Paper ID: 68480
student

IAF SPACE SYSTEMS SYMPOSIUM (D1)
Technologies to Enable Space Systems (3)

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AN ANALYSIS OF PHASE CHANGE MATERIAL FOR THERMAL MANAGEMENT IN LUNAR PERMANENTLY SHADED REGIONS

Abstract

One of the most important areas for the sustainable future of human exploration of our solar system lies within the coldest, darkest craters on the moon. These lunar regions are referred to as Permanently Shaded Regions (PSRs) and have been shown to contain water ice, a valuable resource in space as it can be refined into rocket propellent and used to sustain exploration to Mars and beyond. The NASA Artemis program aims to utilize the presences of these resources by developing a permanent, sustainable, lunar base at the south pole of the moon where PSRs are abundant. Due to the extreme temperatures, as low as 25K in the PSRs and as high as 400K in sunlit areas, the success of operations for a permanent lunar base and adjacent missions will rely on rugged and reliable thermal management solutions.

Phase Change Materials (PCMs) are able to passively store energy through the latent heat of phase change to maintain a specific temperature. The material absorbs thermal energy during periods of excess heat and dissipates heat when needed – similar to how a battery stores electricity. PCM systems have been used to reduce peak loads for commercial HVAC systems, fast charging of lithium-ion batteries for electric vehicle use, and in satellites to reduce thermal variation during orbit. Phase change materials are an attractive option to reduce the heavy transient loads that can come with lunar temperature changes or periodic power generation from photovoltaic sources. This paper discusses a system level approach to incorporating latent heat energy storage into Lunar ISRU technologies as well as presenting a case study of a water refinery located within a PSR. This case-study investigates the sizing, configuration, and phase change material chosen to maintain power storage and conversion equipment of a 1 kW refinery.