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THERMAL CHARACTERIZATION OF A MULTIFUNCTIONAL COMPOSITE STRUCTURE IN EARLY DESIGN PHASE BASED ON THE MASCOT LANDER

Abstract

The DLR Institute of Composite Structures and Adaptive Systems has recently developed an all composite structure for the MASCOT (Mobile Asteroid Surface Scout) Asteroid Landing System. MASCOT is an approximately 10 kg shoebox-sized lander platform developed in cooperation with CNES and JAXA for the Hayabusa 2 sample return mission from the asteroid 1999JU3. It consists of two parts, the Landing Module itself and an Interface Structure to connect the former to the mother spacecraft.

This paper will focus on the currently existing MASCOT Landing Module structure, whose framework walls are made from a CFRP/foam sandwich. The M55J fibres used for the unidirectional sandwich face sheets are of Polyacrylonitrile (PAN) type and have excellent mechanical properties, but poor thermal conductivity. Also the glued connections between the framework walls are realised with PAN fibre patches. This is one reason, which necessitated a thermal sub-system consisting of heat pipes and two aluminium radiators. Both contribute with a total mass of approximately 450g – almost the same as the very lightweight primary composite structure (550g). Also, the structural design itself is highly influenced by the needs of the thermal sub-system. Hence, the Landing Module shall serve as a reference to investigate possible /improved thermo-mechanical design and design principles for future spacecraft missions with all-composite primary structures.

In a first step, the capability of simulating the thermal behaviour of the Landing Module's structure is added in a simplified way. This is necessary, as the existing model was only used for mechanical finite element analysis by neglecting any thermal aspects. The paper describes the applied modelling methods and assumptions that are used to predict the Landing Module's thermal behaviour. Subsequently, the results from the finite element simulation are compared to actual thermal measurements, which were performed in a thermal vacuum chamber. This approach will help to gain a better understanding of the structure's participation in the thermal path in early design phases. By this means and corresponding measures (e.g. using materials with higher/lower thermal conductivity) the additional mass used by thermal sub-systems can be reduced by integrating the thermal functions of a spacecraft with the structure.