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DESIGN AND ANALYSIS OF AN INNOVATIVE CUBESAT THERMAL CONTROL SYSTEM FOR BIOLOGICAL EXPERIMENT IN LUNAR ENVIRONMENT

Abstract

After about 50 years since the Apollo missions, Space Agencies are planning new manned missions beyond LEO, aiming to full functional Lunar and Martian outposts. Leaving the protection of Earth magnetic field, human body will be exposed by a huge amount of harmful radiations coming from both solar wind and cosmic rays, which represent a risk for the astronauts. In order to prepare for future manned exploration missions, many biological experiments have been conducted inside and outside the International Space Station (ISS). From these experiments, engineers and scientists gained knowledge about biological degradation after a long period of exposure to space radiations. Similar experiments were also carried out in small free-flyers. For example, the O/OREOS mission is built with a 3U CubeSat that is evaluating how microorganisms can survive and can adapt to the harsh orbit environment. Small platforms, such as CubeSats, are gaining interest for many applications including science experiments. Biological payloads require very stable environmental conditions, implying that environment requirements are very stringent and that existing passive thermal control systems may not be sufficient to support these class of experiments. The goal of this paper is to describe and discuss the design of an active environmental control system suitable for supporting biological payloads hosted onboard nanosatellites. In particular, we focused the attention on the case of a payload constituted by a bacterial culture that needs oxygen supply for growing up. The rate of growth and vitality are measured through bacteria metabolic parameters. The reference mission is built with a 6U CubeSat in Lunar Polar Orbit, with the main scientific objective of measuring the effect of the lunar radiation environment on a culture of “Bacterium Deinococcus Radiodurans”. This kind of bacteria exhibits significant resistance to ionising radiation and the survival temperature range is $30°C \pm 10°C$. The thermal control system (TCS) is constituted by stirling cryocooler, peltier cells and heaters. The aforementioned equipment operate on the oxygen storage and test chamber in order to control temperature of the oxygen necessary for the growth of the bacteria. To verify the temperature requirements, two kinds of analysis are performed: radiative analysis, to have information about the heat flux from space environment; and lastly, a thermofluid dynamics analisis, to gather data about temperature in the test chamber. As result, it is possible to confirm that, with the chosen TCS, the temperature requirement is verified during the mission.