Column Flotation Results at Powell Mountain Coal Company

by William J. Heimbichner and S. R. Pincott

INTRODUCTION

In 1989 a column flotation process was developed at the CAER, which enabled the economical recovery of coal fines from high ash fine refuse. The laboratory design was expanded to commercial scale and installed at the Mayflower Coal Preparation Plant of Powell Mountain Coal Company in December, 1989. It has been in continuous operation there since that time. This article is a summary of the past two years' experiences with this applied technology, applicable dewatering tests and flotation tests results from the plant.

Recovery of fines-size-coal from a preparation plant fine refuse stream provides additional revenue for the coal company. The main advantage of processing the fine refuse slurry is that the coal present in it is liberated from impurities, thus obtaining a relatively low ash/impurity product will be easy. Conventional processes based on gravity separation are, however, not applicable for recovery of fine-size coal. The froth flotation process, which uses surface chemical principles, is effective in recovery of fine coal.

Conventional froth flotation techniques are not very effective for recovery of very fine size (<4 mm) coal. An advanced froth flotation technique, namely, "Kent-Float" column flotation, provides an economical way to achieve recovery of fine coal. The "Kent-Float" process, developed at the CAER, has shown in laboratory, pilot and commercial scale demonstrations that high recovery of a low-impurity coal product is possible at an economical price.

The column, which is about 20' high, varies in diameter from 2' to 8' for a laboratory and commercial application respectively. A coal slurry containing a small amount of fuel oil and an alcohol enters the column at a distance from the bottom and meets a rising stream of fine bubbles generated at the bottom of the column. Coal-coated air bubbles are carried upwards into the cleaning zone where a gentle spray of wash water removes any residual, entrapped mineral matter. The clean-coal froth product is removed and recovered from the top of the column.

Our research and development efforts predicted that an increase recovery of 1.7 - 2.0% would occur to the total process recovery that ash and sulfur would be

Is There a Simple Way to Obtain a Significant Increase in Underground Mining Productivity?

by J. W. Leesbird, A. H. Paradkar and B. C. Grappe

INTRODUCTION

Now-longwall mining systems can become more competitive and the development phase of longwall mining systems improved, if additional coal tonnage can be placed in the fixed-volume container based scoopys and shuttle cars used to transport raw coal. This article describes research directed at using chemical treatment of mine section spray water to increase loaded coal bulk density and productivity by about 15%.

For an underground mine using continuous miners, the time required to transport coal from the mine face to the belt is an important factor in determining production rate. Continuous miners can mine coal at a very high rate, but the production rate is decreased because present container-based scoopys systems are not capable of moving the removed coal from the face to the conveyor belt fast enough. One of the practical solutions to this problem of using present conveyor systems may be to increase the bulk density of the mined coal.

Increases in coal bulk density allows greater amounts of coal to be placed in transportable fixed-volume containers such as ships, barges, railroad cars, trucks, shuttle cars, scoops etc. Bulk density can be increased by both physical and chemical methods. Research sponsored by the CAER, and performed at the University of Kentucky's Department of Mining Engineering, uses a chemical method to show that an increase of about 15% in bulk density can be

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unchanged, and that the moisture would increase from 0.4 to 0.6 of one percent in the product. The first year in which the column flotation technology was used, produced excellent results and confirmed the figures of our expectations.

As with any new development, a learning curve for our employees had to be established. Good communication, positive interest, and continuous hands-on experience with these flotation units provided a high degree of confidence toward their ability to recover clean coal. Total production hours for these units today exceed 9,000 hours. The employees of PMCC and UIK’s Center for Applied Energy Research deserve much praise for their continuous interest and dedication.

There are many parameters that affect the performance of column flotation. They include:

- Type of frother
- Bubble generating units (oils and foams)
- Retention time
- Tank characteristics
- Washwater rates, etc.
- Column froth depth.

