SPACE TRANSPORTATION SOLUTIONS AND INNOVATIONS SYMPOSIUM (D2)
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DEMONSTRATION OF VERY HIGH INSULATING PERFORMANCES ON CRYOGENIC STAGE FOR EXPLORATION MISSIONS

Abstract

In the frame of exploration programs or long missions in orbit, the choice of propulsion is a key element. The high specific impulse of cryogenic propulsion makes it a natural candidate for this kind of long missions – typically from 1 week to 6 months – and we then talk about Long Term Cryogenic Propulsion (LTCP). But cryogenic propellants require advanced thermal control to make the mission feasible. Indeed, the main challenge for LTCP is the storage of cryogenic propellants for long periods without penalisation of the global mass budget. That's why the question of passive versus active control shall be addressed considering the mission duration. For passive control, a part of the loaded mass is lost daily through the boil-off. With an active system, heat losses are balanced by a cooler but this cooler increases the global mass budget. Anyway, in both cases, the thermal design shall be optimised as far as possible. Thermal budgets for different architectures have been built for a cryogenic stage, and it has been shown that heat entries can be reduced to a few watts thanks to simple passive technologies (MLI, low conductivity struts, etc.). As heat entries through the insulation are preponderant in the global thermal budget and knowing that MLI thermal performance strongly depends on the tank geometry and on insulation implementation, it is highly recommended to consolidate this contribution thanks to experimental measurements. This paper presents the demonstration performed on a cylindrico-spherical tank of 1.2 m of diameter and 2 m of height to characterize the thermal performance of the insulation at 4K on a representative geometry and scale, the test bench, the improvements brought to the insulation, and the measured performances. This demonstration has been performed in the frame of a CNES / Air Liquide Advanced Technologies cooperation.