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ENGINEERING DEVELOPMENT OF ADVANCED PHYSICAL FINE COAL CLEANING FOR PREMIUM FUEL APPLICATIONS

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ABSTRACT

The primary goal of this project is the engineering development of two advanced physical fine coal cleaning processes, column flotation and selective agglomeration, for premium fuel applications. The project scope includes laboratory research and bench-scale testing on six coals to optimize these processes, followed by the design, construction, and operation of a 2-t/hr process development unit (PDU). The project began in October, 1992, and is scheduled for completion by September 1997.

During Quarter 16 (July - September, 1996) three commercial size Microcel™ columns (4' diameter) were installed at the Lady Dunn Preparation Plant. Clean coal is currently being produced with favorable yield and ash product values. Briquetting tests were completed at TraDet, Inc. with very good success.

Under Subtask 3.3, evaluation of the hydrophobic dewatering (HD) process continued. Efforts were directed to determine the effects of coal oxidation on product moisture and hydrophobic substance absorption. Hydrophobic dewatering of unoxidized coal resulted in a product moisture of one to two percent while the oxidized coal produced a moisture of 40 percent.

Subtask 6.5 agglomeration bench-scale testing results confirmed that a Hiawatha coal grind with a d_{80} of approximately 65 microns (100-mesh topsize) would be adequate to meet the 2 lb/MBtu product ash specification. It was also determined that an Indiana VII coal grind finer than that used during the flotation PDU operations would be required for the selective agglomeration PDU operation.

Procurement of coal under Subtask 8.1 continued with 450 tons of Hiawatha coal and 600 tons of Taggart coal stockpiled for use in the Selective Agglomeration Module.

Under Subtask 8.4, operation of the PDU Flotation Module was completed during the quarter. Parametric testing of the Indiana VII and Hiawatha coals was completed as well as the development of associated regression equations, optimization testwork, and extended production runs.

Construction of the PDU selective agglomeration module continued under Subtask 9.1, with construction approximately 94 percent complete. All anticipated purchasing has been completed. SA Module start-up and testing under Subtask 9.2 will commence early next quarter.

Under Task 11, Bechtel Corporation began design of a conceptual premium fuels plant located in the Ohio Valley region. Due to high capital costs and low unit capacity, special attention is being given to the clean coal dewatering and CWF preparation circuits.

EXECUTIVE SUMMARY

This project is a major step in the Department of Energy's (DOE) program to show that ultra-clean coal-water slurry fuel (CWF) can be produced from selected coals and that this premium fuel will be a cost-effective replacement for oil and natural gas now fueling some of the industrial and utility boilers in the United States, as well as for advanced combustors currently under development. The replacement of oil and gas with CWF can only be realized if retrofit costs are kept to a minimum and retrofit boiler emissions meet national goals for clean air. These concerns establish the specifications for maximum ash and sulfur levels and combustion properties of the CWF.

This multi-year cost-share contract started on October 1, 1992, and is scheduled for completion by September 1997. This report discusses the progress made during the 16th quarter of the project from July 1 to September 30, 1996.

SPECIFIC OBJECTIVES OF PROJECT

The project has three major objectives:

- The primary objective is to develop the design base for prototype commercial advanced fine coal cleaning facilities capable of producing ultra-clean coals suitable for conversion to coal-water slurry fuel for premium fuel applications. The fine coal cleaning technologies are advanced column flotation and selective agglomeration.
- A secondary objective is to develop the design base for near-term application of these advanced fine coal cleaning technologies in new or existing coal preparation plants to efficiently process minus 28-mesh coal fines and convert them to marketable products in current market economics.
- A third objective is to determine the removal of toxic trace elements from coal by advance column flotation and selective agglomeration technologies.