Mayflower Preparation Plant processes coals from five mines. Two of the sources are high-sulfur coals. Our experience of the last two years has shown that frothers have significant impact on the performance of columns. We have tested several types of frothers and found that the Sherex Chemical Company frother 177 provided best results for the multiple seam processed at the Mayflower Coal Preparation Plant. From high-sulfur coal fine refuse (feed ash 45%) a clean-coal product containing 6% ash at about 75% coal recovery is being obtained. Similar results are being obtained for low-sulfur coals.

At the Mayflower plant we have tested various operational parameters for the columns to determine how they affect performance of the column. For example, we found that as the percent solids in the feed increases, coal recovery decreases. Similarly, a decrease in coal recovery was observed with an increase in particle size.

Ash of the concentrate is a function of froth depth height. Coal recovery does not change from the use of the two types of bubble generators (coarse tubes versus foam jet). And, froth carry-over capacity is directly related to air induced into the spargers for generating the fine bubbles.

![Figure 2. Results of column flotation tests.](image)

Employee response at the plant to this new technology of coal recovery and desulfurization was skeptical at first. How is it possible to recover these fines? Yes, we can fill the “grit” but how? Well, like many aspects in life—sometimes seeing is believing! Therefore, after many months of communication and coordination with screen bowl manufacturers, we obtained two test units for field desulfurization tests on the fresh concentrate at our coal preparation plant.

Desulfurizing tests on column flotation concentrate were performed on February 21, 1991. Horizontal screen bowl concentrators, manufactured, were used in our tests. The screen opening on each concentrator was 0.012”. Results of the test are shown in Figure 2.

Test results were conclusive. The product moisture of two tests were totally alike. Surface characteristics of particles vary, and as size distribution of minus 325 Mesh in the product concentrate increases, so does the total moisture.

This has been a successful project. Results of this success are evident in today’s market. Many coal users are tending to introduce column flotation concepts and technology in the United States. Bill Pussy’s statement of March, 1988 remains unchanged. “The economics of fine coal recovery in modern coal preparation plants are crucial. The development of this column flotation unit will provide the coal preparation manager with an inexpensive alternative to equipment selection for both flotation. This column flotation unit will optimize quality, recover more clean coal, provide an attractive return on investment, and will reduce losses of fossil fuel particles to coal refuse waste impoundments and/or landfill.”

Bill Pussy, then superintendent of Coal Preparation at Powell Mountain Coal Company, since 1982.

![Dr. Peter Wardenhake of the Office for Economic Coordination and Development (OECF) recently discussed international directions in energy research with CAER investigators.](image)
Underground Mining, (continued)
achieved using extremely small quantities of commercial reagents. This increase in bulk density can produce a proportional increase in the productivity of a mine.

DISCUSSION:
Major factors affecting the bulk density of coal are: moisture content, particle size, particle size distribution, particle density and chemical content.

The bulk density of moist coal is always less than that of dry coal. Bulk density is at its minimum at about 6% moisture content. Surface properties of particles that influence packing are electrical, interparticle friction, surface roughness, interparticle cohesion and the adhesion of liquids and gases. Angular particles can frequently be packed closer than rounder particles owing to the flaking of projections into voids. Research on particle-size distribution shows that fine powders stick less closely than coarse powders. The addition of small amounts of certain reagents enhances consolidation trickling, settlement and coagulation by decreasing particle-to-particle interfacial surface friction. The mechanism responsible for improvements obtained from reagent additions is the reduction of the surface tension of the entrained water holding the coal particles together. This mechanism also enhances the hydrophobicity of the coal surfaces.

RESULTS:
Two types of widely contrasting commercial reagents were used to produce a range of responses. These are referred to as reagent A and reagent B.

Experiments were performed on a difficult, predictably reagent-consumptive, oxidized Western Kentucky ROM coal of full size range. The coal contained 5.8% moisture, 20.4% ash and 36.1% volatile matter. When reagents were added, they were mixed with a given quantity of water before adding to the coal. The mixture was added to the dry ROM coal to attain the required amount of moisture. The wetted coal was placed

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COAL PREPARATION IS READY

Coal Preparation Handbook V, the most popular, longest-running series of the Mining Engineering Society's many technical volumes, has been completely updated to celebrate the 50th anniversary of the first edition's publication in 1941. Total number of first four editions of Coal Preparation published approaches 50,000 volumes. The book is found in all parts of the world where coal is mined, and has been extensively translated in 14 versions written in Russian and Chinese.

