



## ✦ Powder-Collection System for Ultrasonic/Sonic Drill/Corer

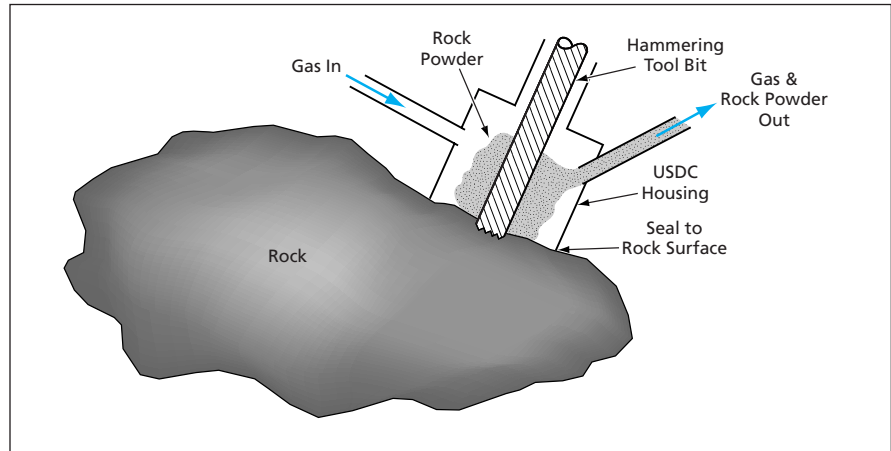
**Powder is blown from the drill/rock interface to sampling locations.**

*NASA's Jet Propulsion Laboratory, Pasadena, California*

A system for collecting samples of powdered rock has been devised for use in conjunction with an ultrasonic/sonic drill/corer (USDC)— a lightweight, low-power apparatus designed to cut into, and acquire samples of, rock or other hard material for scientific analysis. The USDC was described in "Ultrasonic/Sonic Drill/Corers With Integrated Sensors" (NPO-20856), *NASA Tech Briefs*, Vol. 25, No. 1 (January 2001), page 38. To recapitulate: The USDC includes a drill bit, corer, or other tool bit, in which ultrasonic and sonic vibrations are excited by an electronically driven piezoelectric actuator. The USDC advances into the rock or other material of interest by means of a hammering action and a resulting chiseling action at the tip of the tool bit. The hammering and chiseling actions are so effective that unlike in conventional twist drilling, a negligible amount of axial force is needed to make the USDC advance into the material. Also unlike a conventional twist drill, the USDC operates without need for torsional restraint, lubricant, or a sharp bit.

The USDC generates powder as a byproduct of the drilling or coring process. The purpose served by the present sample-collection system is to remove the powder from the tool-bit/rock interface and deliver the powder to one or more designated location(s) for analysis or storage.

The sample-collection system includes parts that are integrated into the USDC



**Powdered Rock** is generated by the hammering action of the tool bit, then entrained in a high-pressure pulse of gas flowing from the inlet, through the outlet, to one or more location(s) for analysis or storage.

(see figure). The USDC is designed so that when the tool bit is brought into contact with the rock, a circular bellows or knife-edge seal at the lower end of the USDC housing is also pressed against the rock, partially sealing the volume enclosed by the USDC housing and the rock face. From time to time during operation of the tool bit, a high-pressure pulse of gas is blown into the volume through an inlet. The resulting flow of gas entrains particles of powder and carries them away through an outlet.

A screen along the path of the powder/gas mixture is used to trap particles above a predetermined size while allowing

acceptably small particles to proceed. The powder can then be further processed in any of several ways. For example, it can be trapped on a porous or adhesive tape for delivery to an instrument or for storage, mixed with fluids by use of a sonicator, or blown into a heating chamber for thermal treatment and analysis.

*This work was done by Stewart Sherrit, Yoseph Bar-Cohen, Xiaoqi Bao, and Zensheu Chang of Caltech for NASA's Jet Propulsion Laboratory and by David Blake of Ames Research Center and Charles Bryson of Bryson Consulting for Ames Research Center. Further information is contained in a TSP (see page 1). NPO-40564*

## ✦ Semiautomated, Reproducible Batch Processing of Soy

**Processing conditions are selectable and are consistent from batch to batch.**

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A computer-controlled apparatus processes batches of soybeans into one or more of a variety of food products, under conditions that can be chosen by the user and reproduced from batch to batch. Examples of products include soy milk, tofu, okara (an insoluble protein and fiber byproduct of soy milk), and whey. Most processing steps take place without intervention by

the user. This apparatus was developed for use in research on processing of soy. It is also a prototype of other soy-processing apparatuses for research, industrial, and home use.

Prior soy-processing equipment includes household devices that automatically produce soy milk but do not automatically produce tofu. The designs of

prior soy-processing equipment require users to manually transfer intermediate solid soy products and to press them manually and, hence, under conditions that are not consistent from batch to batch. Prior designs do not afford choices of processing conditions: Users cannot use previously developed soy-processing equipment to investigate the

effects of variations of techniques used to produce soy milk (e.g., cold grinding, hot grinding, and pre-cook blanching) and of such process parameters as cooking times and temperatures, grinding times, soaking times and temperatures, rinsing conditions, and sizes of particles generated by grinding. In contrast, the present apparatus is amenable to such investigations.

The apparatus (see figure) includes a processing tank and a jacketed holding or coagulation tank. The processing tank can be capped by either of two different heads and can contain either of two different insertable mesh baskets. The first head includes a grinding blade and heating elements. The second head includes an automated press piston. One mesh basket, designated the okara basket, has oblong holes with a size equivalent to about 40 mesh [40 openings per inch ( $\approx 16$  openings per cen-

timeter)]. The second mesh basket, designated the tofu basket, has holes of 70 mesh [70 openings per inch ( $\approx 28$  openings per centimeter)] and is used in conjunction with the press-piston head. Supporting equipment includes a soy-milk heat exchanger for maintaining selected coagulation temperatures, a filter system for separating okara from other particulate matter and from soy milk, two pumps, and various thermocouples, flowmeters, level indicators, pressure sensors, valves, tubes, and sample ports.