APPROACH

The project team consists of Cyprus Amax Minerals Company through its subsidiaries Amax Research & Development Center (Amax R&D) and Cyprus Amax Coal Company (Midwest and Cannelton Divisions), Arcanum Corporation, Bechtel Corporation, Center for Applied Energy Research (CAER) of the University of Kentucky, and the Center for Coal and Mineral Processing (CCMP) of the Virginia Polytechnic Institute and State University. Entech Global manages the project for Amax R&D and provides research and development services. Dr. Douglas Keller of Syracuse University and Dr. John Dooher of Adelphi University are both consultants to the project. Mech EL Contracting, Inc. of Aurora, Colorado, is constructing the Process Development Unit (PDU) Selective Agglomeration Module.

The project effort has been divided into four phases which are further divided into eleven tasks including coal selection, laboratory and bench-scale process optimization research and testing, along with design, construction, and operation of a 2 ton/hr PDU. Tonnage quantities of the ultra-clean coals will be produced in the PDU for combustion testing. Near-term applications of advanced cleaning technologies to existing coal preparation plants is also being studied.

ACCOMPLISHMENTS DURING QUARTER

Activities continued during July - September 1996 on Phases I, II, and III of the project. Work was carried out under Tasks 3, 6, 8, 9, and 11 as described below.

Task 3 Development of Near-Term Applications

A 1993 Bechtel engineering analysis evaluating potential column flotation and selective agglomeration applications found a column flotation application at the Lady Dunn Preparation Plant particularly attractive since the plant was being considered for a major capacity expansion. Because of the potential advantages of installing column flotation rather than mechanical flotation cells in the expanded fine coal cleaning circuit, Lady Dunn management was pleased to offer their plant as the study site for a near-term application of column flotation. The Microcel™ flotation column was selected for this study and the Center for Coal and Mineral Processing (CCMP) at Virginia Tech was assigned the responsibility for the on-site test work. The testing has been completed and the subtask report is being prepared. Subtask 3.3, investigating a novel dewatering process for advanced flotation products is also being performed by CCMP.

Subtask 3.2 Engineering Development

As described during previous Quarterly Progress Reports [11, 12, 13, 14, 15], a 30-inch diameter Microcel™ flotation column was installed in the Lady Dunn Plant for the engineering development studies. The testing results were so good that Cannelton included column flotation in their 1996 plant expansion and the three 4-meter Microcel™ columns are now operating at Lady Dunn. Clean coal is being produced with ash contents below target and with a favorable recovery.

A portion of the clean coal from the 30-inch column testing was submitted to TraDet, Inc. for binderless briquetting tests. Satisfactory quality specimens of the briquette production were returned by TraDet, who reported that the briquetting was done at near-ambient temperature on the flotation product after it had been air-dried to between 1.0 and 2.4 percent moisture.

A model B-100A Komarek laboratory roll-press machine was used. The rolls were preheated to equilibrium operating temperature by briquetting waste material before switching to the test coal. Parametric tests were made at three roll speeds and at five hydraulic roll pressures between 1,300 and 2,800 psig on batches of the coal that had been dried to four different moisture levels. At the product temperatures of 128° to 178° F, these pressures deform coal particles and fuse them together.

The crush strengths of the briquettes were between 50 and 200 lbs, and these strengths correlated well with the amount of energy transferred to the briquettes (between 8 and 29 kWh/ton). TraDet considers any strength over 100 lbs to be acceptable for briquettes such as these. The best briquettes were made when the feed coal had been dried to 1.0 percent moisture. The products from all 58 tests had acceptable moisture reabsorption, weathering and briquette degradation properties. Based upon these results, TraDet suggested follow-up optimization testing in a pilot-size machine to allow scale-up of the laboratory briquetting performance to commercial/production units.

Subtask 3.3 Dewatering Studies

During the hydrophobic dewatering (HD) process, a hydrophobic substance such as butane is added to a coal-water slurry to displace water from the surface of the coal. The hydrophobic substance is subsequently recovered and reused. Earlier testing revealed the ability of the HD process to reduce the moisture content of fine coal to a very low level and included a determination of the potential losses by adsorption of butane onto the coal. Work in the period covered by this report focused on the variations in the adsorbed amounts of butane and residual moisture contents as a function of the oxidation state of the coal sample.