The supply of Coal Preparation IV has been exhausted and is out of print. Work on the new volume was coordinated from the University of Kentucky and has been underway for more than four years. The four previous editions were coordinated from outstanding Mining Engineering Departments at Penn State and West Virginia University.

Several hundred authors and editorial board members have been involved in the production of all five volumes. The fifth edition is a memorial edition and contains an honor roll of all previous participants. The list of participants for all editions could probably qualify as the Who's Who and/or Who Was Who of the American coal preparation industry.

Most authors of this type authors are volunteers, with nationally outstanding credentials, who are actively recruited from among the ranks of academic, consulting and engineering engineers and scientists. Hence, Universities such as Iowa State, University of Kentucky, University of Missouri, State University of New York, The Pennsylvania State University, University of Utah, Virginia Polytechnic Institute, University of Washington, University of West Virginia, agencies such as the United States Bureau of Mines and the Department of Energy and consulting groups such as EPRI/ CQ, Inc. are represented.

The Coal Preparation Handbook V may be purchased from:
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New IEA Coal Research Publication Available from the Center for Applied Energy Research
Advanced Coal Cleaning

Gordon R. Gough
IEACU44, ISBN 92-9029-197-4
95 pp., December 1991

This report reviews recent developments in established coal cleaning practice including:
- principal separation methods (physical, chemical and biological).
- instrumentation and control: management aspects
- and operational philosophy: application to low rank coals.

Physical separation often requires milling the coal to below 100 microns to obtain enough mineral liberation. However, as particles become smaller the effects of turbulence and viscosity during separation increase. Gravity separation, based on microrized magnetism, can be used for particles down to 50 microns. For smaller particles, methods based on wetting differences in surface properties are normally used. This report describes advanced cleaning processes including column flotation, froth flotation, selective agglomeration and flocculation. Chemical cleaning may also remove organic sulfur, but often at the expense of a reduction in volatile matter. Biological methods may remove up to 50% of pyritic sulfur, but reaction rates are slow and process conditions require precise control.

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Figure 1. Change in Bulk Density Versus Amount of Reagent A.

Figure 2. Change in Bulk Density Versus Moisture Content Modified by Reagent A.

The content of coal in the box was determined by weighing. The results obtained are shown in the accompanying graphs.

Figure 1 shows the change in bulk density with increases in the dosage of reagent A at 6% moisture content. The optimum increase in bulk density (about 14%) is obtained at a dosage of 0.58 lbs. of reagent A per ton of coal. Figure 2 shows the bulk density increase with differing moisture contents of coal, while maintaining constant dosages of reagent A, reagent B, and a mixture of the two. The dosage of reagent A used was 0.56 lbs/ton of coal and that of reagent B was 0.25 lbs/ton of coal. Nearly 2% additional gain in bulk density is obtained over the increase already obtained by using reagent A, when using reagents A and B. Thus, the combined effect of these reagents appears to be additive.

CONCLUSION

These studies have shown that an increase of 13 - 15% in bulk density can be obtained simply by adding small amounts of certain reagents. These reagents can be easily added to the water sprayed during the mining of coal. Reagent B appeared to offer little towards the improvement of bulk density. However, the addition of small amounts of reagent A with reagent B increased the bulk density of coal by as much as 15%. This increase in bulk density could have a significant impact on increasing the production rate of a mine while lowering mining and transportation costs. Important industrial research involving the full-scale duplication of laboratory productivity improvements, coal flow, safety, dust management and preparation plant water management is urgently needed. It is hoped that this work will be found valuable and followed up on by industrial sponsors.

