Ultrasonic/Sonic Rotary-Hammer Drills

USDC cutting debris is removed by rotation of fluted drill bits.

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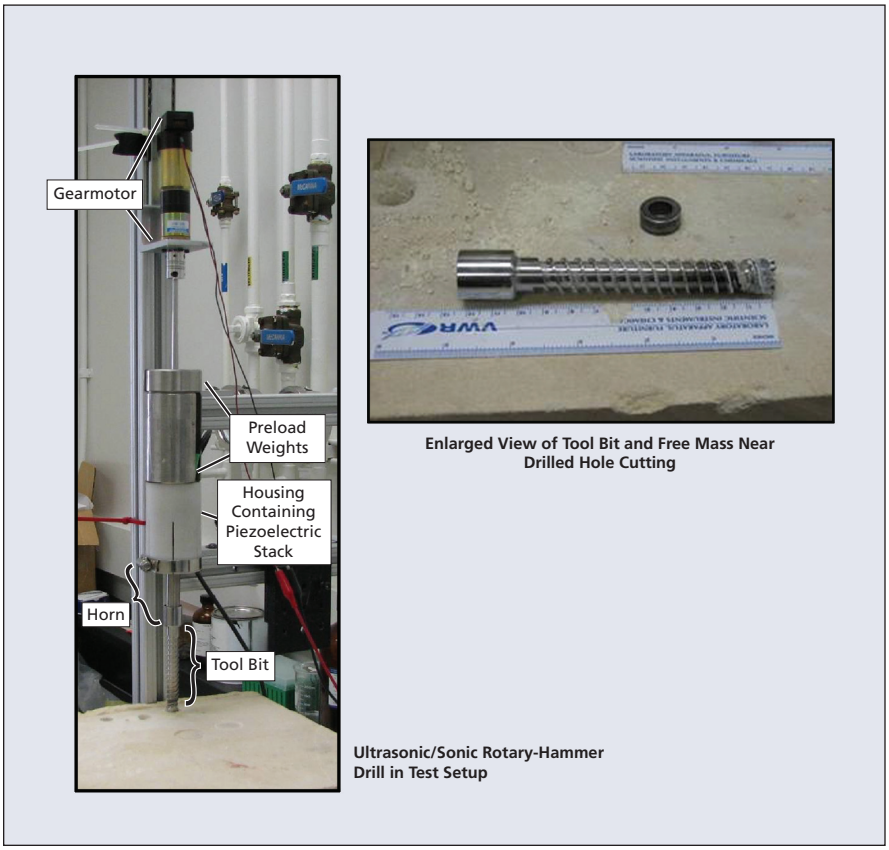
Ultrasonic/sonic rotary-hammer drill (USRoHD) is a recent addition to the collection of apparatuses based on ultrasonic/sonic drill corer (USDC). As described below, the USRoHD has several features, not present in a basic USDC, that increase efficiency and provide some redundancy against partial failure.

USDCs and related apparatuses were conceived for boring into, and/or acquiring samples of, rock or other hard, brittle materials of geological interest. They have been described in numerous previous *NASA Tech Briefs* articles.

To recapitulate: A USDC can be characterized as a lightweight, low-power, piezoelectrically driven jackhammer in which ultrasonic and sonic vibrations are generated and coupled to a tool bit. A basic USDC includes a piezoelectric stack, an ultrasonic transducer horn connected to the stack, a free mass ("free" in the sense that it can bounce axially a short distance between hard stops on the horn and the bit), and a tool bit. The piezoelectric stack creates ultrasonic vibrations that are mechanically amplified by the horn. The bouncing of the free mass between the hard stops generates the sonic vibrations. The combination of ultrasonic and sonic vibrations gives rise to a hammering action (and a resulting chiseling action at the tip of the tool bit) that is more effective for drilling than is the microhammering action of ultrasonic vibrations alone. The hammering and chiseling actions are so effective that unlike in conventional twist drilling, little applied axial force is needed to make the apparatus advance into the material of interest. There are numerous potential applications for USDCs and related apparatuses in geological exploration on Earth and on remote planets.

In early USDC experiments, it was observed that accumulation of cuttings in a drilled hole causes the rate of penetration of the USDC to decrease steeply with depth, and that the rate of penetration can be increased by removing the cuttings. The USRoHD concept provides for removal of cuttings in the same manner as that of a twist drill: An USRoHD includes a USDC and a motor with gearhead (see figure). The USDC provides the bit hammering and the motor provides the bit rotation. Like a twist drill bit, the shank of the tool bit of the USRoHD is fluted. As in the operation of a twist drill, the rotation of the fluted drill bit removes cuttings from the drilled hole.



The USRoHD Partly Resembles a Twist Drill in that it includes a USDC with a fluted tool bit, rotated by a gearmotor.

The USRoHD tool bit is tipped with a replaceable crown having cutting teeth on its front surface. The teeth are shaped to promote fracturing of the rock face through a combination of hammering and rotation of the tool bit. Helical channels on the outer cylindrical surface of the crown serve as a continuation of the fluted surface of the shank, helping to remove cuttings.

In the event of a failure of the USDC, the USRoHD can continue to operate with reduced efficiency as a twist drill. Similarly, in the event of a failure of the gearmotor, the USRoHD can continue to operate with reduced efficiency as a USDC.

This work was done by Mircea Badescu, Stewart Sherrit, Yoseph Bar-Cohen, Xiaoqi Bao, and Steve Kassab of Caltech for NASA's Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1).

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, NASA Management Office–JPL. Refer to NPO-44765.