ROTARY PERCUSSIVE DRILLING IN A VACUUM CHAMBER: A TEST BED FOR LUNAR AND MARS DRILLING. K. Zacny[1], M. Maksymuk[1], J. Wilson[1], C. Santoro[1], P. Chu, G. Paulsen, M. Passaretti, D. Roberts, A. Kusack, N. Kumar . Honeybee Robotics Spacecraft Mechanism Corporation (zacny@honeybeerobotics.com)

Introduction: There is a strong interest for drilling on extraterrestrial bodies. The applications for subsurface access on Mars are sampling water-ice in the regions of Phoenix Lander or assessing mineral potential of regolith on the Moon.

Honeybee Robotics developed a rotary-percussive test bed and a matching vacuum chamber for conducting drilling tests to a depth of 1 meter. Tests will investigate drilling telemetry as well as conduct scientific observations (e.g. volatile loss during drilling).

Rotary-Percussive Drill: The rotary percussive drill, shown in Figure 1, consists of 3 main components: the drill head, drill stand with a Z-axis lead screw, and drill string (auger) and bit. The drill head consists of two motors geared together to provide rotational motion to the drill string as well as a separate actuator for providing a percussive energy to the drill bit. This particular architecture enables varying rotary speed and percussive frequency independently of each other. The drill head also consists of an embedded slip ring assembly for transferring electrical power and data from the actuators or sensors (such as a thermocouple) inside a drill string to a data acquisition system laptop. In addition, an inline load cell system allows for accurate measurement of the Weight on Bit (WOB, or vertical drill force).

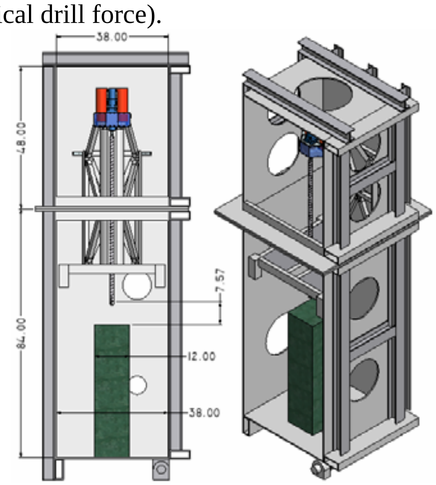

Figure 1. Vacuum chamber will house a rotary-percussive drill. Testing of planetary drills in relevant atmospheres is one of the most important aspects of any drill development.

Vacuum Chamber: Testing of planetary drills in relevant atmospheres is one of the most important aspects of any drill development [1, 2]. A matching vacuum chamber is being fabricated (Figure 1). This vacuum chamber is 11 feet tall, 38 inches wide and 38 inches deep. It consists of two chambers (the bottom one being 84 inches tall and the upper one being 48 inches tall) which can be operated individually.

Preliminary Tests: Preliminary testing has been conducted in lunar regolith simulants to assess the performance of various drill bits. Experiments were conducted in 10wt% water bound and frozen lunar regolith simulant. It was found that drilled holes in the sample were extremely smooth with no amount of hole collapse

A comparison of the performance of the PDC and WC bits at 60 RPM and a similar bit temperature of approximately -10°C shows that the PDC bit is more efficient (specific energy 169 MJ/m^3 vs. 212 MJ/m^3), but requires a higher WOB. Additional data is shown in Figure 4.

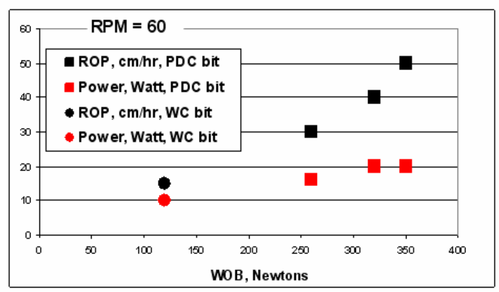

Figure 4. Power and rate of penetration for PDC and WC bits at 60 RPM and a bit temperature of -10° C.

Future tests: the future work will include investigation of drilling efficiencies in various formations (e.g.t JSC-1A) and various rocks. The regolith will be compacted with water saturated to different levels and cooled to different temperatures to determine the effect of these parameters on drilling efficiencies. The loss of volatiles (if applicable) and bit temperatures will be monitored. Different drill bits and auger designs will be tested. Vacuum tests will be done at pressures below and above the triple point of water to mimic conditions that exist in the northern region of Mars (pressure above the triple point of water) and the southern region of Mars and the Moon (pressures below the triple point of water or hard vacuum).

References: [1] Zacny et al. (2008) Drilling Systems for Extraterrestrial Subsurface Exploration, Astrobiology J, Vol. 8, No. 3. [2] Zacny et al., (2004) Laboratory drilling under Martian conditions yields unexpected results, JGR 109, E07S16.