Performance Characterization and Simulation of Amine-Based Vacuum Swing Adsorption Units for Spacesuit Carbon Dioxide and Humidity Control

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Controlling carbon dioxide (CO_2) and water (H_2O) concentrations in the vapor phase of a space suit is critical to ensuring an astronauts safety, comfortability, and capability to perform extra-vehicular activity (EVA) tasks. Historically, this has been accomplished using lithium hydroxide (LiOH) and metal oxides (MetOx). Lithium hydroxide is a consumable material and requires priming with water before it becomes effective at removing carbon dioxide. MetOx is regenerable through a power-intensive thermal cycle but is significantly heavier on a volume basis than LiOH. As an alternative, amine-based vacuum swing beds are under aggressive development for EVA applications which control atmospheric concentrations of both CO_2 and H_2O through a fully-regenerative process. The current concept, referred to as the rapid cycle amine (RCA), has resulted in numerous laboratory prototypes. Performance of these prototypes have been assessed and documented from experimental and theoretical perspectives. To support developmental efforts, a first principles model has also been established for the vacuum swing adsorption technology.

The efforts documented herein summarize performance characterization and simulation results for several variable metabolic profiles subjected to the RCA. Furthermore, a variety of control methods are explored including timed swing cycles, instantaneous CO_2 feedback control, and time-averaged CO_2 feedback control. A variety of off-nominal tests are also explored including high/low suit temperatures, increasingly high humidity cases, and dynamic pressure cases simulating the suit pre-breathe protocol. Consequently, this work builds on efforts previous efforts to fully bound the performance of the rapid cycle amine under a variety of nominal and off-nominal conditions.

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