A Virtual Laboratory for the 4 Bed Molecular Sieve of the Carbon Dioxide Removal Assembly

R. Coker[1], J. Knox[1], B. O'Connor[1]

[1]Marshall Space Flight Center - NASA, Huntsville, AL, USA

Abstract

Introduction: Ongoing work to improve water and carbon dioxide separation systems to be used on crewed space vehicles combines sub-scale systems testing and multi-physics simulations. Thus, as part of NASA's Advanced Exploration Systems (AES) program and the Life Support Systems Project (LSSP), fully predictive COMSOL Multiphysics® software models of the Four Bed Molecular Sieve (4BMS) of the Carbon Dioxide Removal Assembly (CDRA) on the International Space Station (ISS) have been developed. This Virtual Laboratory is being used to help reduce mass, power, and volume requirements for exploration missions. In this paper we describe current and planned modeling developments in the area of carbon dioxide removal to support future missions as well as the resolution of anomalies observed in the ISS CDRA.

Use of the COMSOL Multiphysics® software: The transport of the two concentrated species, water and carbon dioxide, in a carrier gas (air) was modeled as flow through four beds of pellets. The adsorption rates and pellet loading were determined using Toth isotherms. The resulting heat transfer between the gas, the porous media, the solid housing, and the insulation was also modeled. The mass fractions exiting an upstream bed were used as inlet boundary conditions for the next bed. A heater-assisted vacuum desorption model is used for the desorption of the carbon dioxide desorbing bed.

Results: The model has been applied to a variety of run-time conditions for which we have CDRA version 4 ground test bed Engineering Unit (CDRA4-EU) data. In all cases, the carbon dioxide removal rate is predictively matched to within 10% of the CDRA4-eU data; this is better than expected, given the uncertainties in both the model inputs and the experimental conditions. The model is now being used to optimize the 4BMS design for exploration systems, where mass is at a premium.

Conclusions: The need for optimized atmosphere revitalization systems is necessitated by the aggressive new missions planned by NASA. Innovative approaches to new system development are required. This paper presents such an approach for the AES LSSP, where testing is supplemented with modeling and simulation to reduce costs. The application of the 1D COMSOL® model is beginning to provide design guidance, system optimization, and troubleshooting capabilities for atmosphere revitalization systems being considered for use in future exploration vehicles as well as for ISS CDRA.