Dr. Parekh recently visited Poland and Germany to discuss column flotation technology transfer and to inspect some of Poland’s underground mining operations and coal cleaning practices.

Associate director R.K. Parekh left with Mr. Darshor of Dofyans Minerals in Łoskowo, Germany.

In Poland's Krupinski Coal Mine, coal preparation control room.
COAL PREPARATION READIES INDUSTRY FOR THE FUTURE

by Jack Groppo

I almost hate to admit it. Not only am I a baby boomer, but I am also a coal boom, one of those college students who made the all important career choice during the coal boom of the 1970's. Job opportunities were abundant, starting salaries were high, and the unfortunate reality was that after graduation, student loans had to be repaid regardless of my employment situation unless I sought refuge in continuing education (i.e., graduate school). One area particularly ripe with opportunity was coal preparation, long considered a necessary evil by production-oriented mining engineers.

Like it or not, coal preparation has become an integral part of mining. Improvements in underground technology, particularly longwall mining, have successfully boosted productivity while reducing labor requirements. Since earlier generations exploited only the best reserves (who could blame them?), marginal reserves had to be developed in the wake of declining coal prices. Somehow, the resilient coal industry prevailed and annual production continued to increase.

One inevitable consequence was the increased production of fines and higher reject. How do you sell fine, high-ash coal and turn a profit? Good coal preparation is how, and in many respects, coal preparation technologies have helped the industry become more profitable. It has evolved to become the salvation of a struggling industry. The key to coal preparation is to provide the customer with a uniform, high-grade product. But as run-of-mine production continues to provide finer, higher reject material to be cleaned, this is not a simple task - and this is where research can play an important role.

Once upon a time, coal preparation consisted of a line of underpaid workers picking rock off a conveyor belt. Although still practiced in some parts of the world, hand-sorting generally has gone the way of the slide rule. Modern preparation plants use state-of-the-art technology such as computerized control and feed back loops to optimize processes that separate coal from refuse. But still lacking are cost-effective fine coal recovery processes.

Column flotation has made the successful transition from research investigations of fine coal recovery to industrial practice. However, still only one plant exists in the world that uses this technology to treat all of the fine coal processed in the plant. Why? No efficient economical dewatering process exists to handle the fine coal produced by column flotation. With the enormous potential that column flotation represents for recovering high BTU, low ash and sulfur fine coal, one would think that funding for basic dewatering research would be a priority for government agencies responsible for developing energy technologies.

The truth is that it is not. As a mining engineer I am surprised. As a researcher I am frustrated. With the conspicuous absence of coal from the National Energy Policy, the infamous SO2 reduction legislation, severance taxes and trimmed mineral taxes, it is no wonder that employment in this vital area has been steadily decreasing in recent years. Coal is the single largest energy reserve for this country, but with excessive legislation, this enormous resource will remain unequipped in favor of imported energy sources.

In the wake of the present emission requirement changes, everyone is looking to coal preparation research to magically transform high sulfur coal into a low sulfur, permissible fuel. In some cases this can be done, but the cost is enormous. The coal must first be pulverized to face powder consistency so that the pyritic sulfur can be leached, then separated (i.e., column flotation).
Commentary, (continued)

dowdetered and transformed to a more easily handled state by pelletization or briquetting.

These are not new processes and any increases in the cost of cleaning coal by implementing the processes will be passed directly to the consumer, who is facing the prospect of a 20-30% increase in electricity costs in the next few years. If we have any hope of utilizing our domestic coal resources in an environmentally responsible manner, it is going to require the collaborative efforts of coal producers, researchers, consumers and government agencies.

Somehow, the coal industry will prevail. History clearly has shown this to be true. It is an exciting time to be involved with coal-related research. As insurmountable as the problems seem, we keep chipping away, despite the obstacles, in our efforts to make a change. Coal-preparation research is not a panacea, but it is making a difference.

Jack Gruppo is a researcher, who has chipped away at coal preparation for seven years at the CAER. He is presently working on his Ph.D. in UK’s Mining Engineering Department.

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