Absorption losses were determined by tracking the loss in weight of dried coal with time after depressurization. To do this, small bottles containing known weights of coal were filled with liquid butane and held in a pressure chamber for one hour before release of the pressure. It was found that 80 minutes after depressurization, unoxidized coal retained 0.17 percent butane and oxidized coal retained 0.10 percent butane. This suggests that the absorption is due to hydrophobic interaction between butane molecules and the coal surface. A striking difference between hydrophobic interactions was seen when comparing the dewatering effect of butane on a slurry of unoxidized coal with the dewatering effect of butane on a slurry of oxidized coal. The dewatered unoxidized coal retained only 1 to 2 percent moisture while the dewatered oxidized coal retained 40 percent moisture. Because of this striking hydrophobic effect, it appears that the HD process will be successfully applied to fine hydrophobic coals which float well in a preparation plant or premium fuel production plant, but the process will not be applicable to fine oxidized coal which is also difficult to float.

Task 6 Engineering Development of Selective Agglomeration

Task 6 activity during this reporting quarter focused on Subtask 6.4 CWF Formulation Studies, and Subtask 6.5 Bench-scale Testing and Process Scale-up.

Subtask 6.4 CWF Formulation Studies

The primary objective of Subtask 6.4 is to evaluate properties of coal-water-fuel (CWF) slurries prepared from the selective agglomeration products generated during Subtask 6.5, Selective Agglomeration Bench-scale Testing and Process Scale-up. The main thrust during the quarter was to update target specifications for the CWF slurries. Published information was reviewed and telephone contacts made with representatives of organizations who are or were actively involved in developing applications for CWF. Penn State and Penelec appear to be the only well-known groups in the US actively studying the application of CWF for firing boilers at this time. A. D. Little, along with Cooper-Bessemer, remains part of a group developing CWF-fueled diesel engines under a Clean Coal Technology program.

Development of Target CWF Slurry Specifications - Based upon the information gleaned from published accounts of CWF firing in boilers and the testing and the thoughts of those currently engaged in utilizing CWF in the U. S. (specifically at Penn State and Penelec), working specifications were adopted as targets for formulation of premium CWF from coal cleaned by selective agglomeration. Generally, the working specifications require the fuel to have the following attributes:

• Ash Content:	Less than 2 lb/MBtu HHV
• Sulfur Content:	Less than 0.6 lb/MBtu HHV
• Particle Size Distribution:	100% minus 0.20 mm
	98% minus 0.15 mm
	80% minus 0.075 mm
• Higher Heating Value:	Greater then 7,500 Btu/lb CWF
• Viscosity @ $100s^{-1}$ shear rate:	200 to 500 cP
• CWF Slurry Loading:	High but complying to viscosity and HHV constraints
• Rheology:	Newtonian or pseudoplastic
• Stability:	Easily resuspended

The ash and sulfur content and the slurry loading specifications are based on the stated DOE contract objectives. The source coal and particle size distributions are primarily based on the requirements of the coal cleaning operations (advanced flotation and/or selective agglomeration) but are influenced by combustion requirements as well. The heating value, viscosity and rheology specifications are based on the atomization and combustion properties of the CWF, and the stability specification is based upon expected storage and handling scenarios. Utilization of the fuel shortly after production is an important feature of these scenarios as is automatic flushing of lines upon shutdown and continuous or periodic remixing strategies in surge tanks and storage vessels.

Advanced combustion heating systems and large coal-fired diesel engines may represent additional markets for premium CWF. Originally, such programs specified that the coal contain less than 1 percent ash, but over time the specification for diesel engine fuel, at least, has been relaxed to allow up to 2 percent ash in the coal (about 1.5 lb/MBtu). Thus, the specifications outlined above for retrofit boiler fuel applications may be applicable to other advanced combustion systems as well.

Properties of Test Coal CWF - Comparisons of CWF solids loadings (% solids) between as-prepared and projected samples (at 500 cP) were conducted during the quarter. Samples of Taggart, Sunnyside, Hiawatha, Indiana VII, Elkhorn No. 3, and Winifrede coals were used in the evaluation. Overall, the accuracy of the projected loading values was very high with little difference between the predicted and actual solids loadings.

