EFFECT OF COMMINUTION METHOD ON PARTICLE DAMAGE AND BREAKAGE ENERGY. M.S. Moats[1], J.D. Miller[1], C.L. Lin[1] and R. Rajamani[1], [1]Department of Metallurgical Engineering, University of Utah, 135 S 1460 E Rm 412, Salt Lake City, UT 84112, michael.moats@utah.edu.

Introduction: A growing trend in industrial comminution is the application of high pressure grinding rolls (HPGR) to reduce the energy and/or water requirements for particle breakage. The faculty of the Department of Metallurgical Engineering at the University of Utah has used its expertise and facilities to examine HPGR and their effect on internal particle damage. This presentation will examine recent results in this area and indicate how these techniques could be applied toward the preparation and characterization of lunar regolith simulant components.

HPGR Comminution: High pressure grinding rolls differ from conventional jaw or cone crushers in that it applies extremely high compression pressure during comminution. As a result the particle is not only broken but resulting fragments are weakened due to excessive internal fissures introduced during breakage. An example of this difference in product particles in terms is shown in Figure 1.

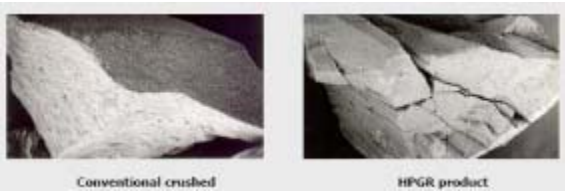
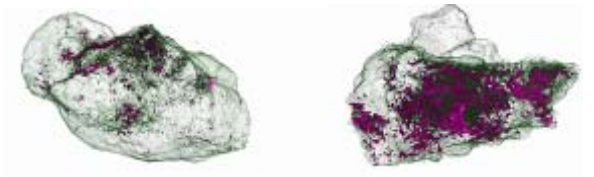


Figure 1. Conventional Crushed vs. HPGR Product

Micro CT Particle Characterization (Breakage/Damage): The characterization of internal cracks and damage can be performed using 2D image analysis of polished cross sections. However, the interlocking nature of the cracks and the formation of crack networks can not be ascertained.

The University of Utah has been a pioneer in the use of High Resolution X-Ray Micro-Tomography (HRXMT) to examine particle damage and cracks. HRXMT has been used to measure particles comminuted by a jaw crusher, and low, medium, and high pressure settings for an HPGR unit. This analysis show increasing residual cracked fractions of 14, 37, 44, and 79 %, respectively when evaluated using HRXMT.

The crack density and networks can be viewed in three dimensions using XRXMT data as shown in Figure 2.



Figures 2A (left) and 2B (right): HRXMT images of particles comminuted by a jaw crusher (A) and HPGR crusher (B). The dark areas highlight internal cracks, internal pores, and crack surfaces.

Ultra Fast Load Cell (UFLC): Particles are made up of individual grains cemented together by geological forces. When they break, a crack travels along defects such as grain boundaries. Hence, the force versus time signature during breakage is a measure of the internal strength of the jointed grains. These signatures can be measured with an ultra sensitive device called Ultra Fast Load Cell at the University of Utah.

The UFLC is a 5 m long rod equipped with strain gauges and a high speed digital oscilloscope. The duration of a breakage event is around 150 μs. This device captures high-resolution force signals during the breakage of a particle. The force signals are then converted into energy.

Application for Lunar Regolith Simulant: The comminution and beneficiation methods used to produce lunar regolith simulant will not only affect the external particle properties (shape, size, morphology), but also its internal structure. As internal cracks will definitely affect the energy needed for comminution and the resulting particle size and shape distribution.

Thus, it is recommended that HRXMT characterization be performed on samples of real lunar regolith to determine the extent of natural internal defects and thus specifications can be produced for lunar regolith stimulants. Once specifications are produced then comminution equipment can be evaluated to determine which produce the most realistic simulant. The effect of differences in internal particle damage of simulants can be measuring using the UFLC.