DOE/PC/94152--T5

TECHNICAL PROGRESS REPORT

APPALACHIAN CLEAN COAL TECHNOLOGY CONSORTIUM

Cooperative Agreement No.: DE-FC22-94PC94152

Project Report for the period

October 1, 1995 - December 31, 1995

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Performing Organizations:

Virginia Polytechnic Institute & State University
Blacksburg, VA

University of Kentucky
Lexington, KY

West Virginia University
Morgantown, WV

Date Submitted: April 23, 1996

Contracting Officer's Representative: Thomas J. Feeley III

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INTRODUCTION

The Appalachian Clean Coal Technology Consortium (ACCTC) has been established to help U.S. Coal producers, particularly those in the Appalachian region, increase the production of lower-sulfur coal. The cooperative research conducted as part of the consortium activities will help utilities meet the emissions standards established by the 1990 Clean Air Act Amendments, enhance the competitiveness of U.S. coals in the world market, create jobs in economically-depressed coal producing regions, and reduce U.S. dependence on foreign energy supplies.

The consortium has three charter members, including Virginia Polytechnic Institute and State University, West Virginia University, and the University of Kentucky. The Consortium also includes industry affiliate members that form an Advisory Committee. Affiliate members currently include AMVEST Minerals; Arch Minerals Corp.; A.T. Massey Coal Co.; Carpc, Inc.; CONSOL Inc.; Cyprus Amax Coal Co.; Pittston Coal Management Co.; and Roberts & Schaefer Company.

OBJECTIVES

In keeping with the recommendations of the Advisory Committee, first-year R&D activities are focused on two areas of research: fine coal dewatering and modeling of spirals. The industry representatives to the Consortium identified fine coal dewatering as the most needed area of technology development. Dewatering studies will be conducted by Virginia Tech's Center for Coal and Minerals Processing. A spiral model will be developed by West Virginia University. The research to be performed by the University of Kentucky remains to be defined. Project management and administration will be provided by Virginia Tech, for the first year.

DISCUSSION

Virginia Tech: Innovative Approach To Fine Coal Dewatering

Introduction

There are no practical solutions to the problems associated with the dewatering of fine coals at the moment. The mechanical dewatering technologies used today are inefficient while thermal drying is capital-intensive and costly to operate. Therefore, there is an impending need for innovative approaches to solving problems in fine coal dewatering.

In this project, two different approaches are taken. One approach involves displacing the water on the surface of coal by a hydrophobic substance that can be readily recovered and recycled. This novel concept, referred to as the Hydrophobic Dewatering (HD) process, is based on improved understanding of the surface chemistry of dewatering. The other approach is to use disposable dewatering substances in mechanical dewatering.

The objectives of the proposed work are i) to test the HD process on a variety of coals from the Appalachian coal fields, and ii) to identify suitable dewatering reagents that would enable mechanical dewatering to reduce the moisture to the levels satisfactory to electrical utilities and other coal users.

Results for the Current Quarter

Task A1 Coal Sample Acquisition and Characterization

Fine coal products (28 mesh x 0 and 100 mesh x 0) were collected from different coal preparation plants in the Appalachian region. The fine coal samples collected were characterized

in terms of % solids, size distribution and ash content. The samples collected were used in the batch HD tests and the mechanical dewatering tests using various dewatering aids.

Task A2 Batch Dewatering Unit Design and Set-Up

During a previous quarter, the batch HD process unit was designed and constructed using butane as the hydrophobic substance. Since butane has a high vapor pressure, a high-pressure vessel made by Parr Instruments was used in the batch HD process unit. The problem in obtaining samples of the dewatered coal product for moisture analyses was resolved and further shakedown tests of the batch unit were conducted. There were no other problems observed with the batch HD process unit.

Task A3 Batch Dewatering Tests

Testing began using the batch HD process unit with butane as the hydrophobic substance. Initial testing utilized froth concentrate from Cyprus Amax Coal Company's Lady Dunn plant near Montgomery, West Virginia, but due to the ready availability and the fine size consist, the column flotation product from Pittston Coal's Middlefork Preparation Plant near Lebanon, Virginia, was chosen as the coal for use in the preliminary test program.

Preliminary tests began to examine the effects of butane dosage, agitation speed, mixing time and phase separation time on the performance of the HD process. The resultant coal products were analyzed for surface moisture and total moisture. Testing is well underway and the results will be reported in the next quarterly report.

