Estimating Hardness From the USDC Tool-Bit Temperature Rise

Temperature rise during drilling is correlated with hardness of the drilled material.

NASA’s Jet Propulsion Laboratory, Pasadena, California

A method of real-time quantification of the hardness of a rock or similar material involves measurement of the temperature, as a function of time, of the tool bit of an ultrasonic/sonic drill corer (USDC) that is being used to drill into the material. The method is based on the idea that, other things being about equal, the rate of rise of temperature and the maximum temperature reached during drilling increase with the hardness of the drilled material.

In this method, the temperature is measured by means of a thermocouple embedded in the USDC tool bit near the drilling tip. [The concept of incorporating sensors into USDC tool bits was described in “Ultrasonic/Sonic Drill/Corers With Integrated Sensors” (NPO-20856), NASA Tech Briefs, Vol. 25, No. 1 (January 2001), page 38.] The hardness of the drilled material can then be determined through correlation of the temperature-rise-versus-time data with time-dependent temperature rises determined in finite-element simulations of, and/or experiments on, drilling at various known rates of advance or known power levels through materials of known hardness. The figure presents an example of empirical temperature-versus-time data for a particular 3.6-mm USDC bit, driven at an average power somewhat below 40 W, drilling through materials of various hardness levels.

The temperature readings from within a USDC tool bit can also be used for purposes other than estimating the hardness of the drilled material. For example, they can be especially useful as feedback to control the driving power to prevent thermal damage to the drilled material, the drill bit, or both. In the case of drilling through ice, the temperature readings could be used as a guide to maintaining sufficient drive power to prevent jamming of the drill by preventing re-freezing of melted ice in contact with the drill.

This work was done by Yoseph Bar-Cohen and Stewart Sherrit of Caltech for NASA’s Jet Propulsion Laboratory. For more information, contact iaoffice@jpl.nasa.gov. NPO-40132