Verification of Disa's High-Pressure Slurry Abrasion Technology for Separating Materials with Bimodal Hardness

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Disa Technologies, Inc, (Disa) is developing a High-Pressure Slurry Ablation (HPSA) particle size reduction technology. This technology pumps slurried mineral feed through two pumps into a collision zone located above the circulation vessel (Figure 1 left-hand side). Materials then collide inside the “size reduction zone” to undergo an attrition style deconstruction mechanism as visualized in the right-hand side of Figure 1. This deconstruction mechanism preferentially wears materials down from the outside and generates a higher fraction of fines that are enriched in the softer material (metals as opposed to quartz). Additionally, this deconstruction system takes advantage of particle-on-particle breakage as opposed to particle deconstruction against a mill surface which could potentially reduce equipment wear.

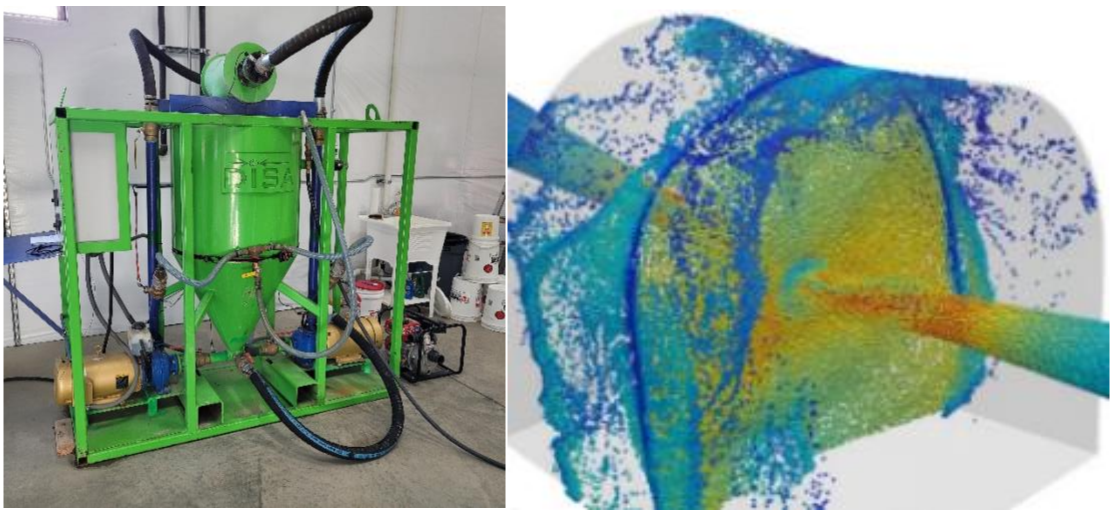

Figure 1: Batch HPSA testing unit (left), CFD modeling image of collision chamber (right)

In this demonstration, HPSA’s main application was to isolate uranium, vanadium and other constituents of concern from low grade waste rock that has been left on the surface of old mine sites. For the Idaho National Laboratory (INL) verification, Disa obtained waste rock from Paradox Valley, CO that contained low concentrations of both Uranium and Vanadium. This material was ground to ¼” and its particle size distribution was analyzed via sieving. Material that was below 270 mesh (53 µm) was set aside as it already contained a significant portion of the U and V of interest. The remaining material (above 270 mesh) was sent through the HPSA process and again analyzed for particle size distribution. A process flow diagram and the particle size distributions for the ¼” ground and HPSA product can be seen in Figure 2. It should be noted that the concentration of metals in these samples was measured by a third party, Pace Analytical, using EPA method 6010C, on samples that were taken by the standard cone and quartering technique from the sieved fractions. The cone and quarter technique should give the best sampling results possible given the high difficultly in accurately sampling larger masses of material when you are taking small sample sizes for analysis.