The predicted loading values were calculated by the method described in the last quarterly report for projecting the viscosity of slurries in cases where wall slip interferes with the normal measurement. These samples were formulated with 0.5 to 1.0 percent dispersant, and loadings were little changed by increasing the amount of dispersant added. Adjustment of the particle size distributions by regrinding a portion of each agglomeration product improved the loadings of the Taggart, Sunnyside and Hiawatha coals by 1 to 3 percentage points but did not improve the loading of the Elkhorn No. 3. No attempts were made to adjust the particle size distributions of the Indiana VII and Winifrede coals since those coals had been ground to very fine mesh sizes ahead of selective agglomeration.

Slurry Preparation Without Dispersant - Cost is a major concern of prospective users of CWF. Since the dispersants used to prepare high slurry loadings represent such a large portion of this cost, several slurries were prepared without the use of A-23M dispersant. In the case of Taggart clean coal, a slurry loading of 53.9 percent was achieved, and a 52.0-percent coal loading was achieved from Hiawatha filter cake when the A-23M was omitted from the formulation. Such CWF still has a heating value of 7,800 to 8,000 Btu/lb, that is, approaching the heating value of some Powder River Basin coals, so the savings of $0.15 to $0.30 per million Btu in formulation costs may be of interest to certain prospective customers.

Subtask 6.5 Bench-Scale Testing and Process Scale-up

Previous Work - During previous testing with the 25 lb/hr bench-scale unit, evaluation of the Taggart (original and new), Sunnyside, Elkhorn No. 3, and Winifrede coals were completed. It should be noted that the Sunnyside coal has since been replaced with the Hiawatha coal for PDU operations.

Recent work has focused on two of the three project coals of primary interest - Indiana VII and Hiawatha. This work has indicated that for the Indiana VII coal, the 2 lb/MBtu product ash specifications could be met at the selected 325-mesh topsize grind. More testing with the Indiana VII coal, ground during Subtask 8.4 PDU operations, was carried out this reporting quarter.

Agglomeration of the Hiawatha coal at a 150-mesh topsize (d_{80} of 47 microns) was evaluated previously, with results indicating that this grind size was sufficiently fine to achieve the desired 2 lb/MBtu product ash specification. Also during the previous quarter, four tests were completed at a coarser (100 mesh) topsize grind with a d_{80} of 65 microns. This grind also proved sufficiently fine to achieve the 2 lb/MBtu product ash specification.

Hiawatha Coal - During this reporting quarter, ten more agglomeration tests were completed using 100-mesh topsize feedstock of the Hiawatha coal. Most of these tests were performed at 7 or 13% solids concentration, with one test carried out at 10% solids. Generally, lower product ash contents were achieved at 7% solids than at 13% solids. Other variables changed during this test work included:

- High-shear tip speed (6.7 to 15 m/s)
- High-shear residence time (0.5 to 1.4 min)
- Low-shear tip speed (3 and 4.8 m/s)
- Low-shear residence time (1.5 to 3.7 min)
- Coal feed rate (17.5 to 75 lb/hr)
- Heptane concentration (20 to 24%, dry ash free coal basis)

All of these tests were successful in that they met the 2 lb ash/MBtu product specification at Btu recoveries ranging from 96.6 to 99.6%. Tailings ash values for these tests ranged from 56.5 to 86.4%. While some variation in product ash content (1.74 to 1.96 lb/MBtu) was observed, the data indicates that as with all previous testing, the primary influences on product ash are solids concentration in feed slurry and agglomerate size.

It is also noted form this data that the highest Btu recoveries, with associated high tailings ash values, were generally achieved when a fast high-shear impeller tip speed (15 m/s) was utilized.

Indiana VII Coal - Continuous agglomeration testing of the Indiana VII coal continued during this quarter. The feedstock used for this work was a new batch of Indiana coal ground in the PDU under Subtask 8.4. This coal was ground in closed-circuit with the fine grinding mill and 270-mesh screens.

