Experimental Investigation of Ice Phase Change Material Heat Exchangers

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Phase change materials (PCM) may be useful for spacecraft thermal control systems that involve cyclical heat loads or cyclical thermal environments. 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. This can result in a decreased turndown ratio for the radiator and a reduced system mass. 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 an overview of the results of this investigation from the past three years.

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