Centrifugal Sieve for Gravity-Level-Independent Size Segregation of Granular Materials

Centrifugal force can significantly shorten the time to segregate feedstock into a set of different-sized fractions.

John H. Glenn Research Center, Cleveland, Ohio

Conventional size segregation or screening in batch mode, using stacked vibrated screens, is often a time-consuming process. Utilization of centrifugal force instead of gravity as the primary body force can significantly shorten the time to segregate feedstock into a set of different-sized fractions. Likewise, under reduced gravity or microgravity, a centrifugal sieve system would function as well as it does terrestrially. When vibratory and mechanical blade sieving screens designed for terrestrial conditions were tested under lunar gravity conditions, they did not function well. The centrifugal sieving design of this technology overcomes the issues that prevented sieves designed for terrestrial conditions from functioning under reduced gravity.

These sieves feature a rotating outer (cylindrical or conical) screen wall, rotating fast enough for the centrifugal forces near the wall to hold granular material against the rotating screen. Conventional centrifugal sieves have a stationary screen and rapidly rotating blades that shear the granular solid near the stationary screen, and effect the sieving process assisted by the airflow inside the unit. The centrifugal sieves of this new design may (or may not) have an inner blade or blades, moving relative to the rotating wall screen. Some continuous flow embodiments would have no inner auger or blades, but achieve axial motion through vibration. In all cases, the shearing action is gentler than conventional centrifugal sieves, which have very high velocity differences between the stationary outer screen and the rapidly rotating blades. The new design does not depend on airflow in the sieving unit, so it will function just as well in vacuum as in air.

One advantage of the innovation for batch sieving is that a batch-mode centrifugal sieve may accomplish the same sieving operation in much less time than a conventional stacked set of vibrated screens (which utilize gravity as the primary driving force for size separation). In continuous mode, the centrifugal sieves can provide steady streams of fine and coarse material separated from a mixed feedstock flow stream. The centrifugal sieves can be scaled to any desired size and/or mass flow rate. Thus, they could be made in sizes suitable for small robotic exploratory missions, or for semi-permanent processing of regolith for extraction of volatiles of minerals.

An advantage of the continuous-mode system is that it can be made with absolutely no gravity flow components for feeding material into, or for extracting the separated size streams from, the centrifugal sieve. Thus, the system is capable of functioning in a true microgravity environment. Another advantage of the continuous-mode system is that some embodiments of the innovation have no internal blades or vanes, and thus, can be designed to handle a very wide range of feedstock sizes, including occasional very large oversized pieces, without jamming or seizing up.

This work was done by Otis R. Walton of Grainflow Dynamics, Inc.; Christopher Dreyer of the Colorado School of Mines; and Edward Riedel of Ned Riedel Engineering, LLC for Glenn Research Center. For more information, contact kimberly.a.dalgleish@nasa.gov.

Inquiries concerning rights for the commercial use of this invention should be addressed to NASA Glenn Research Center, Innovative Partnerships Office, Attn: Steven Fedor, Mail Stop 4–8, 21000 Brookpark Road, Cleveland, Ohio 44135. Refer to LEW-19033-1.

Ion Exchange Technology Development in Support of the Urine Processor Assembly

Resins can filter gypsum out of urine, improving the water recovery rate.

Lyndon B. Johnson Space Center, Houston, Texas

The urine processor assembly (UPA) on the International Space Station (ISS) recovers water from urine via a vacuum distillation process. The distillation occurs in a rotating distillation assembly (DA) where the urine is heated and subjected to sub-ambient pressure. As water is removed, the original organics, salts, and minerals in the urine become more concentrated and result in urine brine. Eventually, water removal will concentrate the urine brine to super saturation of individual constituents, and precipitation occurs. Under typical UPA DA operating conditions, calcium sulfate or gypsum is the first chemical to precipitate in substantial quantity. During preflight testing with ground urine, the UPA achieved 85% water recovery without precipitation.

However, on ISS, it is possible that crewmember urine can be significantly more concentrated relative to urine from ground donors. As a result, gypsum precipitated in the DA when operating at water recovery rates at or near 85%, causing the failure and subsequent replacement of the DA. Later investigations have demonstrated that an excess of calcium and sulfate will cause precipitation at water recovery rates greater than 70%. The source of the excess calcium is likely physiological in nature, via crewmembers' bone loss, while the excess sulfate is primarily due to the sulfuric acid component of the urine pretreatment. To prevent gypsum precipitation in the UPA, the Precipitation Prevention Project (PPP) team has focused on removing the calcium ion from pretreated urine, using ion exchange resins as calcium removal agents. The selectivity and effectiveness of ion exchange resins are determined by such factors as the mobility of the liquid phase through the polymer matrix, the density of functional groups, type of functional groups bound to the matrix, and the chemical characteristics of the liquid phase (pH, oxidation potential, and ionic strength).

