

FINAL TECHNICAL REPORT
September 1, 1996, through August 31, 1997

Project Title: **TESTING OF IMPROVED FROTH WASHING & DRAINAGE
DEVICE FOR FLOTATION MACHINES**

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ABSTRACT

The purpose of this project was to develop an improvement to increase the performance of both subaeration cells and flotation columns. The focus of this project was to improve performance in froth flotation processes, i.e. increase the throughput and improve the quality of material produced, by removing entrapped, unselectively attached and mechanically carried over impurities from the froth at higher throughput levels. Very few attempts have been made to attain these goals in subaeration cells. Columns provide a better chance for froth drainage and washing although the froth washing system in columns is not perfect. In a column, the water flows down through the froth and carries contaminants down as the froth rises and has the opportunity to pick up those contaminants and carry them up again. The efficiency of the washing system decreases as contaminants reattach to the froth and the concentration of the contaminants increases with the depth of the froth which, in turn, increases the probability of contaminants reattaching to the froth. One way that has been used to decrease the carry over of contaminants is to increase the depth of the froth, but increased depth results in decreased throughput in most columns partly because of reattachment.

The ISGS designed an improved froth washer that minimizes the proportion of impurities attached to, entrapped in and mechanically carried over by the froth into the clean coal product. In this project, the initial development of this improved system was completed. In the first phase of this development, the improved froth washer was used with a subaeration cell. We anticipate the improvement will be effective in virtually any froth flotation system.

During this year, flotation tests were carried out in a packed column under the supervision of Dr. Yang at Morgantown, WV on the same material used in the ISGS improved subaeration cell. Release curves had been developed for the same coal previously. The first tests performed showed that the improved cell produced a product with lower ash and greater Btu recovery than predicted by the release curve. Advanced flotation washability tests were carried out for the same material at SIU using a procedure developed by Dr. Honaker and his graduate student M. Mohanty. The data from these tests were used to evaluate the performance of the ISGS improved subaeration cell under different test conditions. The results of these tests showed that the ISGS improved froth washer used with a subaeration cell performed better than the packed column, especially in rejection of pyrite. The grade of concentrate produced approached the advanced flotation washability curve.

EXECUTIVE SUMMARY

Pyrite in most of the US coals occurs in large quantities as a fine grained mineral varying in size between 32 microns to 20 microns. In Illinois Herrin seam coal, a significant part of pyrite is less than 20 microns. To utilize this coal fully, coal cleaning methods capable of processing very fine grained coal in which most of the pyrite has been liberated, should be developed.

Effective cleaning of some Illinois coals could produce a coal that is better than western coal because not only its pyrite but also substantial amounts of other ash forming mineral matter has been removed. Reduced ash can result in better heat exchange and superior boiler performance. Thus, developing methods of improving the effectiveness and decreasing the cost of cleaning Illinois Basin coals to improve their marketability is important. Also since every coal mining and preparation plant produces fines in the course of extraction and processing the coal, a failure to recover the coal from fines will increase the proportion of coal that is discharged into ponds. The discharge of fines into tailing ponds not only represents a loss of revenue but disturbs the land and perhaps causes environmental problems.

Over the past decades, to provide the customer with cleaner coal at comparatively lower rates, operation of coal cleaning methods has been improved and new methods introduced. The methods commonly used at present to remove pyrite and other minerals from fine coal on an industrial scale are froth flotation in subaeration cells and flotation in columns. The performance of both of these systems are costly, and they are limited in their throughput and/or quality of product produced. As a result no plant grinds coal to clean it and substantial amounts of fine coal produced in the preparation plants are discharged into tailing ponds.

As in any other physical beneficiation method, separation of particles from each other by flotation is possible only if the species are liberated. Near complete liberation of pyrite in Illinois coal would require grinding to particle sizes not exceeding a few micrometers in size. In fine size ranges the separation of fine particles in subaeration cells and flotation columns is adversely affected by 1) non-selective adhesion of particles to air bubbles, 2) by entrapment of the mineral matter in the froth and 3) by mechanical carryover of the particles suspended in the slurry. Unlike coarser particles the detaching forces working on the un-selectively attached fine particles are small and thus they are not easily mechanically dislodged once they get "hooked" on the bubbles. One way to dislodge these un-selectively attached particles will be to wash the froth with enough water so that they are transferred back to the aqueous phase. The purpose of this project was to design an improved froth washing system that could overcome these problems and permit producing a cleaner product.

We anticipate that use of this improvement can allow a single subaeration flotation cell to produce a product that is cleaner than that produced by a flotation column at the high throughput rate of a subaeration cell. In other words, this device would reduce or eliminate the need for the old system of subaeration cell batteries in which the froth or tails were cleaned and re-cleaned to generate a product of desired quality. Equipped with this device, each cell would produce the final product in a single run, leading to increased capacity of

the plant or a decrease in the number of the cells required to process a given stream of the material. The result may be considerable savings in installation and/or operational cost. More costs would be saved because of the greater cleaning efficiency and because of the associated saving on disposal of the fines.

The goal of this research was to determine the range of application of the improvement and its limits of operation so that it could be adjusted to produce a fine coal product that was cleaner than that produced by a column at throughput rates near or greater than that of a subaeration flotation cell.

Release analysis curves like those already determined as part of the Illinois Basin Coal Sample Program were used to objectively compare the performance of flotation machines equipped with this device with those operating without it. The release analysis curve technique has been used recently not only to depict the performance of a subaeration cell under certain conditions but to suggest limits for cleanability of a given coal in any froth flotation machine. However, the limits of cleanability represented by the release analysis curve may not represent the performance limit for a flotation machine equipped with the new froth washer. That machine can produce better results.

To achieve the goal of this research the following tasks were carried out under well defined and documented conditions.

1. Selection and sampling of coal for testing
2. Characterization of feed and products
3. Sample Preparation
4. Sink-float analysis of the feed
5. Flotation tests
- 5.1 Establish grade-recovery curves using standard subaeration cell equipped with the improvement under various conditions
- 5.2 Establish an optimum grade-recovery curve using a packed column
6. Data handling and evaluation
7. Project management and reporting
8. QA/QC

The sample chosen for the first series of tests was IBC-112 from the Illinois Basin Coal Sample Program. This sample was chosen because characterization data was available including release analysis on -100, -200, and -400 mesh samples.

The work carried out was geared to develop an understanding of the new device which, when attached to a subaeration cell, made it produce consistently at higher rate, in single stage flotation tests, a product that compares well with that produced in a packed column. Modifications in the device were made throughout the year to make it run smoothly and predictably and to ensure more positive washing of the froth and precise delivery of the reagents. These and similar modifications assured better performance of the new device so urgently needed for an improved cleaning of Illinois coals.

Tests were also carried out on the same feed coal at University of West Virginia, Morgantown (WVU) and at Southern Illinois University in Carbondale, IL (SIU) to establish a base line for comparison. Tests at WVU were conducted in a packed column under conditions that can be maintained in a plant. The tests at SIU were aimed at achieving maximum recovery of the cleanest product obtained in a subaeration cell and its further fractionation in a packed column.

The pyrite rejection values under flooded conditions compare well with those of the advanced flotation washability analysis. The ash rejection obtained in the improved subaeration cell continued to compare well with that of the packed column and approached those of the advanced flotation washability curve.

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