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STRUCTURAL- AND THERMOMECHANICAL ANALYSES OF ADHESIVELY BONDED JOINTS FOR MODULAR SATELLITE STRUCTURES

Abstract

A satellite's primary structure has several crucial tasks. It is responsible for the spacecraft's overall integrity and provides interfaces and mounting points for secondary structures, subsystem components and the payload. It has to withstand all static and dynamic loads during the launch phase and provides an interface to the launch vehicle. Depending on the mission's profile the primary structure has also to withstand a wide spectrum of mechanical, thermal and radiation loads during its lifetime in space. Moreover, the primary structure should also possess good thermal properties, like a small CTE (Coefficient of Thermal Expansion) to meet payload requirements or regarding the thermal control subsystem good thermal conductance, in order to spread heat around the satellite. With the common goal to reduce launch costs, lightweight design focuses on optimizing the structure and reducing its mass.

Within a funded research program a modular satellite system is developed, considering multiple distinct modules which are connected to each other. After assessing the system requirements and analyzing different structure concepts for the modules in previous studies, the shear-web structure shows here the highest lightweight potential. The current structural design consists of a CFRP (Carbon Fiber Reinforced Plastic) frame with aluminum corner nodes and sandwich panels with CFRP face sheets. In order to reduce mass and complexity the design focuses on adhesive bonding technics. Hence not only the tubular beams are bonded to the nodes, but also the sandwich panels to the beams. This design shows advantages regarding thermal properties, when selecting a CFRP with low CTE and high thermal conductance, combined with a suitable adhesive. This paper numerically analyses the two main types of bonded joints, first the tubular connection between beam and node and second the idealized single lap joint between beam and sandwich panel. Both joints have to withstand on the one hand the load spectrum during launch and provide on the other hand a superior thermo-mechanical behavior in orbit, in order to satisfy the modular satellite's requirements. Besides the structural and thermomechanical analysis, a damage analysis is provided to estimate the overall residual strength and performance of the satellite structure in case of local non catastrophic bonding failure, followed by a prediction of the damage progressing due to cycling thermal loads in earth orbit.