Extreme Temperature Drill System for Venus Exploration A Breakthrough Development

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Extreme Temperature Drill System

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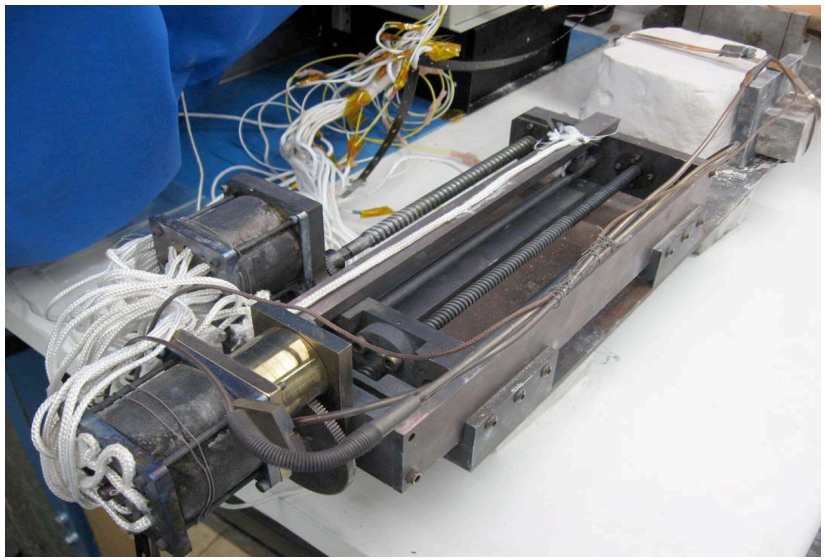
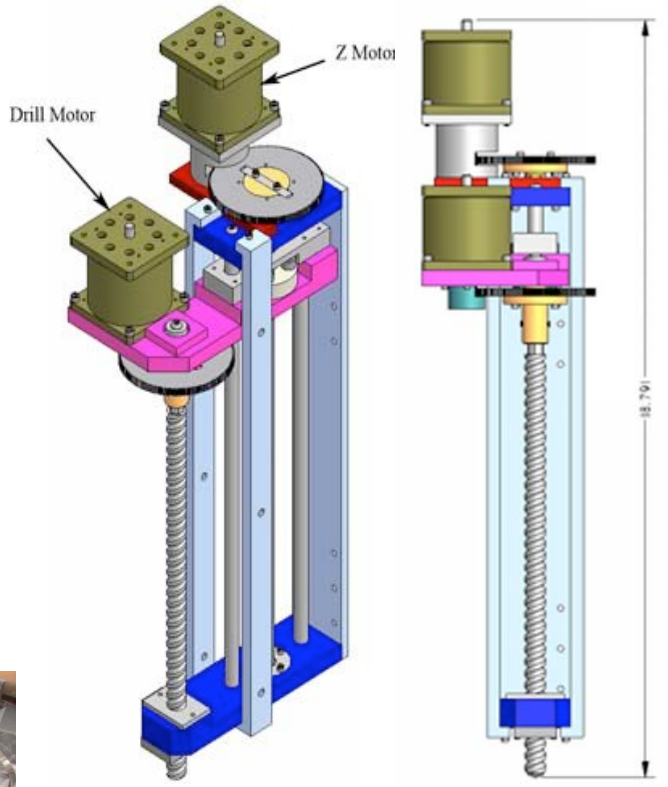
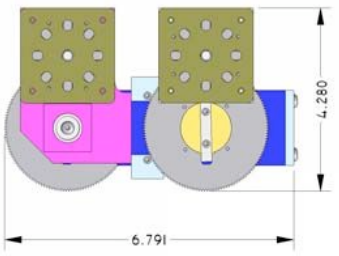
- The extreme temperature drill remains functional after operating more than 20 hours at 460C.
- The prototype high temperature drill can operate with low thrust reaction in low gravity environment. Overall envelope is 6.8 in x 4.3 in x 18.8 in with 10 inches of drill stroke. System was designed to fit existing test chamber.
- Two high temperature switched reluctance motors were integrated into the system to actuate the Z and Auger axes. Both were driven by the custom controller Honeybee has developed using sensorless control algorithm.
- Due to budget constraints, an off the shelf half inch diameter radial drill bit was integrated for this high temperature drill system. Other components of the drill including gears, bearings and bushings were all selected based on the requirement to survive temperatures above a minimum of 460°C, at earth atmosphere.







