7th ECCOMAS Thematic Conference on Smart Structures and Materials
SMART 2015
A.L. Araújo, C.A. Mota Soares, et al. (Editors)

Abstract ID-161

MULTIBODY DYNAMIC MODEL FOR A TWO SPACECRAFT CONFIGURATION WITH A COMPOSITE MATERIAL DOCKING STRUCTURE

Jorge Ambrósio

LAETA, IDMEC, Instituto Superior Técnico, University of Lisbon, Portugal
Jorge.ambrosio@tecnico.ulisboa.pt

Keywords: Flexible Multibody Dynamics; Modal Superposition; Composite Spacecraft Configuration; Composite Beams; Satellite Flexible Appendages.

Summary: Aerospace applications have been among the foremost proving grounds for the development of structural and mechanical concepts involving composite materials that ensure the low weight of the structural components and their high resistance. Satellites are not only among the type of spacecrafts for which the demand for low weight are more stringent but are also among those that present a larger flexibility of their structural components. In this work the dynamics a spacecraft, operating in earth orbits, is described with a flexible multibody dynamics methodology, which effectively couples the large rotations of the complete vehicle with the small flexible deformations of its structural components. The formulation used enables not only a detailed finite element description of the structural components made of laminated composite materials but also the introduction of active piezoelectric elements that allow for the control of the vibrations of very flexible appendages and their influence in the overall dynamics. A suitable set of reference conditions is defined in order to ensure the uniqueness of the displacement field of the vehicle flexible components. Then, the mode component synthesis is used to reduce the number of degrees of freedom of the system leading to a system of equations of motion that can be efficiently dealt computationally allowing for the real time simulation of the spacecraft model.
When considering the docking of spacecrafts among each other, or with orbital stations, docking or clamping mechanisms need to be deployed, thus leading two an extra level of flexibility. For a situation in which two spacecrafts execute a rendezvous maneuver, a mechanical system is deployed in to attach the vehicles to each other. Due to the weight and stiffness restriction in the application case considered here, the mechanism deployed is achieved with beams made of a composite material. The model for the composite two spacecraft assemblage is developed and its dynamics is analyzed in a deorbiting scenario. In the process, special attention is paid to the time integration requirements of the equations of motion so that these can be used in real time, such as when the model is used in the context of deorbiting control strategies.