Four test were completed with this feedstock and conditions evaluated were as follows:

- Coal feed rates of 12.5, 17.5, and 25 lb/hr
- Feeds solids concentration of 7 and 10%
- High-shear tip speeds of 15 and 18 m/s
- Low shear tip speed of 4.8 m/s

- Asphalt concentration of 20 lb asphalt/ton of coal
- Heptane concentrations in the 32 to 35 % on a dry ash free basis

Btu recoveries for these tests were in the 96 to 98% range with product ash contents in the 2.9 to 3.7% range, or approximately 2.2 to 2.7 lb ash/MBtu. As such the target ash content of 2 lb/MBtu was not met with this grind. This, however, was not unexpected since this grind was tailored to achieve project goals utilizing advanced flotation, which generally results in lower Btu recoveries and therefore, corresponding lower product ash contents.

Task 8 PDU and Advanced Column Flotation Module

Work continued during this reporting quarter on Subtask 8.1 Coal Selection and Procurement and Subtask 8.4 PDU Flotation Module Operation and Production as discussed below.

Subtask 8.1 Coal Selection and Procurement

Approximately 450 tons of Hiawatha seam coal are on hand to begin the selective agglomeration module testing in the PDU. Approximately 300 tons of Taggart coal and 200 tons of Indiana VII coal also are in storage at a Denver coal yard.

Subtask 8.4 PDU Flotation Module Operation and Production

Operation of the PDU Flotation Module concluded during the third quarter of 1996. Parametric testing of the Indiana VII and Hiawatha coals was completed as well as associated optimization testing and extended production runs.

Parametric Testing of PDU Flotation Module (Indiana VII Coal) - Parametric testing of Indiana VII coal in the PDU Flotation Module was completed during the third quarter of 1996. A test matrix was established to determine the effects of independent variables such as air rate, % solids, feed rate, wash water, and reagent dosage on response variables such as product ash and yield. Fifteen (15) tests were conducted during the period.

The quality goal of 2.00 lb/MBtu of ash was achieved on five occasions. Unfortunately, the overall yield and energy recovery suffered significantly during these tests. The clean coal yield varied from 12.0% to 89.7% while the energy recovery and product ash varied from 13.2% to 96.4% and 1.81 lb/MBtu to 3.25 lb/MBtu, respectively.

Development of PDU Flotation Module Regression Equations (Indiana VII Coal) - Data from PDU Flotation Module parametric testing was compiled and multiple regression models (equations) were generated for Indiana VII coal. Forward stepwise regression produced equations which link output variables such as yield and clean coal quality to input variables such as feed rate, wash water rate, air rate, collector addition, and frother addition.

The equations indicate that the most important variable that affects yield and energy recovery is frother dosage while air rate has the largest impact on product ash. It is important to note that though yield, energy recovery, and clean coal ash are dependent on the feed coal ash content, the ash content itself is not a controllable variable and should be considered a covariant.

Optimization of PDU Flotation Module (Indiana VII Coal) - Optimization of Indiana VII coal in the PDU Flotation Module was completed during the quarter. A total of four tests were performed to determine the optimum Microcel™ setpoints needed to achieve the process development goals of 2.00 lb/MBtu of ash and 80 percent energy recovery with maximum yield.

Equations were first developed to estimate the effects of tested input variables on Microcel™ outputs such as yield and quality. The equations were developed by evaluating the input and output variables of parametric tests by multiple linear regression. The resulting equations were then used to determine optimum Microcel™ test setpoints.

Due to an apparent buildup of frother in the clarified water system, the overall quality goal of 2.00 lb/MBtu of ash was not achieved during optimization. In addition, the test work indicated that very subtle changes in frother dosage have a tremendous impact on yield, energy recovery, and product quality.

Extended Production Run of PDU Flotation Module (Indiana VII Coal) - An extended production run of the PDU Flotation Module was successfully completed during the week of July 22, 1996. Due to the extremely poor filtering characteristics of this coal, 16 hours each day were dedicated to operation of the PDU while the remaining 8 hours were used for filtering accumulated clean coal slurry. Like the Taggart coal, the operation was entirely successful except for a failed belt splice.

