Testing and Failure Mechanisms of Ice Phase Change Material Heat Exchangers

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Phase change materials (PCM) may be useful for thermal control systems that involve cyclical heat loads or cyclical thermal environments such as Low Earth Orbit (LEO) and Low Lunar Orbit (LLO). Thermal energy can be stored in the PCM during peak heat loads or in adverse thermal environments. The stored thermal energy can then be released later during minimum heat loads or in more favorable thermal environments. One advantage that PCM's have over evaporators in this scenario is that they do not use a consumable. The use of water as a PCM rather than the more traditional paraffin wax has the potential for significant mass reduction since the latent heat of formation of water is approximately 70% greater than that of wax. One of the potential drawbacks of using ice as a PCM is its potential to rupture its container as water expands upon freezing. In order to develop a space qualified ice PCM heat exchanger, failure mechanisms must first be understood. Therefore, a methodical experimental investigation has been undertaken to demonstrate and document specific failure mechanisms due to ice expansion in the PCM. A number of ice PCM heat exchangers were fabricated and tested. Additionally, methods for controlling void location in order to reduce the risk of damage due to ice expansion were investigated. This paper presents the results of testing that occurred from March through September of 2010 and builds on testing that occurred during the previous year.

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