Crushing for ISRU Applications: D.S Boucher[1], D. Roberts[1], M.Viel[1], T Atwell[1], J Kutchaw[1], R Theiss[1],
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Introduction: As In Situ Resource Utilization processes evoplve, it will become necessary to fractionate the feed to these processes. This is a requirement for any process which will rely upon surface contact for reactions, such as in the Hydrogen reduction of Ilmenite. In such processes, the need for increasing exposed surface area of particulates and the requirement for small sizees imposed by processing equipment such as augers or mixers will require the raw feed stock be sized and/or crushed. This presentation will discuss the evolution of a crushing system for the NASA funded RESOLVE prospecting mission.

Background: The Regolith & Environment Science & Oxygen & Lunar Volatile Extraction (RESOLVE) prospecting mission is a NASA funded project intended to prospect for volatiles and water in places such as the lunar south pole. The intent is to drill a metre deep hole and extract a complete pristine metre long core form subsurface. This core is then to be parsed into 25 cm sections and processed in an analysis plant to determine presence of a suite of volatiles (such as H2, He3, H2O, etc) and to ascertain the required energy to release these from the regolith. It is expected that some of the volatiles will be released by simple mechanical handling of the sample, while still others will require some heating and mixing to release. NASA is tasked with development of the analysis system and NORCAT was tasked with development of the sample acquisition and sample conditioning system for this mission.

The sample acquisition system is a custom designed coring drill capable of capturing a 1 metre core sample in a single sample tube. A sample transfer system is used to remove the core tube from the drill and transfer it to the analysis suite. During the early pghases of this project, it was determined that the analysis reactor would require a sample that was sized to a nominal 1mm particulate. As this could not be guaranteed in pristine core samples, it was decided to develop a crushing system as an intermediate stage between the sample tube and the reactor vessel.

Sample Conditioning System Constraints: The Sample Conditioning System, also called the Sample Processing Unit (SPU), is required to accept a pristine core of 15 mm diameter and up to 1 metre in length. The sample must be parsed into 25 cm sections and reduced to a 1mm nominal grain size. This is important, as the coring drill is capable of drilling through racks larger than 10 mm diameter and up to and including solid bedrock. It is known that some volatiles are entrapped in eicles inside regolith structure, so it is exoected that some gases will be evolved during the crushing process. An attempt is required to capture these ghases and pass them to the on board GC (part of the NASA analysis system). Finally, it is also expected that the regolith will contain some amount of water ice (originsal thoughts were in the 5 to 10 % by weight range of ice, based on Clementine data sets). Thus we could expect the regolith to be highly cohesive and adhesive.

Crusher Evolution: Earlier studies by NORCAT under CSA contract examined potential crushing and sizing techniques for use in planetary exploration. Various crushing techniques were examined, with the result being the choice of a roll crusher for the RESOLVE application. The benefits were primarily related to the ability of the roll crusher to be self cleaning and thereby not readily packed or gummed during processing.

The effort started with a full size roll crusher designed specifically to produce a 1mm nomimnal particle size, thus it has a 1 mm nip. A prototype was fabricated and testing on various rock types proceeded. A sample parsing tool was also designed and fabricated to section off 25 cm pieces of the 1 metre core.

After a series of performance tests with various rock types and integration to the rest of the sample acquisition system, it was determined that the crusher could be substantially modified, the parsing unit eliminated and the entire subsystem drastically reduced in mass and power consumption, resulting in the lightweight crusher sytem in use today. The system as it is masses less than 5 kg and consumes less than 150W peak power with an average power of less than 80 watts.