Extreme Temperature Drill System

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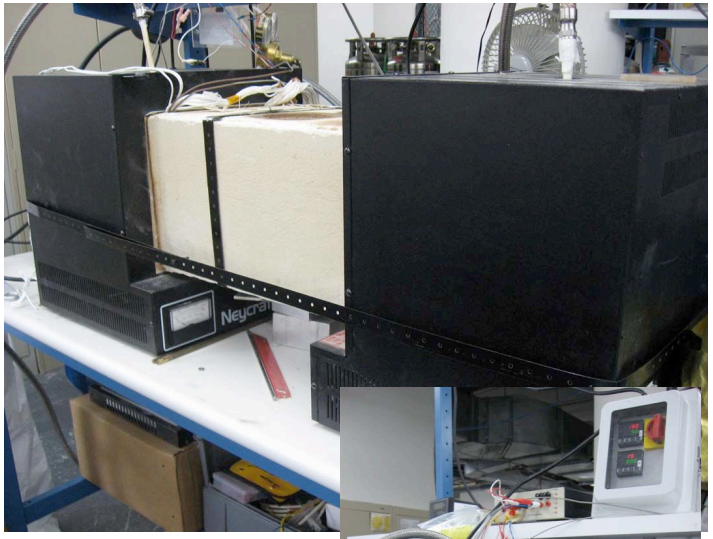
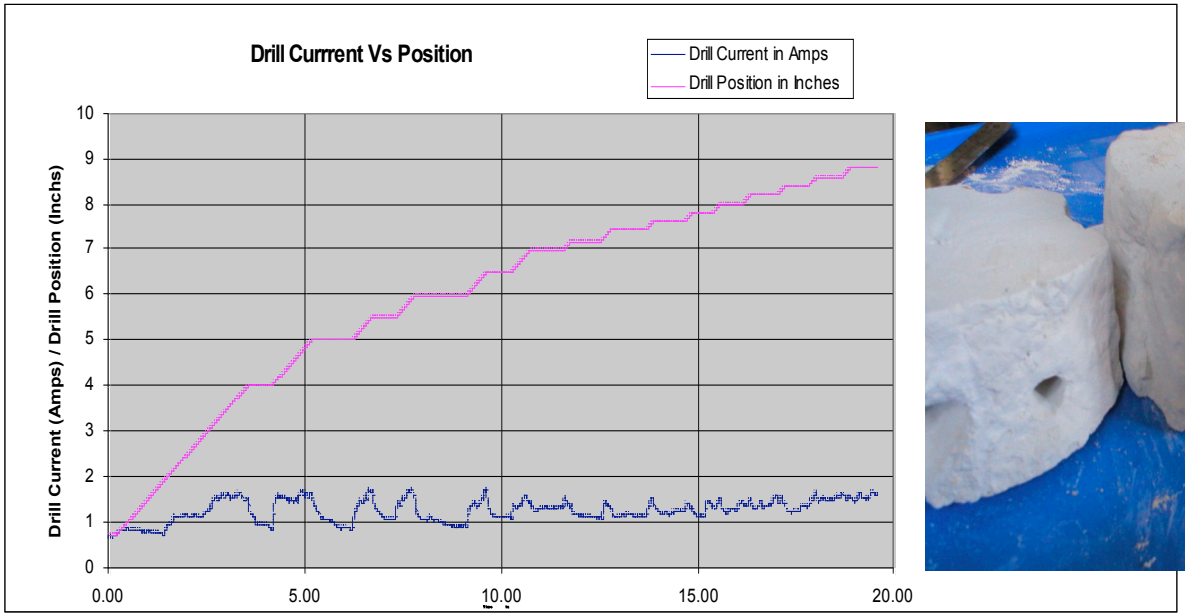
- A test chamber was built with two furnaces, capable of operating at temperatures between 200°C (392°F) and 1100°C (2012°F).
- Constant CO2 purge provided a decrease in O2 content from about 20% to about 5% by volume to roughly simulate Venus surface conditions.
- The drill was tested at 460°C three times and drilled 6" deep into chalk during each test.
- Typical test data show that the drill's average Z-axis rate, in chalk, is about 0.3 in/min (6 inches in about 20 minutes); average drilling current is about 1.5 amps at 400 rpm.





High Temperature Motor Breakthrough

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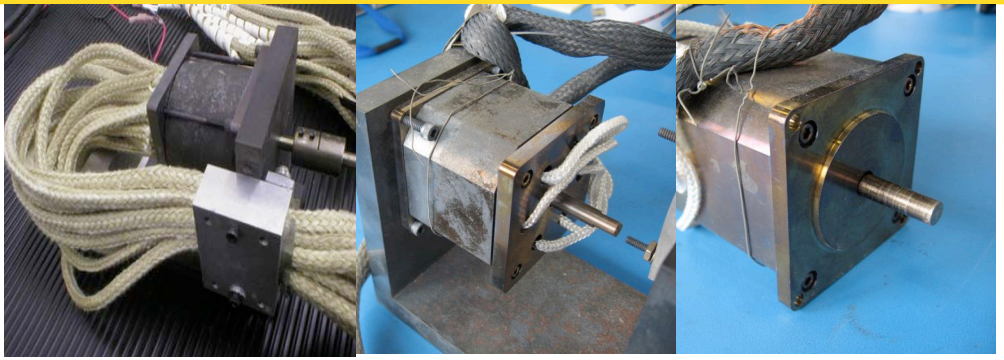
- Two types of motors have been developed, all materials and components are rated above 460°C:
  - Switched Reluctance Motor
  - DC Brushless Motor with resolver
- The next generation BLDC motor and resolver will be integrated into a high temperature sample acquisition scoop and high temperature joint (awarded SBIR Phase II in October, 2007).
- Both the SR and BLDC motors will undergo extensive testing at Venus temperature and pressure (TRL6) and are expected to be mission ready before the next New Frontiers AO release.
- Scalable high temperature motor and bearing developments allow for creation of long lasting sample acquisition systems, booms, robot arms and even mobility systems. This allows for major restructuring of traditional Venus surface exploration scenarios.



Characteristics	Units	Maxon RE-25	SRM Prototype
		Range at 25°C	Range at 460°C
Applied Voltage	V	4.5 - 48	20 - 48
Maximum Speed	Rpm	5500	7500
No-Load Speed	rpm	4790 - 5500	7000-7500
No-Load Current	mA	7 - 80	1000-1200
Stall torque	mNm	119 - 144	200 – 250

Motor Characteristics Comparison of Existing Maxon RE-25 to Current SRM Prototype, all test data are from motor test controlled by a custom controller which we are still optimizing.