Task A5 Use of Disposable Dewatering Substances in Mechanical Dewatering

Considerable laboratory scale vacuum filtration tests have been conducted on different fine coal products collected in Task A1. Based on the preliminary reagent screening, one particular reagent called "reagent A" was chosen for more detailed testing. Determining the relationship of

moisture and reagent dosage for filtration tests on several coals was the major emphasis during this reporting period. Tests were conducted on actual fine clean coal products provided by several coal companies. The samples tested were filter feed (28 mesh x 0) and flotation product (100 mesh x 0) from a Pittsburgh No. 8 coal provided by CONSOL Inc. and column flotation product (100 mesh x 0) from Pittston Coal Management Company's Middle Fork plant in Southwest Virginia. Some tests were also conducted on 100 mesh x 0 Lower Kittanning run-of-mine coal samples that were dispersed in water. The slurry was subjected to vacuum filtration using a Buchner filter with a coarse glass frit (40-60 μ m). In these dewatering tests, the dewatering aid was added to the slurry and the slurry was then agitated for one minute. The coal slurry was then subjected to vacuum filtration with drying times from one to ten minutes after liquid drainage. The dewatered coal samples were recovered from the filter and analyzed for moisture content.

Tables 1 to 4 show the effect of reagent dosage on product moisture content. Although results varied, reagent dosages of around 1 pound per ton of feed solids produced significantly lower moistures than that obtained without any reagent. The moisture was reduced by at least 10 percentage points for nearly all coals tested. In general the higher dosages produce lower moistures, but there is usually an optimum dosage above which there was no improvement in product moisture. This optimum dosage appears to vary for different coals.

**Table 1. Dewatering of Lower Kittaning Coal
(-100 mesh, 14% solids feed)**

Reagent A Dosage (lbs/ton)	% Moisture
0	27.1
1.52	11.5
3.04	3.9

**Table 2. Dewatering of Pocahontas No. 3 Concentrate
(-28 mesh, filter feed)**

Reagent A Dosage (lbs/ton)	% Moisture
0	28.7
2	14.3
4	11.1

**Table 3. Dewatering of Pittsburgh No. 8 Concentrate
(-100 mesh flotation concentrate, 20% solids feed)**

Reagent A Dosage (lbs/ton)	% Moisture
0	36.2
1	18.6
2	16.7

**Table 4. Dewatering of Middle Fork Column Concentrate
(-100 mesh flotation concentrate, 15% solids feed)**

Reagent A Dosage (lbs/ton)	% Moisture
0	26.0
0.32	15.2
0.96	15.2
1.60	14.2

In order to more closely represent actual plant conditions, several cake thicknesses were tried in the vacuum filter tests using the Buchner filter. As shown in Table 5, the moisture results were significantly better with the thinner cakes, even though a constant reagent dosage of 2 lbs/ton was used. This is apparently due to cracks in the filter cake caused by the higher filtration rate in the Buchner filter. These cracks then take all of the air flow and the resulting short circuit prevents sufficient pressure drop across the remaining cake for further dewatering to take place.

**Table 5. Dewatering of Pittsburgh No. 8 Concentrate
(-28 mesh filter feed)**

Cake Thickness (inch)	% Moisture
0.5 (w/o Reagent A)	32.3
0.7	23.1
0.5	18.1
0.4	15.6
0.2	11.7

Testing in the next quarter will focus on evaluation of new families of reagents as well as investigating the optimum reagent dosages. Methods to reduce reagent consumption, such as the use of a carrier agent, will also be attempted.

West Virginia University: Spiral Modeling

Introduction

The most promising approach to improving spiral separation efficiency is through extensive computer modeling of fluid and solids flow in the various operating regions of the spiral. Previous efforts at accurate modeling have failed, primarily due to the use of incorrect physical models describing the flowing slurry stream.

Several key issues must be resolved to improve the performance of spirals. Since movement of particles into the separation zone of the spiral is the key to improving efficiency, the most important issue is control of fluid and particle flow. Critical questions to be answered include determining the optimum location for makeup water addition, how to control the position of the Roberts and Knoll lines, and how to control the movement of particles from the upper Grandy region into the lower Grandy region. In addition, the effects of spiral diameter, pitch and height on fluid/particle behavior need to be determined.

The objective of this project is to use computer modeling to develop better, more efficient spiral designs for coal cleaning. The fully-developed model will predict spiral performance based on variations in spiral profile, flow rate, and pitch. Specific goals are to: i) design spirals capable of making separations at a specific gravity of 1.5, and ii) broaden the size range at which spirals make effective separations.