A typical process carried out in this apparatus comprises the following steps:

1. Dry soybeans are placed into the okara basket of the processing tank.
2. The grinding/heating head is put in place, and a drain valve in the tank closes automatically.
3. Water is added to the tank automatically, and the beans are soaked for a programmed time.

4. The drain valve opens automatically to dump the soaking water.

5. The beans are rinsed and drained automatically a selected number of times, each time using a selected amount at a selected temperature.

6. The valve closes, and a selected amount of water at a selected temperature is added automatically. The beans can then be cooked, blanched, and/or ground as chosen by the user. For the sake of example only, the subsequent steps are based on a process known in the soy industry as the Illinois cook process.

7. The beans are blanched for a selected time.

8. Blanching stops automatically and the valve opens, draining the blanching water.

9. The beans are automatically rinsed with cold water, which is then drained.

10. The valve closes. A selected amount of water chilled to a selected temperature is added to the beans automatically.

11. The beans are automatically ground and cooked as user has specified.

12. The user removes the grinder/heater head and replaces it with the press head.

13. Warm water automatically begins to circulate in the holding or coagulation tank.

14. Chilled water is fed to the heat exchanger.

15. The valve opens, and soy milk is automatically pumped through the heat exchanger and selected filters. The soy milk reaches the holding tank at a specified temperature, coagulant is added, and the solution remains at that temperature until coagulation is complete.

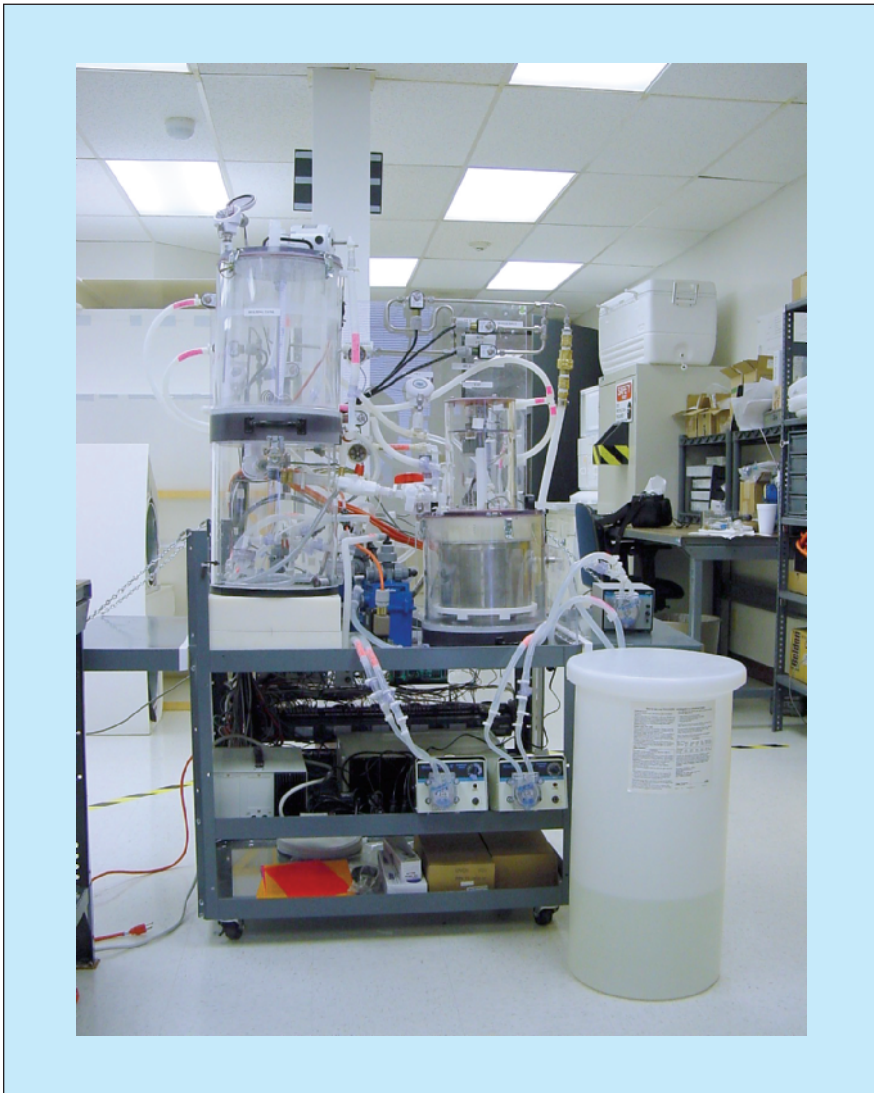
16. During coagulation, the press head and okara basket are removed from the processing tank, then the press head is reinserted with the tofu basket.

17. Once coagulation is complete, the mixture is made to flow back into the processing tank.

18. The piston is actuated to press the tofu according to the user's specification.

19. The piston is retracted, then the user removes the head, retrieves the basket, and adjusts the bottom of the basket to release the tofu.

*This work was done by Mary Toerne, Ivan W. Byford, Jack W. Chastain, and Beverly E. Swango of Johnson Engineering Corp. for Johnson Space Center. For further information, contact the Johnson Commercial Technology Office at (281) 483-3809. MSC-23313*



This **Laboratory Apparatus** is a prototype of scientific, industrial, and household soy-processing systems for processing batches of soy under selectable, reproducible conditions.