IAF SPACE EXPLORATION SYMPOSIUM (A3)
Interactive Presentations - IAF SPACE EXPLORATION SYMPOSIUM (IP)

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ANALYSIS OF LUNAR ROVER RADIATORS' HEAT BALANCE USING THERMAL CIRCUIT THEORY AND IMPACT OF LUNAR REGOLITH ON ITS PERFORMANCE

Abstract

Lunar exploration greatly contributes to technological advancements as it constantly pushes the limits of scientific knowledge. Not only do missions like the Lunar Gateway set the stage for deep space exploration, but they can also provide a better understanding of human health science and astrophysics. Moreover, lunar rovers allow us to tackle such missions without exposing astronauts to harsh environments, as demonstrated during various expeditions, such as with China's Yutu-2 rover that is still operating to this day.

One of the most important aspects to consider while designing such a vehicle is the heat balance within the spacecraft. Extreme temperatures in space have a big impact on the performance of mission critical subsystems of the rovers, such as batteries and on board computers. Additionally, due to its low thermal conductivity, the accumulation of lunar regolith hinders the thermal regulation of the rover. These circumstances can present significant challenges as electronic components operating outside of their recommended temperature range will see their efficiency and lifetime reduced. As there is no convection in space, conduction and radiation are the most efficient ways to regulate the internal temperature of the rover. The goal of the PEEKbot rover, a project done in collaboration with the Canadian Space Agency (CSA), is to develop a lunar rover whose chassis is made entirely of PEEK (Polyether ether ketone) and that is equipped with two 30x30cm radiators placed vertically on either side of the craft.

This paper aims to characterize the radiators' heat dissipation capacity assuming an equatorial mission. Computational analysis using thermal circuit theory is performed for the worst temperature condition (the hot case), which implies a perfect alignment of the Sun and the Earth with the radiators. The accumulation of lunar regolith on the radiators is studied and different lunar regolith particle properties are simulated in order to account for the variation according to depth in the lunar ground. Additional parameters such

as the radiator's surface and its angle with respect to the rover's chassis are also evaluated. The impact of the aforementioned parameters on the radiators' efficiency are presented and a refined thermal system design is proposed.