Results for the Current Quarter

As of the quarter being reported West Virginia University had not signed the contract and no work was reported for the quarter. The paperwork should be complete by the following quarter however and work will resume.

University of Kentucky: Study of Novel Approaches for Destabilization of Flotation Froth

Introduction

Fine coal recovery from fine waste stream using froth flotation technique is becoming an important and integral part of coal preparation plans. Column flotation technique has proven to be the most effective and cost efficient in recovery of fine coal. However, in some columns use of glycol based frother produces a stable froth, which is not destroyed easily. The main objective of this proposal is to develop novel approaches for destabilization of stable froth. The approaches involve addition of either chemically treated coarse coal or addition of chemically treated magnetite-limestone suspended in an oil medium to the froth to break it down. Mechanical approaches to be tested involve utilization of ultrasonic energy or cyclone or vacuum. This report discusses technical progress made during the quarter from October - December 1995.

In froth flotation process, frothers are utilized to provide smaller size stable bubbles which would carry the floatable particle. In case of an ideal froth flotation, the froth should have good fluidity and optimal rigidity. The froth should be just stable enough to carry the floated particles out of the flotation cell. Once the froth is scraped out of the cell, it should collapse to free and concentrate the volume of floated particles. Such a froth will minimize the entrainment of undesired mineral particles into the concentrate and can provide additional selectivity for the flotation processes. Too stable or too unstable froths penalize the separation efficiency and operation smoothness. If the froths are too stable, they will not break up after skimming out from the flotation cell. Usually, such overly stable froth have low fluidity. The unwanted excessive stability can cause serious problems for downstream processes, like dewatering of flotation concentrate, handling tailings, and re-use of processing waters.

Generally, alcohol based frothers provide froth which collapses as soon as froth is removed from the flotation cell and sprayed with water. Glycol based frothers on the other hand provides a much more stronger froth which is difficult to break by simple physical techniques and requires large amount of chemical to break the froth, which adds to the processing cost.

Objectives And Scope

The main objective of the proposed project is to develop new defoaming techniques for destruction of overly stable froths produced in fine coal froth flotation. It is also the objective of the project to study chemical dynamics of the three phase froth.

The focus of this project will be to investigate new defoamers. Existing commercial defoamers, such as surfactants, copolymers, hydrophobic silica, amide particle, etc, are expensive and are thus economically unfavorable for breaking-up fine coal froths. In this project, new defoamers will be developed that can effectively and economically accomplish the destruction of fine coal froths. Two approaches will be studied. One will be to use coarse coal particles. To ensure that the surfaces of coal particles are sufficiently hydrophobic, the coal particles will be pretreated with cationic surfactant. The second approach will be to use magnetite and limestone particle. Since both magnetite and lime stone particles are naturally hydrophilic, it is necessary to coat the particles with specific chemicals to make the surface highly hydrophobic (contact angle $>120^\circ$). The hydrophobic particles are then dispersed in oil. It is anticipated that these new defoamers will be advantageous over existing defoamers. Besides their low cost, the use of hydrophobic limestone particles can also help to capture the sulfur dioxide and thus reduce the emission.

Results for Current Quarter

The project consist of four (4) tasks. Progress made in each task is given below.

Task 1. Sample Acquisition and Characterization

The ACCTC board recommended that the froth generated in columns at the Pittston Coal Company be used for the study. Contacts were made with the Pittston to arrange for obtaining froth and flotation feed samples.

Task 2. Dynamic Stability Studies of Fine Coal Froth

A "Foam Stabo System" developed at UKCAER (Figure 1) will be utilized to study the stability of froth. The foam stability will be characterized with respect to

- half-life time
- drainage time constant
- diffusion time constant

Task 3. Fine Coal Froth Destabilization Studies

This task will consist of two activities, namely, chemical and mechanical. In chemical approach, coal particles or magnetite or limestone particles coated with surfactant will be sprayed on froth.

Activities For Next Quarter

A student (Mr. X. Jiang) from China has been assigned this project as his M.S. thesis topic. Mr. Jiang will start his studies in January 96. Work will then immediately begin on the first two tasks discussed above. Dr. X. H. Wang of Betz PaperChem, who was one of the P.I., has been retained as a consultant on the project.

Figure 1. Apparatus for measuring the total surface area and the drainage rate of foam.

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