Ultrasonic/Sonic Jackhammer

Advantages include low noise, low vibration, and low average power demand.

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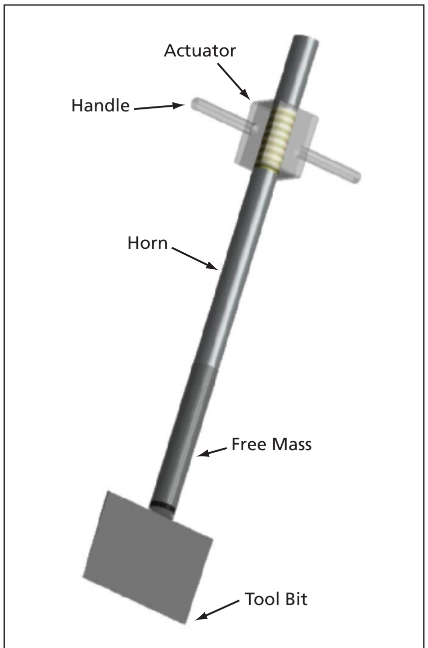
An ultrasonic/sonic jackhammer (USJ) is the latest in a series of related devices, the first of which were reported in "Ultrasonic/Sonic Drill/Corers With Integrated Sensors" (NPO-20856), *NASA Tech Briefs*, Vol. 25, No. 1 (January 2003), page 38. Each of these devices cuts into a brittle material by means of hammering and chiseling actions of a tool bit excited with a combination of ultrasonic and sonic vibrations. A small-scale prototype of the USJ has been demonstrated. A fully developed, full-scale version of the USJ would be used for cutting through concrete, rocks, hard asphalt, and other materials to which conventional pneumatic jackhammers are applied, but the USJ would offer several advantages over conventional pneumatic jackhammers, as discussed below.



The **Ultrasonic/Sonic Jackhammer** is driven electrically instead of pneumatically. It offers several advantages over a conventional pneumatic jackhammer.

In the USJ (see figure) as in the previously reported ultrasonic/sonic drill/corers (USDCs) and related devices, the actuator assembly includes a piezoelectric stack and a horn for mechanical amplification of the piezoelectric displacement. A cylindrical shank of a chisel-shaped tool bit is mounted on the lower end of the horn. A bobbin-like cylindrical mass is free to move axially through a limited range between the lower end of the horn and the upper end of the blade portion of the tool bit. The sharp edge of the bit is placed in contact with the rock or other hard material to be cut. Unlike a pneumatic jackhammer, the USJ need not be heavy because its principle of operation does not require a large contact force.

The piezoelectric stack is electrically driven at its resonance frequency, and a bolt holds the stack in compression to prevent fracture during operation. The free mass bounces between hard stops at the limits of its range of motion at a sonic frequency. The impacts of the free mass on the hard stops create stress pulses that propagate along the horn, to and through the tool bit, to the tool-bit/rock interface. The rock becomes fractured when its ultimate strain is exceeded.

A conventional pneumatic jackhammer generates enormous amounts of noise, along with severe vibrations that propagate back into the operator's body and that are so strong as to sometimes injure the operator. Every object encountered by the tool bit is damaged. This indiscriminate cutting action is particularly disadvantageous in situations in which there is a need to cut through concrete or asphalt without damaging such embedded objects as pipes, cables, and reinforcing steel bars.

In contrast, even a full-scale USJ would generate much less noise and much less back-propagating vibration. The full-scale USJ would also demand less average power. Moreover, on the basis of experience with the USDCs, it is expected that such relatively flexible materials as wood, plastics, metals, and human tissues will not be damaged by brief contact with the tool bit of the operating USJ. Yet another advantage is that like a USDC as described in the noted prior *NASA Tech Briefs* article, the USJ could be instrumented with mechanical-impedance sensors that could be used to obtain feedback to optimize the electrical excitation for cutting and/or to utilize the vibrations to probe the hard material in the vicinity of the tool bit.

This work was done by Yoseph Bar-Cohen and Stewart Sherrit of Caltech and Jack Herz of CTC for **NASA's Jet Propulsion Laboratory.** *Further information is contained in a TSP (see page 1).*

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Refer to NPO-40771, volume and number of this NASA Tech Briefs *issue, and the page number.*