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DYNAMIC SIMULATION AND EXPERIMENT OF ELECTROMAGNETIC FLEXIBLE DEPLOYMENT FOR LARGE SPACECRAFT STRUCTURE

Abstract

The structure of many previous large spacecrafts has been deployed using boom, spring and truss mechanism, employing an elastic force. The complicated system leads to some challenges such as reliability and lightweight. With the ability of electromagnets to exert a force or torque at a distance without contact, current research has proposed an electromagnetic subsystem that leverages the interaction of magnets with an external magnetic field to perform structural functions as well as some of the duties of traditional large spacecrafts. Several primary benefits of the electromagnetic subsystem can be offered to the aerospace community, such as continuous reversible control, less mass of space spacecraft, dimensionally larger structure stowed in the same launch vehicles, reconfigurability of structures following the initial deployment.

Up to now, previous electromagnetic deployment research neglected to investigate the coupling between the structure and electromagnetic force/torque. Actually, the structure of electromagnetic deployable spacecraft contains flexible cable and truss mechanism. The coupling between the flexible structure and electromagnetic force/torque should be investigated during electromagnetic deployment dynamic study, because the high non-linearity not only exists in the structure but also in the electromagnetic field.

In this paper, a dynamic model has been established to study the electromagnetic deployment when the structure flexibility is integrated with electromagnetic field. The simulation model has two parts, the structure flexibility model and electromagnetic force/torque model. For structure flexibility model, the flexible structure was discretized with a hypothetical displacement field model based on the Rayleigh-Ritz method. For electromagnetic filed, we optimized the electromagnetic field model published in IAC 2017. We have associated the structure flexibility with electromagnetic force/torque through geopotential energy, elasticity potential energy, stiffness matrix and corresponding mass matrix. To verify the simulation

model, we have constructed an experimental platform ,which consists of two air-bearing electromagnetic subsystems connected with flexible cable and truss mechanism, to measure the displacement, velocity and accelerator of mark points on the electromagnetic subsystems and flexible structure, through the displacement sensors and NDI Kinect Survey System. The simulation result shows a good agreement with experimental results, with a deviation below 10%.

The objective of the paper is to conduct dynamic simulation study for the actual electromagnetic deployment and to conduct an initial study for the optimization of electromagnetic deployable mechanism. The future work will focus on the optimization of dynamic simulation considering the actual application environment.