneously are the primary cause of disturbance forces and moments that are discharged on the satellite structure at the wheel assembly mounting points. Second-order defects like geometric imperfections inside the bearings rolling elements increase undesirable broadband frequency disturbances which can then excite resonances that amplify the disturbances.

This work focuses on developing an analytical rotordynamic theory supported by high-fidelity reaction wheel finite element analysis. This rotordynamic model explores in detail the coupling phenomena between the many rotating parts acting simultaneously. One of the main aims consists of studying how these microvibration disturbances are generated and propagated, and the possible strategies to mitigate the dangerous effects produced. A second experimental part was conducted to support the theoretical predictions of the analytical models developed above. These experiments recorded the micro accelerations generated by a reaction wheel spinning with different rotating velocity profiles. The results are compared with the high-fidelity finite element analysis in the time and frequency domain to confirm and highlight resonance conditions that are excited by the rotating parts. Campbell diagrams and waterfall plots will be experimentally and numerically generated to be later compared with the reaction wheel microvibration profile recorded before. The finite element analysis may evaluate the flywheel Coriolis effect due to the high rotational speed ranges involved by considering the gyroscopic matrix of the rotating structure. These gyroscopic forces can be added to the coupling effect between the flywheel's rotational speed and the natural frequencies of the spinning rotor (resonance condition). Accordingly, this work suggests potential improvements to reduce microvibration disturbances by adopting specific structural solutions.