Miniature Piezoelectric Shaker for Distribution of Unconsolidated Samples to Instrument Cells

This design could be applicable for handling powders in the pharmaceutical industry.

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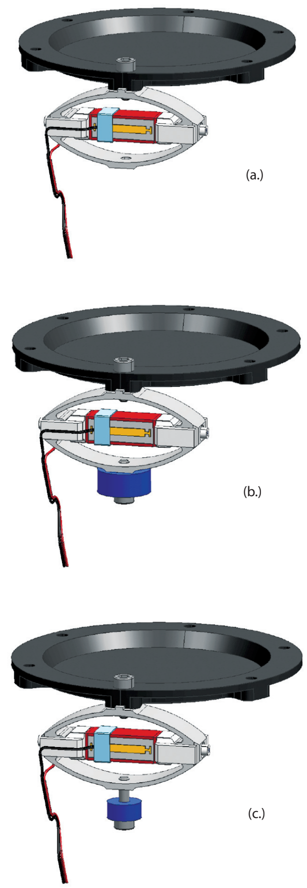
The planned Mars Science Laboratory mission requires inlet funnels for channeling unconsolidated powdered samples from the sampling and sieving mechanisms into instrument test cells, which are required to reduce cross-contamination of the samples and to minimize residue left in the funnels after each sample transport. To these ends, a solid-state shaking mechanism has been created that requires low power and is lightweight, but is sturdy enough to survive launch vibration.

The funnel mechanism is driven by asymmetrically mounted, piezoelectric flexure actuators that are out of the load path so that they do not support the funnel mass. Each actuator is a titanium, flextensional piezoelectric device driven by a piezoelectric stack. The stack has Invar endcaps with a half-spherical recess. The Invar is used to counteract the change in stress as the actuators are cooled to Mars' ambient temperatures. A ball screw is threaded through the actuator frame into the recess to apply pre-stress, and to trap the piezoelectric stack and endcaps in flexure. During the vibration cycle of the flextensional actuator frame, the compression in the piezoelectric stack may decrease to the point that it is unstressed; however, because the ball joint cannot pull, tension in the piezoelectric stack cannot be produced. The actuators are offset at 120°. In this flight design, redundancy is required, so three actuators are used though only one is needed to assist in the movement.



A graphic of the **Actuator Mechanism** mounted on the funnel rim out of the load path. The other end of the flexure can be modified to (a) be free, (b) drive a fixed mass, or (c) drive a free mass at low resonance and produce impacts.

The funnel is supported at three contact points offset to the hexapod support contacts. The actuator surface that does not contact the ring is free to expand. Two other configurations can be used to mechanically tune the vibration. The free end can be designed to drive a fixed mass, or can be used to drive a free mass to excite impacts (see figure). Tests on this funnel mechanism show a high density of resonance modes between 1 and 20 kHz. A subset of these between 9 and 12 kHz was used to drive the CheMin actuators at 7 V peak to peak. These actuators could be driven by a single resonance, or swept through a frequency range to decrease the possibility that a portion of the funnel surface was not coincident with a nodal line (line of no displacement).

The frequency of actuation can be electrically controlled and monitored and can also be mechanically tuned by the addition of tuning mass on the free end of the actuator. The devices are solid-state and can be designed with no macroscopically moving parts. This design has been tested in a vacuum at both Mars and Earth ambient temperatures ranging from –30 to 25 °C.

This work was done by Stewart Sherrit; Curtis E Tucker, Jr.; John Frankovich, and Xiaoqi Bao of Caltech for NASA's Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1). (see page 1)

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Lunar Soil Particle Separator

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The Lunar Soil Particle Separator (LSPS) beneficiates soil prior to *in situ* resource utilization (ISRU). It can improve ISRU oxygen yield by boosting the concentration of ilmenite, or other iron-oxide-bearing materials found in lunar soils, which can substantially reduce hydrogen reduction reactor size, as well as drastically decreasing the power input required for soil heating. LSPS particle size separations can be performed to "de-dust" regolith, and to improve ISRU reactor flow dynamics. LSPS mineral separations can be used to alter the sintering characteristics of lunar soil, and can also be used to separate and concentrate lunar materials useful for manufacture of structural materials, glass, and chemicals.

An initial centrifugal particle size separation is integrated by the LSPS and is followed by magnetic, gravity, and/or electrostatic separations. LSPS hardware for each unit operation exhibits favorable properties of low mass and low power requirements. A single feeder delivers soil to the system where sorted particles cascade by gravity to the next unit operation, or to product collection bins. The centrifugal particle separator avoids the use of heavy, eccentric drives that require high power input, and does not require the use of screens that can plug with near-size particles. The magnetic separator uses high-strength, permanent magnets and requires power only to ro-