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CARBON DIOXIDE REMOVAL SYSTEM FOR CLOSED LOOP ATMOSPHERE REVITALIZATION, PACKED BED AND STRUCTURED SORBENT EXPERIMENTAL TEST RESULTS

Abstract

The state-of-the-art carbon dioxide removal system for closed loop atmosphere revitalization is the 4-bed molecular sieve currently operating on the International Space Station. This spaceflight adsorption system as well as conventional commercial systems use packed beds filled with pellets that are composed of zeolite crystals and clay binder. One drawback to packed beds is the production and release of fines into process air. Fines are generated when pellets rub together due to fluidic and thermally induced movement of pellets. A second drawback of packed beds is their poor thermal conductivity, retarding the escape of the heat of adsorption. The high temperatures generated during adsorption limit further adsorption. During bed regeneration, or desorption, the effect is reversed, with low temperatures limiting further desorption. Finally, poor thermal conductivity makes evenly heating the sorbent difficult and results in complex and space wasting heater designs. Structured sorbents are emerging in the separations industry as a new approach to sorbent systems. Structured sorbents are produced as monoliths, with an open structure for airflow, or by fixing sorbents on an inert substrate such as paper-like honeycomb structures or expanded metal sheets. This approach provides two important advantages over conventional packed beds. First, a well designed structured sorbent is not subject to attrition as is a packed bed. Secondly, by using a thermally conductive substrate, the heat of adsorption can be transferred out of the bed, possibly to the cold desorbing bed if geometry permits. However, structured sorbents must be evaluated to determine their applicability to commercial process and space flight. It must be shown that, in addition to providing a more robust solution, the resource requirements (i.e., weight, power, volume, etc.) are similar to, if not less than, the state-of-the-art packed bed configuration An accurate assessment of structured sorbents and comparison with packed bed designs is desirable as soon as possible. Experimental results show unanticipated variation in packed bed breakthrough for identical beds held (as much as possible) to same conditions. It is suspected that small packing irregularities can propagate downstream in large beds and impact process efficiency. This indicates a margin of error inherent in packed bed fabrication and likely superiority of structured sorbents for process efficiency and control. This paper discusses experimental results from packed bed tests and structured sorbent tests.