

FINAL TECHNICAL REPORT
September 1, 1997, through September 30, 1998

Project Title: **TESTING THE ISGS FROTH WASHER ON A STREAM OF COAL PREP PLANT FINES**

ICCI Project Number: 97-1/2.1A-5
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ABSTRACT

The purpose of this project was to continue the development of the ISGS froth washer for producing clean coal from fines rejected from an operating coal processing plant and to test the washer on a packed column using IBC-112. The washer has been developed at the ISGS to increase the throughput and improve the grade of clean coal from a froth flotation circuit using a subaeration cell or column. In this washer, the froth goes through several wash stages. The opportunity for removing contaminants from the froth is increased in four ways: 1) the area over which the froth is exposed to clean wash water can be increased providing an opportunity for multiple stage washing; 2) the amount of wash water and the force or intensity of washing can be increased; 3) the wash water carries the contaminants down through froth only a short distance quickly separating the contaminants from the froth; and 4) the total depth of the froth is decreased, decreasing the tendency for the weight of upper levels of froth to crush the froth underneath.

During the first phase (1996-1997), the ISGS washer was adapted to a subaeration cell and was tested under various conditions. Tests were conducted on IBC-112 from the Illinois Basin Coal Sample Program. The results were compared to an advanced flotation washability curve, a float/sink curve and the results from packed column tests. Tests indicate that the subaeration cell equipped with the ISGS washer can consistently produce a cleaner product than the packed column at a similar throughput. Particularly good results (especially in pyrite rejection) were obtained when the inclined washer was run under water saturated conditions.

During the second phase (1997-1998) a representative sample of prep plant fines was collected, homogenized, and subdivided into smaller lots. Sink-float and advanced flotation washability tests were carried out to establish what type of product may be generated out of this coal under ideal conditions. This was followed by qualitative tests in a subaeration cell to determine dosages of the reagent that may be required to float the coal. The impact of variables such as the dosage of frother, aeration rate and feed rates on the quality and quantity of material produced were carried out in the subaeration cell equipped with the ISGS washer. These tests indicate that the modified subaeration cell can produce results approaching the advanced flotation washability curve at feed rates of 50 lb/hr/ft³. The maximum throughput tested without significant deterioration of cell performance was 61 lb/hr/ft³. The yield from the packed column retrofitted with the ISGS froth washer increased with decreased wash water and increased pulp level for both IBC-112 and plant fines.

Pages 1-21 contain proprietary information.

EXECUTIVE SUMMARY

This work was proposed to carry out a detailed investigation of the cleaning efficiency of the ISGS washer for processing a stream of fines from an existing coal processing plant and to see if it could improve the efficiency of a packed column in cleaning IBC-112 coal. This washer, when attached to a subaeration cell, has produced consistently, in single stage flotation tests, a product that was cleaner than that produced with a packed column using the same feed material. The ability of this device to make a subaeration cell produce a cleaner product from the fine rejects generated at the coal processing plants could have a significant impact on the cost of coal production and future of the coal industry in Illinois.

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

As in any other physical beneficiation method, separation of particles from each other by flotation is possible only if the species are liberated. Nearly complete liberation of the pyrite in Illinois coal would require grinding to particle sizes not exceeding a few micrometers in size. Recovering coal from the fines produced in a coal preparation plant takes advantage of the liberation of minerals by recovering a cleaner coal than the plant produces in its coarse circuit. 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. The forces that detach particles from the air bubbles vary as the cube of its radius. Unlike coarser particles, the detaching forces working on the non-selectively attached fine particles are small, and thus, fine particles are not easily mechanically dislodged once they get "hooked" on the bubbles. One way to dislodge these unselectively attached particles will be to wash the froth intensively so that the particles are transferred back to the aqueous phase. Care must be taken that the detached particles are not reattached to the bubbles, remaining trapped or mechanically carried over. These problems are avoided with the ISGS washer.

