Modeling of Coring Mechanics for Optimization of Mars Sample Acquisition Hardware

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While the study of Martian geology by robotic spacecraft has proven extremely valuable in developing an understanding of the planet's history, geologic samples returned to Earth would allow for vastly superior analyses. A significant engineering obstacle in returning samples to Earth is the acquisition and handling of structurally delicate, thermally sensitive, and chemically volatile rock cores. To ensure the success of a sample return mission, it is crucial to understand the fundamental phenomena that govern the production of cylindrical rock samples and optimize coring hardware to effectively produce such samples.

Purpose and Hypothesis

Of the extensive number of tunable parameters in coring hardware design and operation, I propose that a performance model can be constructed using a relatively small subset. I propose that the equivalent of a Reynolds number can be formed to link a few key inputs, such as axial weight on the bit and bit angular velocity to high level outputs of principle concern, such as bit penetration rate and rate of heat generation. Identifying important parameters and forming models are chief among my research goals.

Materials and Methods

Computer models based on classical stress solutions, such as Hertz contact stress, have been adapted to simulate complex indenter geometries. These models provide a basis for understanding static stress states produced by an axial weight on bit. Since geologic specimens are extremely brittle, tensile loading produces the majority of rock fracture and must be accurately predicted.

In addition, dynamic effects such as stress wave propagation generated from percussive bit impact is an important component of rock failure which needs to be understood and modeled. These waves, interacting with cracks in the rock produce conical failure patterns that may extend far beneath the impact surface.

Near-term future work includes the use of a 3D laser scanner to map the geometries of holes created by JPL Mars rover test hardware. These maps will be used to verify the roles of rotary and percussive forces in coring and to help view any unforeseen phenomena that may be occurring. Ultimately this technique will aid in helping to identify the parameters that play the largest role in determining coring performance.

Conclusions

Experimental tests performed by myself and others have shown that rotary-percussive techniques are most effective at penetrating rocks. Further study of dynamics in rock media and a more complete model for stress wave propagation are therefore crucial in determining how to model and optimize coring performance.

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Bibliography

http://www.allaboutgemstones.com/images/gem_fracture_conchoidal_obsidian.jpg

Further Information

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