Title:

Sorbent, Sublimation, and Icing Modeling Methods: Experimental Validation and Application to an Integrated MTSA Subassembly Thermal Model

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Abstract:

This paper details the validation of modeling methods for the three core components of a Metabolic heat regenerated Temperature Swing Adsorption (MTSA) subassembly, developed for use in a Portable Life Support System (PLSS). The first core component in the subassembly is a sorbent bed, used to capture and reject metabolically produced carbon dioxide (CO_2). The sorbent bed performance can be augmented with a temperature swing driven by a liquid CO_2 (LCO_2) sublimation heat exchanger (SHX) for cooling the sorbent bed, and a condensing, icing heat exchanger (CIHX) for warming the sorbent bed. As part of the overall MTSA effort, scaled design validation test articles for each of these three components have been independently tested in laboratory conditions. Previously described modeling methodologies developed for implementation in Thermal Desktop® and SINDA/FLUINT are reviewed and updated, their application in test article models outlined, and the results of those model correlations relayed. Assessment of the applicability of each modeling methodology to the challenge of simulating the response of the test articles and their extensibility to a full scale integrated subassembly model is given. The independent verified and validated modeling methods are applied to the development of a MTSA subassembly prototype model and predictions of the subassembly performance are given.

These models and modeling methodologies capture simulation of several challenging and novel physical phenomena in the Thermal Desktop and SINDA/FLUINT software suite. Novel methodologies include CO_2 adsorption front tracking and associated thermal response in the sorbent bed, heat transfer associated with sublimation of entrained solid CO_2 in the SHX, and water mass transfer in the form of ice as low as 210 K in the CIHX.