During washing, both the particles that are unselectively attached and those that are trapped between the air bubbles have a greater tendency to be flushed out. To decrease the tendency of the flushed particles to get trapped in the lower layers of the froth as they are transported, the vertical height of the froth that is being washed is limited to a few inches. In the ISGS washer the washed out minerals are carried a short vertical distance to a separate stream along the lower part of the washer and not allowed to get entrapped in the froth again.

Without the usual multiple stages of cleaning and re-cleaning, this washer can make a single flotation cell produce a product that is more pure than that produced by a flotation column but at the throughput rate of a common subaeration cell. Thus this device is an improvement of the old system of subaeration cell batteries in which the froth or tails were recleaned to generate a product of desired quality. Equipped with this device, each cell can 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 of these costs will be saved also because of the better cleaning efficiency of fines and because of the associated saving on disposal of the fines.

The purpose of this project is to find the range of application of the ISGS froth washer and its limits while processing a stream of fines from an existing coal processing plant. In addition a packed column was retrofitted with the washer and the impact of this modification on performance of the column was tested.

In this study the impact of variables such as the vertical height of the froth, the amount of wash water, stages of washing/length of the washer, aeration rate and feed rate on the quality and quantity of material produced was determined.

The main objective of this research was to determine the performance of a subaeration cell and a packed column equipped with the new device by carrying out the following tasks under well defined and documented conditions.

1. Sampling of the coal from a preparation plant
2. Characterization of feed and products
3. Sample Preparation
4. Flotation tests
 - 4.1 Establish grade-recovery curves using a standard subaeration cell equipped with the ISGS washer under various conditions
 - 4.2 Assess the impact of retrofitting a packed column with the ISGS washer on its efficiency of processing fine (-200 mesh) IBC-112.
5. Sink-float analysis of the feed
6. Data handling and evaluation
7. Project management and reporting
8. QA/QC

During the first phase (1996-1997) the ISGS washer was adapted to a subaeration cell and was tested under various conditions. Tests were conducted on IBC-112 from the Illinois Basin Coal Sample Program. The results were compared to an advanced flotation washability curve, a float/sink curve and the results from packed column tests. Tests indicate that the subaeration cell equipped with the ISGS washer can consistently produce a cleaner product than the packed column at a similar throughput. Particularly good results (especially in pyrite rejection) were obtained when the inclined washer was run under water saturated conditions.

The goal of the work for 1997-1998 was to determine the conditions under which the ISGS washer can process a stream of preparation plant fines more effectively in a single-stage subaeration cell with an increased throughput while maintaining the quality of the clean coal and to improve the quality at a lower throughput. The fines chosen contained unusually large amounts of clayey minerals, had a broad particle size distribution, and contained large quantities of comparatively fine mineral matter. These fines required a different set of test variables. The impact of variables such as the aeration rate and feed rates, and dosages of frother on the quality and quantity of material produced were determined.

A representative sample of prep plant fines was collected, homogenized, and subdivided into smaller lots. Sink-float and advanced flotation washability tests were carried out to establish what type of product may be generated out of this coal under ideal conditions. This was followed by qualitative tests in a subaeration cell to determine dosages of the reagent that may be required to float the coal. The impact of variables such as the dosage of frother, aeration rate and feed rates on the quality and quantity of material produced were carried out in the subaeration cell equipped with the ISGS washer. These tests indicate that the modified subaeration cell can produce results approaching the advanced flotation washability curve at feed rates of 50 lb/hr/ft³. The maximum throughput tested without significant deterioration of cell performance was 61 lb/hr/ft³.

A two-inch by six-foot packed column was retrofitted with the ISGS froth washer and tested using both IBC-112 and prep plant fines. The samples produced are being analyzed. For IBC-112, the yield from the column was highly dependent on wash water rate and decreased from 85% to 17.4% while the wash water was increased from 0 to 780 mL/min if the pulp level remains constant. Recovery was increased again by increasing the pulp level. For the plant fines at higher pulp levels the yield remained constant with increased wash water. However, compared to the retrofitted subaeration cell, the yield was still low in the packed column. This may have been related to the throughput. Both systems were tested at about 30 lb/hr/ft³.