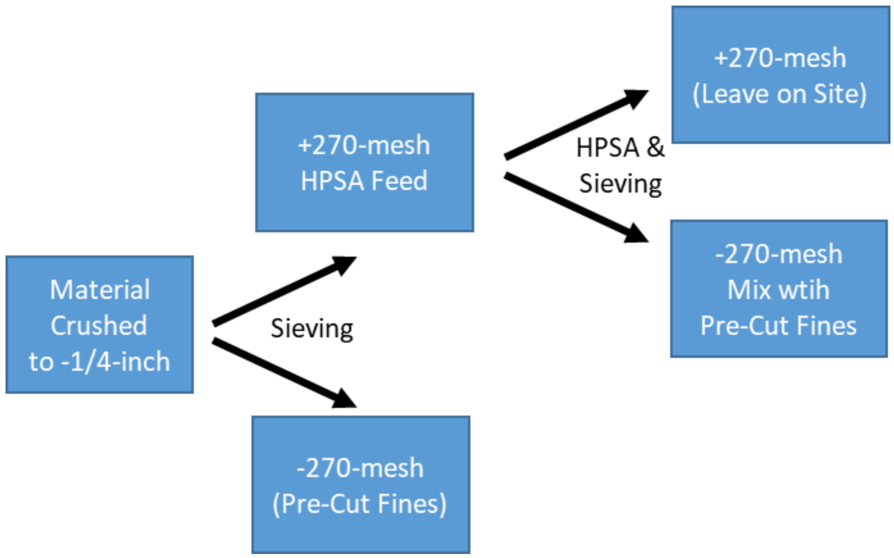

Figure 2: Material processing scheme with HPSA

The initial sieving of the fines helps capture a significant portion of the valuable metals (~50%) in about 10-15% of the mass as can be seen below in Figure 3. This sieving also helps reduce the amount that must be processed in the HPSA size reduction system.

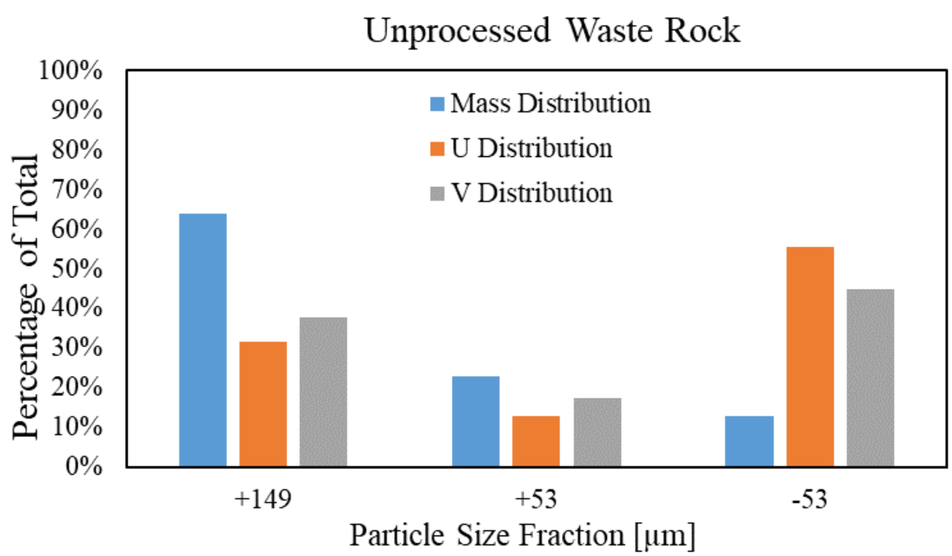

Figure 3: Initial mass, uranium, and vanadium distributions for the Paradox waste rock that had been crushed to 1/4"

After processing about 50lbs of waste rock mixed with 30 gallons of water for 16 minutes in the HPSA system, the fines can be separated again to further isolate the U, V and other constituents of concern in a smaller overall mass fraction. The theory is that the softer metals that reside on the surfaces of the larger particles will ablate into the fines fraction and be separable in a screening process in the same manner that the first set of fines was. Figure 4 show the distribution for the sample masses and metals content once the fines from the HPSA process have been added to the fines from the initial sieving.

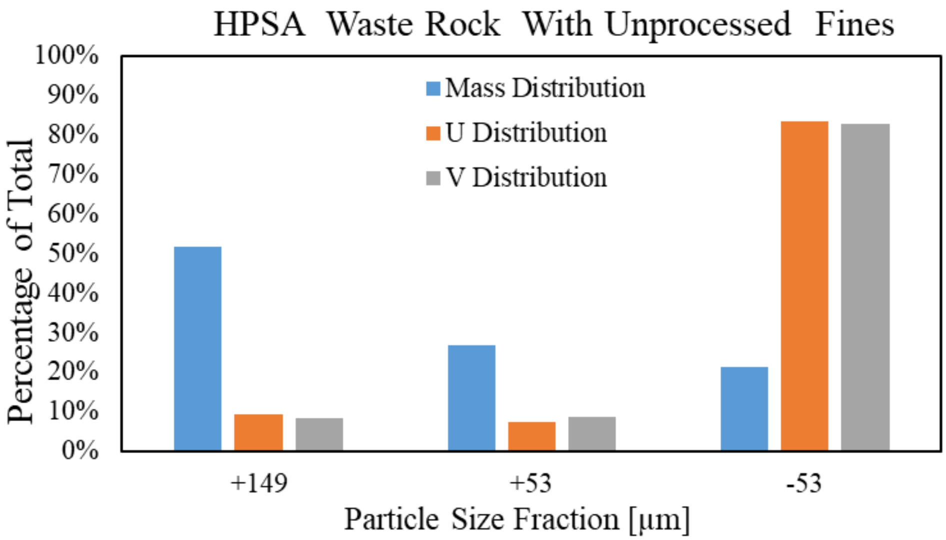

Figure 4: Mass and metals concentration distribution by particle size for the HPSA fines mixed with the initial "pre-cut" fines.