Previous experience with ion exchange resins has demonstrated that the most effective implementation for an ion exchange resin is a cartridge, or column, in which the resin is contained. Based on the results of equilibrium and sub-scale dynamic column testing, a possible solution for mitigating the calcium precipitation issue on the ISS has been identified. From an original pool of 13 ion exchange resins, two candidates have been identified that demonstrate substantial calcium removal on the sub-scale. The dramatic reduction in resin performance from published calcium uptake demonstrates the need for thorough evaluation of resins at the low pH and strong oxidizing environment present in the UPA. Chemical variations in the influent (calcium concentrations and pretreatment dosing) appear to have a noticeable impact on the calcium capacity of the resin. Low calcium concentrations and high pretreatment dosing will likely result in a decrease in calcium capacity. Conversely, low pretreatment dosing will likely result in an increase in calcium capacity. In contrast, investigations at a variety of flow rates, length-to-diameter ratios, resin volumes, and flow regimes (continuous versus pulsed) show that changes in physical parameters do not have substantial impacts on resin performance in the very low specific velocity ranges of interest. This result is particularly useful because most commercial applications at higher specific velocities do show a relatively strong relationship between flow and capacity. The lack of a strong relationship will allow more flexibility in the implementation of an ion exchange bed for flight. Verification of subscale tests with flight-scale resin beds is recommended prior to implementation in the on-orbit UPA.

This work was done by Julie Mitchell, James Broyan, and Karen Pickering of Johnson Space Center. Further information is contained in a TSP (see page 1). MSC-25338-1

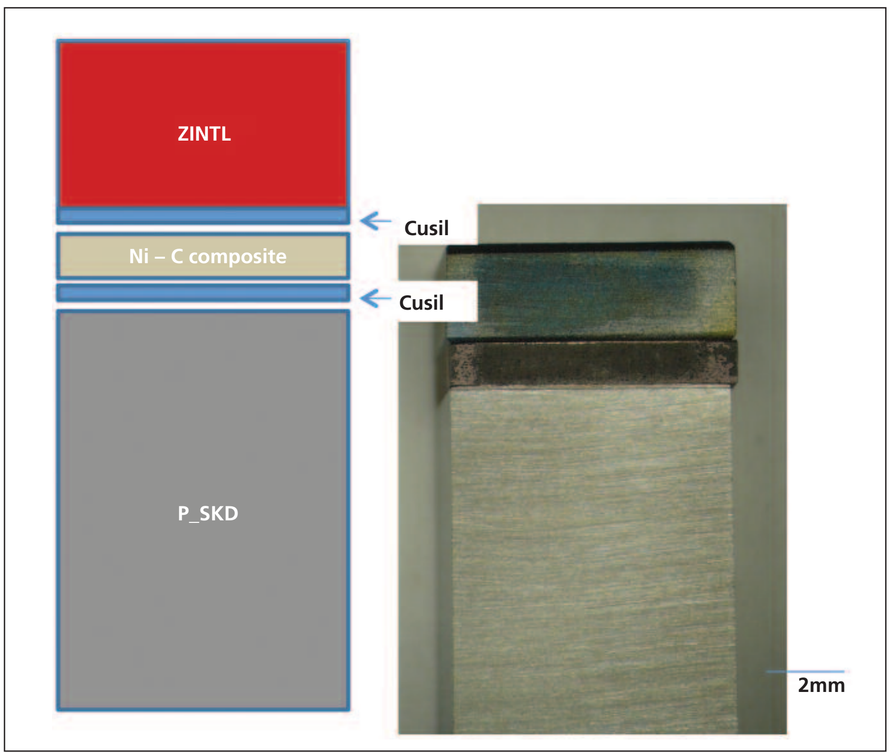
Nickel-Graphite Composite Compliant Interface and/or Hot Shoe Material

This innovation is a technique for joining various thermoelectric materials into segmented device architectures.

NASA's Jet Propulsion Laboratory, Pasadena, California

Next-generation high-temperature thermoelectric-power-generating devices will employ segmented architectures and will have to reliably withstand thermally induced mechanical stresses produced during component fabrication, device assembly, and operation. Thermoelectric materials have typically poor mechanical strength, exhibit brittle behavior, and possess a wide range of coefficient of thermal expansion (CTE) values. As a result, the direct bonding at elevated temperatures of these materials to each other to produce segmented leg components is difficult, and often results in localized microcracking at interfaces and mechanical failure due to the stresses that arise from the CTE mismatch between the various materials. Even in the absence of full mechanical failure, degraded interfaces can lead to increased electrical and thermal resistances, which adversely impact conversion efficiency and power output.

The proposed solution is the insertion of a mechanically compliant layer, with high electrical and thermal conductivity, between the low- and high-temperature



The freestanding segmented Zintl/skutterudite leg fabricated using a **Nickel-Graphite Composite-Based Compliant Layer** brazed to the metalized surfaces of the Zintl and skutterudite (SKD) segments.