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ENVIRONMENTAL ANALYSIS AND OPTIMISATION OF AN IN-ORBIT SHAPE MEMORY ALLOY DEPLOYMENT MECHANISM

Abstract

This study presents the analysis and optimisation of a novel deployment mechanism that utilises the shape memory effect inherent in Nickel-Titanium alloys, namely Nitinol. The mechanism is currently designed to secure and deploy solar panels on board a nanosatellite – specifically a CubeSat, however the applications of this design can be extended beyond the deployment of just solar panels. The advantages of this mechanism include the ability to repeatedly test the deployment process using the exact components that will be onboard the satellite during the mission, this is possible because the deployment device can be reset after it has been actuated, allowing for multiple tests prior to launch – something that is not possible with traditional release methods such as nichrome burn wire. The actuation only requires a minimal amount of electrical power and the controlled deployment over several seconds results in a negligible shock, this helps to reduce the effect of deployment on the satellite's attitude.The investigations that are conducted utilise orbital environmental analysis software as well as mechanical and thermal finite element analysis. These tools are used in tandem to build a simulation representative of the conditions that the satellite and mechanism can be expected to experience across the full mission. These conditions are combined in to one simulation so that a multi-domain optimisation approach can be achieved. Axial accelerations, as well as random and sinusoidal vibration tests are conducted to ensure that the mechanism has sufficient structural integrity to survive the intense environment of a rocket launch. The areas of particular interest are the short-period high-intensity vibrations that occur from pyrotechnic shocks at key launch events - such as stage separations. The results from the analysis are used to drive the optimisation of the mechanism, by refining the mass and / or location of the Nitinol.Thermal loading is also investigated to analyse the mechanism's response to the intense radiation experienced in low earth orbit. The Nitinol is thermally actuated so prolonged exposure the sun's radiation could lead to the mechanism deploying before it is intended to. To address this, a 'worst-case' approach is used for the thermal analysis – the satellite is simulated in a 'dawn-to-dusk' sun-synchronous orbit, meaning that one face of the satellite is constantly exposed to the sun's radiation. This analysis will determine if additional protective materials or coatings are required to prevent the Nitinol from reaching its actuation temperature prematurely.