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FEA OF THERMAL COATINGS ON PROPULSION PAYLOAD STRUCTURES PRODUCED BY METALLIC ADDITIVEMANUFACTURING.

Abstract

A key benefit of Additive Manufacturing (AM) is the ability to produce highly complex shapes that is not possible with conventional manufacturing techniques. This is especially useful in nanosatellites where AM can be employed to produce weight-optimized structures and payloads that also conform to the tight confines of the nano-satellite internal space. The surfaces of space payloads are typically treated with thermal coatings to improve radiative thermal exchange within the internal spaces of the nanosatellite. Currently, the thermo-optical properties of metallic AM-produced structures treated with thermal coatings are not as well understood compared to conventional metallic structures. This study looks at the thermal behaviour of a CubeSat system in Low Earth Orbit (LEO) and how thermal coatings can influence the thermal management of CubeSats with AM-produced payloads.

The Finite Element Analysis (FEA) tool from Siemens NX Space Systems Thermal was employed to simulate the thermal behaviour of the CubeSat system subjected to orbital heating at an altitude of 400 km in LEO, corresponding to the orbit of the International Space Station. The payload is a propulsion module, with the main structure designed using AlSi10Mg, an AM material that resembles AL2024 in terms of mechanical properties. The structure will be built using EOS M290 Direct Metal Laser Sintering (DMLS) machine. Thermal coatings under investigation are Alodine and Aeroglaze Z306. These were simulated by inputting the emissivity, absorptivity, and transmissivity values. Transient thermal analyses were then carried out and the nodal temperatures at the various points of interest, for example, solar panels, OBC, and payload were monitored to study the temperature fluctuations.

The simulation results showed that there was an insignificant difference over most of the CubeSat surfaces when AM-produced structures were treated with Aeroglaze Z306 compared to Alodine alone. The exception was the nadir-facing surface, which showed a smaller temperature fluctuation between the hot and cold cases.

It can be concluded that in the context of CubeSats, thermal coatings may not help to improve the thermal management of the CubeSat. This is probably due to the small size of the CubeSat, and the correspondingly short conductive heat path. Conductive heat transfer is likely the dominant mode of heat transfer within the confines of the CubeSat, with radiative heat exchange playing a smaller role. Further studies will be needed to study the behaviour of thermal coatings on AM-produced structures in bigger systems like smallsats.