

Water Phase Change Heat Exchanger System Level Analysis for Low Lunar Orbit

Moses Navarro, Eugene Ungar, Rubik Sheth, Scott Hansen

In low Lunar orbit (LLO) the thermal environment is cyclic – extremely cold in the eclipse and as warm as room temperature near the subsolar point. Phase change material heat exchangers (PCHXs) are the best option for long term missions in these environments. The Orion spacecraft will use a n-pentadecane wax PCHX for its envisioned mission to LLO.

Using water as a PCM material is attractive because its higher heat of fusion and greater density result in a lighter, more compact PCHX. To assess the use of a water PCHX for a human spacecraft in a circular LLO, a system level analysis was performed for the Orion spacecraft. Three cases were evaluated: 1) A one-to-one replacement of the wax PCHX on the internal thermal control loop with a water PCHX (including the appropriate control modifications), 2) reducing the radiator return setpoint temperature below Orion's value to enhance PCHX freezing, and 3) placing the water PCM on the external loop.

The model showed that the water PCHX could not be used as a drop-in replacement for the wax PCHX. It did not freeze fully during the eclipse owing to its low freezing point. To obtain equivalent performance, 40% more radiator area than the Orion baseline was required. The study shows that, although water PCHXs are attractive at a component level, system level effects mean that they are not the best choice for LLO.