

Report Title:

**USE OF THE GRANUFLOW PROCESS IN COAL PREPARATION
PLANTS TO IMPROVE ENERGY RECOVERY AND
REDUCE COAL PROCESSING WASTES**

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CAUTION

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ABSTRACT

CQ Inc. engineers visited two coal companies in Alabama—Jim Walter Resources, Inc.(JWR) and PinnOak Resources, LLC—to discuss the possibility of performing GranuFlow demonstration testing at their coal preparation plants. JWR operates three coal cleaning plants—No. 4, No.5, and No. 7—near Brookwood, Alabama. PinnOak owns and operates the Concord Plant, located near Hueytown and formerly owned by U.S. Steel. GranuFlow setup testing was performed at the Concord Plant March 29-31, 2004. Prior to these tests, the Heritage Research Group performed bench-scale centrifuge tests to evaluate asphalt emulsion types, and to help select the emulsion and dosages to be tested at Concord.

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PROJECT SUMMARY

OBJECTIVES

The overall objective of the project is to generate all necessary information and data required to commercialize the GranuFlow™ Technology. GranuFlow uses a bitumen emulsion to displace water from fine coal, agglomerating the coal prior to dewatering and thereby improving coal recovery in coal preparation facilities. The technology will be evaluated under full-scale operating conditions at three commercial coal preparation plants to determine operating performance and economics. The handling, storage, and combustion properties of the coal produced by this process will be compared to untreated coal during power plant combustion tests.

SCOPE OF WORK

Bench-, pilot-, and limited full-scale testing of Granuflow indicates that treating coal fines with a bitumen emulsion prior to dewatering can improve coal recovery, reduce clean coal moisture content, and improve fine coal handling characteristics. Granuflow will be demonstrated at three commercial coal cleaning plants to confirm previous test results and establish operating parameters for future commercialization. In collaboration with each of the host test sites, test plans will be developed to define a test program which meets the requirements and expectations of all parties. Initially, set-up tests will be performed at each site over a one-week period to evaluate various emulsion dosages (0.5 to 2.0 percent) under steady plant operating conditions. During this period, extended shift-long (8 hours) tests will be conducted to evaluate the effects of longer-term emulsion addition. Subsequently, a one-week evaluation will be performed at each host site at an optimum emulsion dosage as determined by the set-up tests. Finally, a comprehensive one-month test of the GranuFlow process will be performed at one of the host sites to evaluate its long-term performance and impacts on plant operations, and to generate data for future commercialization efforts. Power plant tests will provide information on the handling, storage, combustion, and emission properties of the treated coal as compared to untreated coal.

TASK SCHEDULE

The major tasks to be performed during this project will be guided by the Work Breakdown Structure(WBS) shown in the table below.

