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MATERIALS AND STRUCTURES SYMPOSIUM (C2)
Space Structures II - Development and Verification (Deployable and Dimensionally Stable Structures) (2)

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IMPORTANCE OF STRUCTURAL DAMPING IN THE DYNAMIC ANALYSIS OF COMPLIANT DEPLOYABLE STRUCTURES

Abstract

Compliant mechanisms such as tape springs are often used on satellites to deploy appendices, e.g. solar panels, antennas, telescopes and solar sails. Their main advantage comes from the fact that their motion results from the elastic deformation of structural components, unlike usual hinges or prismatic joints, the motion of which is dictated by contact surfaces. This deformation allows the storage of elastic energy during the folding, which is then released during the deployment to put the mechanism into motion. Thus, no actuators or external energy sources are required and the deployment is purely passive, which appears as a decisive feature for the design of low-cost missions with small satellites or cubesats.

Although the deformations mostly remain in the elastic regime, the mechanical behaviour of a tape spring is intrinsically complex and nonlinear. Its geometry involves a buckling phenomenon when a fold is created and an hysteresis behaviour is linked to loading-unloading cycles which leads to a self-locking phenomenon. High-fidelity mechanical models are then needed to get a detailed understanding of the deployment process, improve the design and predict the actual behaviour in the space 0-g environment.

In a previous work [1], dynamic simulations were performed without any physical representation of the structural damping. These simulations could be successfully achieved because of the presence of numerical damping in the transient solver (e.g. Newmark, HHT or generalized-α time integration scheme). However, in this case, the dynamic response turns out to be quite sensitive to the amount of numerical dissipation, so that the predictive capabilities of the model are questionable. In this work, we show that the simulator can be made less sensitive to numerical parameters if the structural dissipation is taken into account. We also conclude that the dissipative properties of the materials should be carefully estimated in order to perform a reliable simulation.

[1] S. Hoffait, O. Brüls, D. Granville, F. Cugnon, and G. Kerschen. Dynamic analysis of the self-locking phenomenon in tape spring hinges. Acta Astronautica, Vol. 66, 1125–1132, 2010.