Overall, 77 tons of feed coal were processed. The PDU flotation module produced a clean coal product with an ash content of 2.33 lb/MBtu, a yield of approximately 75%, and an energy recovery of approximately 82%. Though the product quality ash goal of 2.00 lb/MBtu was not achieved, the shortfall is most likely attributable to inadequate liberation of mineral matter (high d80 values) and an apparent buildup of frother in the clarified water system during the second half of the production run.

Delivery of Hiawatha Coal to Amax PDU Site - Delivery of crushed Hiawatha coal to the Amax PDU site concluded during the quarter. Diamond Trucking, Inc. delivered twenty one (21) loads of crushed coal totaling approximately 504 tons. Not all Hiawatha coal delivered was used in the PDU flotation module. The unused portion is currently being stored for use in the selective agglomeration module.

Release Analysis (Hiawatha Coal) - To better define the theoretical grade-yield curves associated with different feed size distributions, release analysis test work was performed on the Hiawatha coal during the quarter. Two Microcel feed slurries, one having a size distribution with 80% passing 54 microns and a second with 80% passing 49 microns, were evaluated

Observation of the data revealed that though the ash goal of 2.00 lb/MBtu can be achieved at both size distributions, there is a subtle change in the flotation characteristics when the d80 is reduced from 54 microns to 49 microns. At a product ash value of 2.00 lb/MBtu, the yield improves from about 92% to 93% while the Energy Recovery rises from 98% to about 99%. However, at a product ash of 1.90 lb/MBtu, the yield increases from 89% to 92% while the Energy Recovery improves from about 94% to 98%.

Overall, it can be concluded that grinding the Hiawatha coal to a d80 of 49 microns typically improves the yield and energy recovery when operating near the "knee" of each curve.

Parametric Testing of Grinding Circuit (Hiawatha Coal) - Parametric testing of the PDU grinding circuit was completed during the third quarter of 1996. Nineteen (19) tests, aimed at optimizing the mineral liberation potential of the grinding circuit, were conducted. Because the Hiawatha coal was not evaluated in the 12-inch Microcel during Subtask 4.4 (Hiawatha replaced Sunnyside), no data was available for indicating expected performance.

Release analysis of the Hiawatha coal suggests that the product ash quality goal of 2.00 lb/MBtu can be achieved with size distributions having d80 values of 54 and 49 microns respectively. Improved performance, however, was indicated when the coal was ground to a d80 size of 49 microns.

The parametric testwork revealed that a product d80 of 49 microns can be achieved under the following conditions:

- Primary Mill Media Loading: 9,100 pounds
- Secondary Mill Media Loading: 9,100 pounds
- Classifying Cyclones: 2-inch diameter
- Screen Cloth Size: 145 mesh

These conditions listed are considered optimal for the PDU grinding circuit and were used for all flotation module test work.

Ground Product d80 Evaluations - Microtrac vs. Wet Screening - Due to a suspected performance difference between the Microtrac and wet screening methods of size analysis, a series of comparative test were performed. Four hourly samples were collected during test H-13 for evaluation by both methods.

The testing revealed that wet screening gave lower d80 values (5 micron average difference) and was more consistent than the Microtrac unit. As a result, use of the Microtrac was temporarily abandoned until repairs can be made. A Microtrac technician is scheduled to repair the unit during the first week of October, 1996.

Parametric Testing of PDU Flotation Module (Hiawatha Coal) - Parametric testing of Hiawatha coal in the PDU Flotation Module was completed during the quarter. A test matrix was established to determine the effects of independent variables such as air rate, % solids, feed rate, wash water, and reagent dosage on response variables such as product ash and yield. Twenty (20) tests were conducted during the period.

The quality goal of 2.00 lb/MBtu of ash was achieved on two occasions. Unfortunately, the overall yield and energy recovery suffered significantly during one of these tests. The clean coal yield varied from 12.3% to 94.0% while the energy recovery and product ash varied from 13.8% to 98.7% and 1.43 lb/MBtu to 2.87 lb/MBtu, respectively. The Microcel feed d80 values averaged 50 microns with a standard deviation of 3 microns.