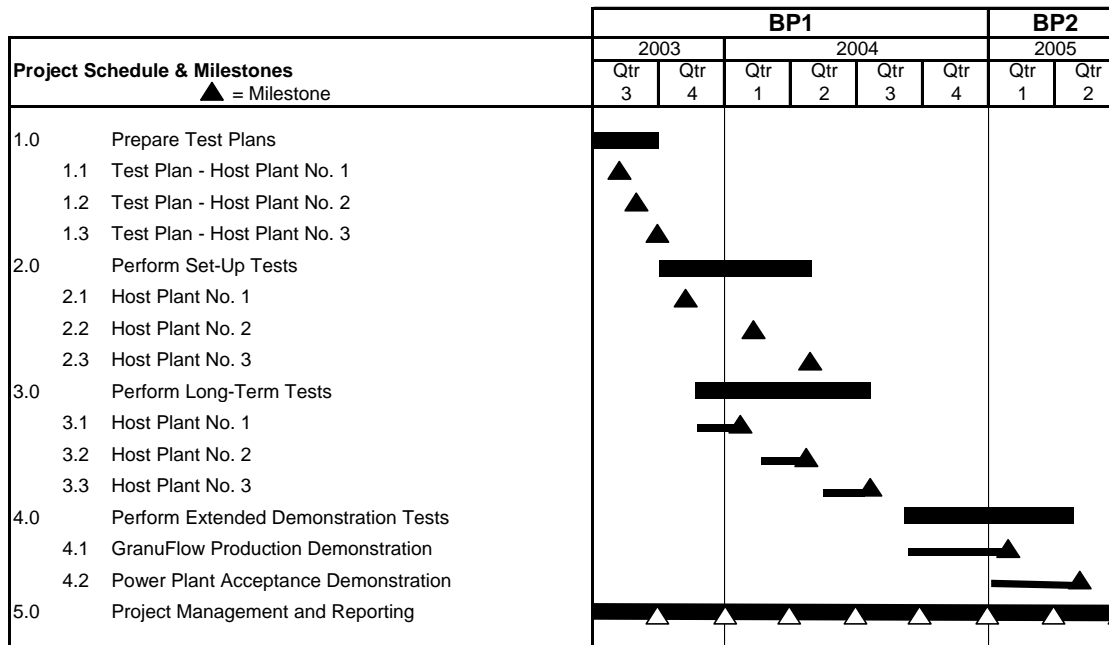
Project Work Breakdown Structure

WBS	Description	Duration (mos.)
1.0	Prepare Test Plans	3
2.0	Perform Set-Up Tests	6
3.0	Perform Long-Term Tests at Optimum Conditions	6
4.0	Perform Extended Demonstration Tests	9
5.0	Project Management and Reporting	<u>24</u>
	Total Project	24

INTRODUCTION

The Cooperative Agreement was executed in July 2003, with a 24-month term starting July 17, 2003 and continuing through July 16, 2005. A project budget/cost plan and milestone schedule was promptly prepared and submitted to the DOE Project Officer.

PROJECT MILESTONE SCHEDULE DOE DE-FC26-03NT41788 GranuFlow Demonstration



During the past quarter, tests were performed in a commercial coal cleaning plant to assess the suitability of a sampling device designed to capture a representative sample of a high-flow, coal slurry stream. CQ engineers visited two coal operations in Alabama, and set-up tests were initiated at PinnOak Resources' Concord Coal Preparation Plant (Hueytown, AL) in March 2004. Heritage Research Group performed bench-scale centrifuge tests to evaluate asphalt emulsion type and dosage in support of the set-up tests at Concord.

EXECUTIVE SUMMARY

CQ Inc. engineers visited two coal cleaning operations in Alabama—Jim Walter Resources, Inc. (JWR) and PinnOak Resources, LLC—to determine their interest in the GranuFlow technology and to evaluate these sites as potential test demonstration sites for the project. Both companies operate plants (nominal 1000-tph) that produce metallurgical and steam coal, and experience high losses of the fine coal during the dewatering process. Froth flotation concentrate samples were collected for characterization and emulsion selection testing. Following the plant visits, draft test plans were prepared, defining the test conditions and parameters required to perform GranuFlow set-up tests, including test conditions and procedures; sampling & analytical plan; test schedule; and project team responsibilities. The plans were subsequently submitted to JWR and PinnOak for review. GranuFlow setup testing was subsequently scheduled for PinnOak's Concord Plant.

The Heritage Research Group (Indianapolis, IN) performed bench-scale centrifuge tests to evaluate different emulsions for the Concord demonstration tests. The Heritage emulsions are emulsified hydrocarbon residues consisting of complex mixtures of high-molecular weight hydrocarbons produced from crude petroleum in suspension with water. Three emulsions were evaluated for the Concord test program: cationic CCB, cationic HES-C, and anionic HES-A (with proprietary additive). All three emulsions achieved significant increases in solids capture as compared to tests without emulsion. Adding 1% emulsion to the feed slurry (flotation concentrate) resulted in solids capture in the 80-95 percent range as compared to only 25% when no emulsion was used. At the 1.0% dosage rate, the HES-A resulted in the greatest solids capture (94.1%), with only 5.9% of the feed solids reporting to the centrate. HES-A was selected for testing at the Concord Plant.

