Machinery/Automation

Centrifugal Adsorption Cartridge System

Notable features include efficient collection of bioproducts and removal of bubbles.

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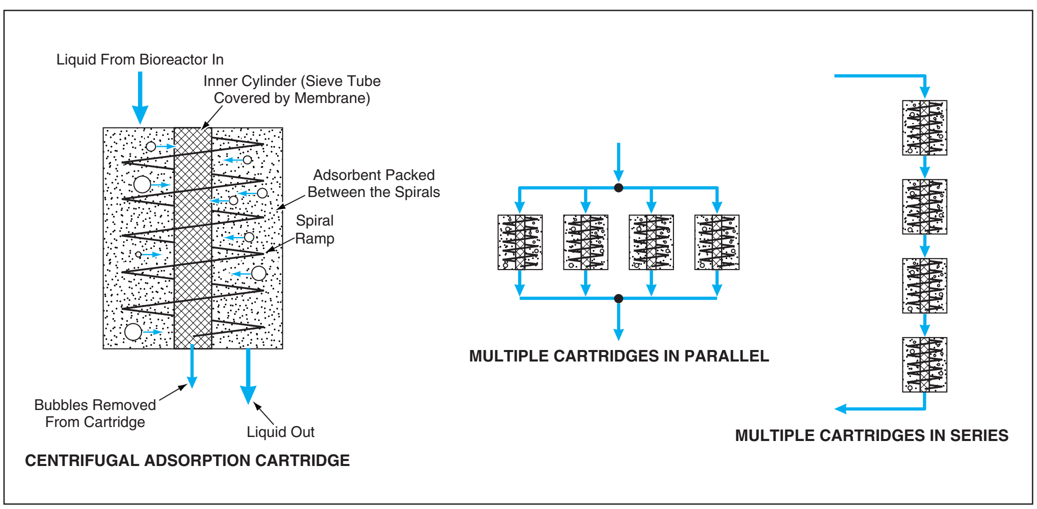
The centrifugal adsorption cartridge system (CACS) is an apparatus that recovers one or more bioproduct(s) from a dilute aqueous solution or suspension flowing from a bioreactor. The CACS can be used both on Earth in unit gravity and in space in low gravity. The CACS can be connected downstream from the bioreactor; alternatively, it can be connected into a flow loop that includes the bioreactor so that the liquid can be recycled.

A centrifugal adsorption cartridge in the CACS (see figure) includes two concentric cylinders with a spiral ramp between them. The volume between the inner and outer cylinders, and between the turns of the spiral ramp is packed with an adsorbent material. The inner cylinder is a sieve tube covered with a gas-permeable, hydrophobic membrane.

During operation, the liquid effluent from the bioreactor is introduced at one end of the spiral ramp, which then constrains the liquid to flow along the spiral path through the adsorbent material. The spiral ramp also makes the flow more nearly uniform than it would otherwise be, and it minimizes any channeling other than that of the spiral flow itself.

The adsorbent material is formulated to selectively capture the bioproduct(s) of interest. The bioproduct(s) can then be stored in bound form in the cartridge or else eluted from the cartridge.



In a **Centrifugal Adsorption Cartridge**, the liquid effluent from a bioreactor is channeled along a spiral flow path through a selectively adsorbent material. The length of the spiral path contributes to efficient collection of a bioproduct suspended or dissolved in the liquid. Multiple centrifugal adsorption cartridges can be connected in series or parallel.

The centrifugal effect of the spiral flow is utilized to remove gas bubbles from the liquid. The centrifugal effect forces the bubbles radially inward, toward and through the membrane of the inner cylinder. The gas-permeable, hydrophobic membrane allows the bubbles to enter the inner cylinder while keeping the liquid out. The bubbles that thus enter the cylinder are vented to the atmosphere. The spacing between the ramps determines rate of flow along the spiral, and thereby affects the air-bubble-removal efficiency. The spacing between the ramps also determines the length of the fluid path through the cartridge adsorbent, and thus affects the bioproduct-capture efficiency of the cartridge.

Depending on the application, several cartridges could be connected in a serial or parallel flow arrangement. A parallel arrangement can be used to increase product-capturing and flow capacities while maintaining a low pressure drop. A serial arrangement can be used to obtain high product-capturing capacity; alternatively, series-connected cartridges can be packed with different adsorbents to capture different bioproducts simultaneously.

