Direct Modeling of Packed Bed Channeling

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Abstract

An analysis to quantify the effects of packed bed channeling in the narrow passages of the ISS (International Space Station) CDRA (Carbon Dioxide Removal Assembly) is presented. The CDRA contains two pelletized adsorbent beds to remove CO2 respired by the crew. Each CO2 adsorbent bed is paired with an upstream desiccant bed to condition the inlet air (i.e. remove water vapor) prior to entry into the adsorbent bed. While one adsorbent bed is actively capturing CO2 at near ambient pressure the other is regenerated through applied heat and vacuum desorption. The heaters and associated fins form many small axial channels through the length of the adsorbent beds (which are approximately 10mm x 15mm in cross section). The channels are filled with spherical adsorbent pellets less than 2.5mm in diameter such that each channel span may only contain 4-6 pellets across. At this small size wall effects may be laterally felt deep into the channel domain and increased bed porosity near the wall may affect axial pressure drop, lateral heat transfer and adsorbent performance. The small size of a single adsorbent bed channel provides a unique opportunity to attack this low Reynolds number, three dimensional flow problem directly with the pellet geometry immersed in the flow field formed by the channel heater and fin walls. COMSOL Multiphysics® software is utilized to model a truncated channel in three dimensions and investigate the suitability of empirical relations for use in one dimensional bed models. Results from the 3D simulation are presented and contrasted against empirical pressure drop and heat transfer correlations for packed bed flow under vacuum desorption and ambient pressure adsorption conditions.