The initial GranuFlow setup tests were performed at the Concord Plant March 29-31, 2004. The HES-A asphalt emulsion was added to the froth flotation concentrate stream at dosages ranging from 0.5% to 1.5%. Baseline tests (no emulsion added) were conducted immediately prior to and after each emulsion test. For each test, samples were collected around a single screen bowl centrifuge (#4), including the centrifuge feed, filter cake product, main effluent, and screen drain effluent. A total of ten tests were completed over this period, and additional setup tests will be performed in the next quarter.

STATUS BY WBS ELEMENT

WBS 1.0 – Test Planning

In January 2004, CQ Inc. engineers visited two coal companies in Alabama—Jim Walter Resources, Inc.(JWR) and PinnOak Resources, LLC—to discuss the possibility of performing GranuFlow demonstration testing at their coal preparation plants. JWR operates three coal cleaning plants—No. 4, No.5, and No. 7—near Brookwood, Alabama. PinnOak owns and operates the Concord Plant, located near Hueytown and formerly owned by U.S. Steel. These plants produce both metallurgical and steam coal with plant coal feed rates at nominally 1,000 tph, and experience high losses of the fine coal during the dewatering process. Froth flotation concentrate samples were collected for characterization and emulsion selection testing.

Jim Walter Resources

JWR operates in the Blue Creek seam of Alabama, producing clean coal for both the steam and metallurgical markets. Plants #5 and #7 are dual-circuit plants, while Plant #4 is single circuit. Flowsheets for all three plants are very similar: heavy-media cyclones to clean the coarse coal, and a combination of classifying cyclones, spirals, and froth flotation to clean the intermediate-



and fine-sized coal. Plant #5 was suggested by JWR as the potential demonstration host site. The clean coal products from the spirals and froth flotation cells are dewatered by 44" x 132" screen bowl centrifuges. Moisture content of the screen bowl cake ranges from 15 to 18 wt%. Samples of the froth flotation concentrate were collected for future bench-scale testing to evaluate emulsion type and selection.

Jim Walter Resources Plant No. 5 (Brookwood, AL)

A draft test plan was subsequently prepared and submitted to JWR for their review and comments. The plan describes the test conditions and parameters required to perform potential GranuFlow set-up tests, including test conditions and procedures; sampling & analytical plan; test schedule; and project team responsibilities.

PinnOak Resources

PinnOak Resources, LLC owns and operates the Concord Coal Cleaning Plant, located in Hueytown, Alabama. The plant processes both steam and metallurgical coals, with a design plant feed rate of 1,000 tph and typical clean coal yields of 55%-60%.

The intermediate/fine coal circuit consists of primary classifying cyclones (PCC), spirals, secondary classifying cyclones (SCC), froth flotation, and screen bowl centrifuges. The overflow from the PCCs are fed to the SCCs; the SCC underflow is the feed stream to flotation (4 banks of five 180-ft³ cells), while the SCC overflow is piped to a refuse thickener. The coal being processed is very soft and fine in size consist; as a result, the feed to the flotation cells can be as much as almost twice that of the design flowsheet rate (design 54 tph vs. actual 80-100 tph). The

feed to the flotation cells is approximately 80% minus 325 mesh (0.045 mm). The flotation and spiral clean-coal products are combined and then dewatered via four 44" x 132" screen bowl centrifuges (total design feed rate of 2,200 gpm and 242 tph). A draft test plan was subsequently



PinnOak's Concord Plant (Hueytown, AL)

prepared and submitted to PinnOak for their review and comments. The plan describes the test conditions and parameters required to perform GranuFlow set-up tests, including test conditions and procedures; sampling & analytical plan; test schedule; and project team responsibilities. Setup tests were subsequently scheduled to be performed in March 2004.

WBS 2.0 – Set-Up Tests

GranuFlow setup testing was performed at PinnOak's Concord Plant March 29-31, 2004. Prior to these tests, the Heritage Research Group performed bench-scale centrifuge tests to evaluate asphalt emulsion types, and to help select the emulsion and dosages to be tested at Concord.