It can be seen in Figure 4 that the mass of the fines fraction has increased to about 20% while Uranium and Vanadium increased to about 80%. Correspondingly, the mass of U and V in the two larger size fractions has dropped to about 10% in each of them. A notable effect is that there has been a significant reduction in the metals content of the particles that are greater than 100 mesh (149 µm), from about 30% of the metals to about 10%, while the overall mass fraction of the larger particles has only decreased from about 60% to about 50%. This result provides strong evidence that the ablative process selectively removes the softer metals from the larger particles and deposits them in the fines fraction. The data for the mass distributions based on sieving and the analytical results from Pace can be seen in the appendix.

Aside from the technical results described above, it should be noted that the team at Disa had a clean and organized facility with a strong attention to safety. Safety glasses and half face respirators to protect from dust hazards were common practice. An emphasis on understanding the processing mechanisms behind the particle ablation in the HPSA process was also evident. Figure 5 shows a collision chamber that allows visualization of the particle impact zone.

Figure 5: Slurry collision visualization chamber.

This chamber is part of what led to improvements in the system design that included two pumps (seen in Figure 1) as opposed to a single pump with a split in the slurry stream before the collision chamber. The two-pump method allows for greater control over the collision zone by giving independent control over the pump speeds to make sure that the impact area is maximized (the two slurry streams impact with equal force as opposed to one nozzle overpowering the other one). A greater number of samples taken and run through Pace to characterize the variability in the sampling process is the only item of note that could help with future process development as new samples are run.

Overall, the data gathered in this test indicates that the HPSA process appears to significantly liberate and separate softer valuable metals in the fines fraction without needing to fully size reduce all the material. In this experiment, a combination of sieving and HPSA isolated ~80% of the Uranium and Vanadium metals in ~20% of the waste rock mass with the greatest recovery in metals being from the particles that were larger than ~149 µm.

Appendix

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Paradox Sample					
Size Fraction [US Mesh]	Class Size [micron]	Mass Retained [g]	% Retained	Cumulative % Passing	Cumulative % Retained
+10	2000	34.87	11.82%	88.18%	11.82%
+25	707	20.1	6.81%	81.36%	18.64%
+50	297	44.73	15.16%	66.20%	33.80%
+100	189	89.3	30.28%	35.92%	64.08%
+140	105	41.78	14.16%	21.76%	78.24%
+200	74	16.18	5.49%	16.27%	83.73%
+270	53	9.65	3.27%	13.00%	87.00%
+325	44	1.44	0.49%	12.51%	87.49%
+400	37	2.83	0.96%	11.55%	88.45%
-400	0	34.08	11.55%	0.00%	100.00%

HPSA Product					
Size Fraction [US Mesh]	Class Size [micron]	Mass Retained [g]	% Retained	Cumulative % Passing	Cumulative % Retained
+10	2380	7.4	0.62%	99.38%	0.62%
+25	707	7.47	0.63%	98.75%	1.25%
+50	297	130.74	11.02%	87.73%	12.27%
+100	189	561.06	47.28%	40.45%	59.55%
+140	105	226.55	19.09%	21.36%	78.64%
+200	74	96.4	8.12%	13.24%	86.76%
+270	53	44.52	3.75%	9.49%	90.51%
+325	44	5.36	0.45%	9.03%	90.97%
+400	37	7.54	0.64%	8.40%	91.60%
-400	0	99.68	8.40%	0.00%	100.00%

Paradox Feed						
Size Fraction [US Mesh]	Size [micron]	Mass Distribution	U concentration [ppm]	U Percentage of Total	V Concentration [ppm]	V Percentage of Total
+100	+149	64.08%	160	31.72%	748	37.64%
+270	+53	22.92%	180	12.77%	968	17.43%
-270 (pre-cut fines)	-53	13.00%	1380	55.51%	4400	44.93%
Totals		100.00%	323	100.00%	1273	100.00%

Paradox HPSA Product						
Size Fraction [US Mesh]	Size [micron]	Mass Distribution	U concentration [ppm]	U Percentage of Total	V Concentration [ppm]	V Percentage of Total
+100	+149	59.55%	60	20.24%	258	13.24%
+270	+53	30.97%	90	15.79%	507	13.53%
-270	-53	9.49%	1190	63.97%	8960	73.24%
Totals		100.00%	176	100.00%	1161	100.00%

Paradox Final (Total Balance – pre-cut fines added back to HPSA product)						
Size Fraction [US Mesh]	Size [micron]	Mass Distribution	U concentration [ppm]	U Percentage of Total	V Concentration [ppm]	V Percentage of Total
+100	+149	51.81%	60	9.34%	258	8.45%
+270	+53	26.94%	90	7.28%	507	8.63%
-270	-53	21.25%	1306	83.38%	6171	82.92%
Totals		100.00%	333	100.00%	1582	100.00%