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ABSORPTIVITY DETERMINATION OF SATELLITE MATERIALS FROM THE TRANSIENT HEATING PHASE OF A THERMAL-VACUUM TEST.

Abstract

Controlling the level of temperature of payloads, satellites and their components is essential to protect flight hardware and to guarantee the optimum performances. Solar absorptivity and infrared emissivity of materials are parameters necessary to estimate the spacecraft temperature above all for passive satellites such as LARES and LARES 2. In addition, for these satellites their thermo-optical properties are also required to estimate a very small but not negligible perturbation called thermal thrust which has to be considered in the accurate orbit determination of those satellites. This work, to be presented in IAC 2019 conference, has the aim to find an alternative and original approach on the determination of the thermo-optical properties of materials by the use of standard thermo-vacuum tests. In particular this work focuses on the absorptivity measurement. A sun simulator with AM0 spectrum is used to heat the specimen suspended in the thermo-vacuum chamber. The transient governing equation used in this work is:

$$(\mathrm{m}_1 * c_1) \div (\sigma * \varepsilon * A_R) \left[1 \div 4 * T_E^3\right] * ln\,|(T_E + T_1) \div (T_E - T_1)| \div |(T_E + T_*) \div (T_E - T_*)| + 1 \div 2T_E^3 \left[arctg\,(T_1 \div T_E) - arctg\,(T_* \div T_E)\right] - t = 0$$

and TE is given by:

$$\mathrm{T}_E^4 = \left[(\alpha_1 * A_P * C) + \left(\sigma * \epsilon_1 * A_R * T_2^4\right)\right] \div (\sigma * \epsilon_1 * A_R)\,.$$

The terms are described in the paper clearly.

The above equation is transcendental and shows the absorptivity in implicit form. The input data for the formula are provided by the experimental tests that we performed in two different conditions. The first test was performed using liquid nitrogen to cool the walls of the chamber. The second test was performed without. The time histories of the walls and of the specimen were recorded and used as input to the governing equation. This transcendental equation has been solved at several times with two independent numerical approaches. The values of absorptivity obtained are compatible with the ones of ESA/ESTEC laboratory that measured it with the dedicated instrument Cary 5000 UV/Vis. It is remarkable that our results are practically the same whether the walls are cooled with liquid nitrogen or not. The measurement of the absorptivity can be performed without liquid nitrogen thus sensibly reducing the cost of the thermovacuum tests.