Heritage – Bench Scale Emulsion Tests

Froth flotation concentrate, at approximately 15 wt% solids, was collected from the Concord Plant in January 2004 and shipped to Heritage Research (Indianapolis, IN) for bench-scale centrifuge tests. Tests were performed using a lab-scale IEC chemical centrifuge, consisting of seven variable speeds ranging from 0 to 15,000 rpm. The centrifuge consists of an 8-inch horizontal rotating stainless basket (with a plastic filter cloth) which applies the centrifugal force to drive off moisture from the coal slurry through the filter cloth. A speed setting of 4 (6,500 rpm) was selected for the tests, and the centrifuge basket was rotated for one minute. The moisture content of the resultant filter cake and percent solids of the concentrate were measured for each test, and the solids distribution then calculated to determine the amount of solids reporting to the product (cake) and concentrate under each test condition.

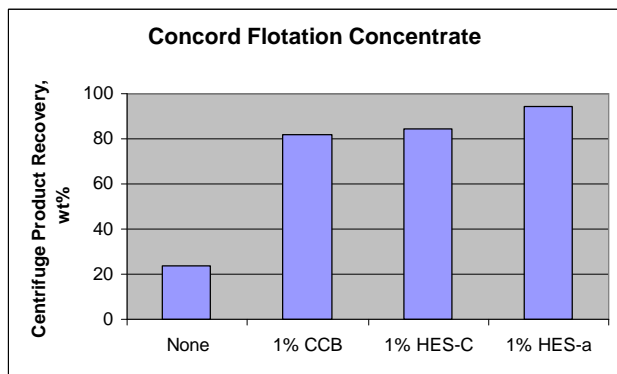
The emulsions used in these tests are emulsified hydrocarbon residues consisting of complex mixtures of high-molecular weight hydrocarbons produced from crude petroleum in suspension with water. Three emulsions were evaluated for the Concord test program:

- ? Cationic CCB
- ? Cationic HES-C
- ? Anionic HES-A (with proprietary additive)

Table 1 compares the dewatering performance and solids capture for the three emulsions at an emulsion dosage of 1 wt% (wt% of emulsion per wt. of coal); the product recovery data are also shown graphically below.

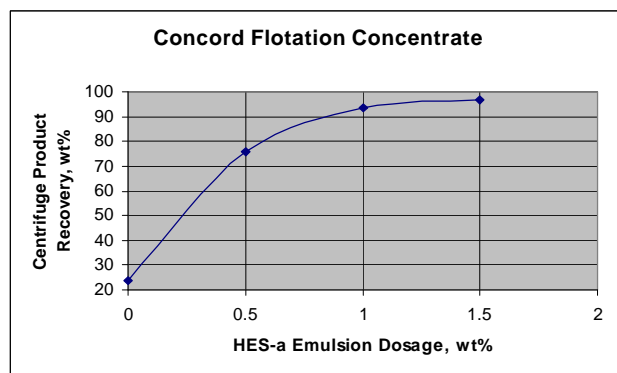
Table 1. Emulsion Type vs. Product Solids Recovery

Emulsion	Dosage, wt%	Product Moisture, wt%	Solids Balance, wt%		
			Feed	Product	Centrate
None	0.0	34.2	100	23.6	76.4
CCB	1.0	32.3	100	81.6	18.4
HES-C	1.0	35.4	100	84.3	15.7
HES-A	1.0	33.6	100	94.1	5.9



As shown in Table 1 and the chart to the left, all three emulsions achieved significant increases in solids capture as compared to the test without emulsion. Without emulsion, over $\frac{3}{4}$ of the solids passed through the basket and filter cloth with the centrate, with about $\frac{1}{4}$ of the material being captured as the product cake. Adding 1% emulsion to the feed slurry resulted in solids capture in the 80-95 percent range, with a significant reduction in the amount of solids

found in the centrate. This is an indication that the emulsion is agglomerating the ultrafines, resulting in increased particle size and allowing better capture by the filter. At the 1.0% dosage rate, the HES-A resulted in the greatest solids capture (94.1%), with only 5.9% of the feed solids reporting to the centrate.