This work was done by Steve R. Gonda of **Johnson Space Center** *and Yow-Min D. Tsao and Wenshan Lee of Wyle Laboratories.*

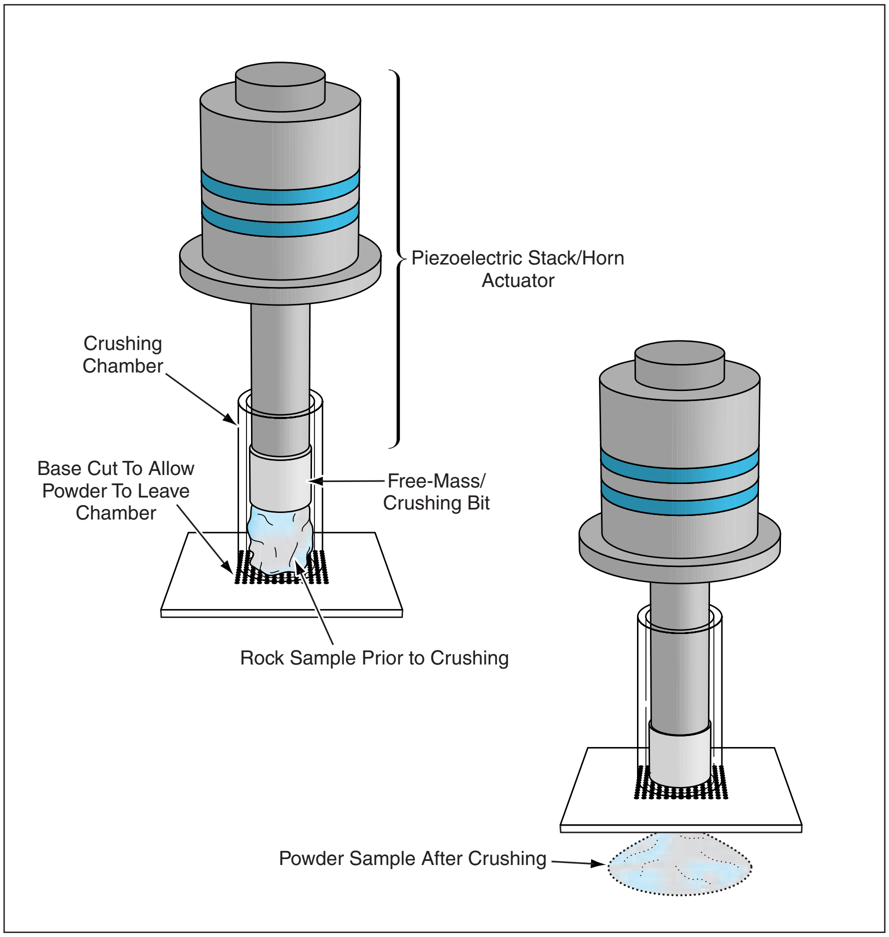
This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Johnson Space Center, (281) 483-0837. Refer to MSC-22863.

Ultrasonic Apparatus for Pulverizing Brittle Material

Characteristics include light weight, low preload, and low power demand.

NASA's Jet Propulsion Laboratory, Pasadena, California

The figure depicts an apparatus that pulverizes brittle material by means of a combination of ultrasonic and sonic vibration, hammering, and abrasion. The basic design of the apparatus could be specialized to be a portable version for use by a geologist in collecting powdered rock samples for analysis in the field or in a laboratory. Alternatively, a larger benchtop version could be designed for milling and mixing of precursor powders for such purposes as synthe-



Driven by the Piezoelectric Stack/Horn Actuator, the free-mass hammers the rock sample in the crushing chamber. Particles of rock leave the chamber through a sieve-covered hole at the bottom.

sis of ceramic and other polycrystalline materials or preparing powder samples for x-ray diffraction or x-ray fluorescence measurements to determine crystalline structures and compositions. Among the most attractive characteristics of this apparatus are its light weight and the ability to function without need for a large preload or a large power supply: It has been estimated that a portable version could have a mass <0.5 kg, would consume less than 1 W·h of energy in milling a 1-cm^3 volume of rock, and could operate at a preload <10 N.

The basic design and principle of operation of this apparatus are similar to those of other apparatuses described in a series of prior *NASA Tech Briefs* articles, the two most relevant being "Ultrasonic/Sonic Drill/Corers With Integrated Sensors" (NPO-20856), Vol. 25, No. 1 (January 2001), page 38 and "Ultrasonic/Sonic Mechanisms for Deep Drilling and Coring" (NPO-30291), Vol. 27, No. 9 (September 2003), page 65. As before, vibrations are excited by means of a piezoelectric actuator, an ultrasonic horn, and a mass that is free to move axially over a limited range. As before, the ultrasonic harmonic motion of the horn drives the free-mass in a combination of ultrasonic harmonic and lower-frequency hammering motion.

In this case, the free-mass is confined within a hollow cylinder that serves as a crushing chamber, and the free-mass serves as a crushing or milling tool. The hammering of the free-mass against a material sample at the lower end of the chamber grinds the sample into powder in a relatively short time. The restriction of the free-mass to axial motion only makes the grinding very efficient. The free-mass can be fabricated to have teeth on its lower face to enhance the grinding effect. Optionally, there can be a hole at the bottom of the chamber covered with a sieve to tailor the size distribution of the powder leaving the crushing chamber.

This work was done by Stewart Sherrit, Xiaoqi Bao, Yoseph Bar-Cohen, Benjamin Dolgin, and Zensheu Chang of Caltech for **NASA's Jet Propulsion Laboratory**. *Further information is contained in a TSP (see page 1).*
NPO-30682