Additional tests were performed with the HES-A emulsion at three dosages—0.5%, 1.0%, and 1.5%. Product recovery is plotted in the graph to the left. Product recovery increased as more emulsion was added, from 75.7% recovery at 0.5% emulsion to a maximum of 96.7% at 1.5% emulsion. Based on these results, it was determined that the HES-A emulsion would be used for the field set-up tests at the Concord Plant.

PinnOak Concord – Setup Tests

The initial setup test series was performed at the Concord Plant March 29-31, 2004. In the week immediately prior to these tests, CQ Inc. and Heritage staff traveled to the site to prepare for the tests, including the delivery and installation of the emulsion pump and discharge hose, and to locate one tanker load of the HES-A emulsion adjacent to the plant. Sampling equipment and containers were also provided at this time. Concord staff were responsible for the electrical hookup of the emulsion pump, and plant circuit modifications required to collect the appropriate samples around the test centrifuge (installing 3-way valves, cutting an opening into the filter cake discharge chute, etc.).

The setup tests were performed according to the following procedures as defined in the test plan:

- ? All relevant plant/circuit operations, test parameters, and test data were continuously observed and logged by a test engineer for the duration of each test. In addition, for each test, the test engineer recorded the plant raw coal feed, clean coal output, and clean coal yield continually.
- ? The feed rate to the plant was maintained at or near its maximum.
- ? Any plant shutdowns or significant prolonged reductions in plant/test circuit feed rate were followed by a minimum of 30 minutes of normal resumed operation prior to the resumption of sampling.
- ? A minimum of 30 increments were taken for each sample at appropriate intervals to ensure the collection of sufficient mass for all analytical procedures.
- ? In as much as operations, sampling location accessibility, and sampler safety considerations allow, full-stream samples were collected.
- ? Flow rates (gpm) for the centrifuge effluent streams (main and screen drain) were measured and recorded via timed measurement. The centrifuge feed flow rate was estimated using a portable ultrasonic flow meter.
- ? The flow rate (gpm) of the emulsion was pre-set manually to allow for a minimum of 30 minutes of treatment of the appropriate dosage before the initiation of sampling and data collection activities.
- ? The flow rate (gpm) of the emulsion was monitored continually by an in-stream flow meter for the duration of each test.



Asphalt Emulsion Tanker at the Concord Plant



Sampling Screen Bowl Centrifuge Filter Cake

The HES-A asphalt emulsion was added to the flotation concentrate stream at a point immediately downstream of the screen bowl feed sump (screen bowl feed pump discharge). The emulsion was added at dosages ranging from 0.5% to 1.5% (1 to 3 gpm). Baseline tests (no emulsion added) were conducted immediately prior to and after each emulsion test. For each test, the plant circuit was allowed to stabilize for 15 minutes following a condition change (emulsion on or off) before sampling was initiated. Following the 15-minute stabilization period, samples were collected for one hour around a single screen bowl centrifuge (#4), including the centrifuge feed, filter cake product, main effluent, and screen drain effluent. All samples were collected in 55-gal drums, sealed, and transported to SGS Labs (Birmingham, AL) for the following analyses:

- ? % Moisture (% Solids)
- ? % Ash
- ? % Sulfur
- ? Heating Value (Btu/lb)
- ? Size Consist & Ash Distribution @ + 28 mesh, 28M x 150M, 150M x 325M, and – 325M

Plant operational problems encountered during the week reduced the number of tests performed, and additional setup tests are planned for Q2 2004.

Plans for Q2/2004

Project activities planned for the 2nd quarter of 2004 include:

- ? Analyze test samples from the initial Concord setup tests.
- ? Analyze sample and test data for Concord setup tests.
- ? Complete setup testing at Concord.
- ? Finalize Test Plan for the setup tests to be performed at EME's Homer City Coal Cleaning Plant.
- ? Perform setup tests at EME's HCCP.