Development of PDU Flotation Module Regression Equations (Hiawatha Coal) - Data from PDU Flotation Module parametric testing was compiled and multiple regression models (equations) were generated for Hiawatha coal. Forward stepwise regression produced equations which link output variables such as yield and clean coal quality to input variables such as feed rate, wash water rate, air rate, collector addition, and frother addition.

The equations indicate that the most important variables that affect yield and energy recovery are Feed Ash % and Frother Dosage while Recirculation Rate (affects bubble size) and Wash Water have the largest impact on product ash. It is important to note that though yield, energy recovery, and clean coal ash are dependent on the feed coal ash content, the ash content itself is not a controllable variable and should be considered a covariant.

Optimization of PDU Flotation Module (Hiawatha Coal) - Optimization of Hiawatha coal in the PDU Flotation Module was completed during the quarter. A total of eight tests were performed to determine the optimum Microcel™ setpoints needed to achieve the process development goals of 2.00 lb/MBtu of ash and 80 percent energy recovery with maximum yield.

Equations were first developed to estimate the effects of tested input variables on Microcel™ outputs such as yield and quality. The equations were developed by evaluating the input and output variables of parametric tests by multiple linear regression. The resulting equations were then used to determine optimum Microcel™ test setpoints. Overall, the product ash goal of 2.00 lb/MBtu was achieved on two occasions. The setpoints used during one of these tests (with lower frother dosage) was used for the extended production run.

Extended Production Run of PDU Flotation Module (Hiawatha Coal) - An extended production run of the PDU Flotation Module was successfully completed during the month of September, 1996. The effort commenced the morning of Monday, September 23 and concluded 72 hours later on the morning of Thursday, September 26. No downtime was experienced during the time period.

Overall, 155.1 tons of feed coal was processed. The PDU flotation module produced a clean coal product with the following average values:

- Ash: 1.89 lb/MBtu
- Sulfur: 0.44 lb/MBtu
- Yield: 81.8%
- Energy Recovery: 88.0%

Not only was the extended production run successful from an operating point of view, all project development goals were accomplished.

Electric Power Usage - Hiawatha Extended Production Run - To better define the economics associated with operating the PDU Flotation Module, electric power usage related to the Hiawatha Extended Production Run has been determined. Public Service Company of Colorado was very helpful in this regard. Overall, the PDU consumed 16,560 kWh of electricity during the 72 hour period. This results in a usage rate of 155.14 kWh / feed ton of coal.

Disposal of Clean Coal Filter Cake - Fifty bags (supersacks) of Taggart filter cake as well as one bag of Indiana VII filter cake were shipped to The Pennsylvania State University on Tuesday, August 13, 1996. Though 200 bags of Taggart product were initially scheduled for delivery to Penn State, difficulties in finding storage space resulted in a reduced delivery. The remaining bags of Taggart and Indiana VII filter cake were disposed as refuse.

There were 131 bags (supersacks) of Hiawatha filter cake produced during the extended production run. So far, 75 bags have been disposed to date with 53 sent to landfill and 22 transported to the Western Aggregate facility near Golden, Colorado. Currently, 56 bags remain on site.

Since the flatbed trucks used for transport hold a maximum of 22 bags, two truckloads (44 bags) are tentatively scheduled for delivery to The Pennsylvania State University during the upcoming quarter. Two bags will be stored for possible future use by Amax R&D and the remaining 10 bags will be sent to Western Aggregate.

Task 9 Selective Agglomeration Module

Subtask 9.1 PDU Selective Agglomeration Module Construction

During the previous reporting quarter, Mech El Contracting, Inc. (MEI) of Aurora, Colorado, was selected to carry out the construction of the PDU Selective Agglomeration (SA) module. Construction began on March 11, 1996. MEI is constructing the SA Module based on the detailed design prepared by Bechtel and is providing all the labor and materials for the construction except the major pieces of equipment which are provided by Amax R&D.

Equipment Purchasing - Orders were placed and Purchase Orders issued for a number of different equipment items and services as well as other miscellaneous electrical, instrumentation, and Distributive Control System (DCS) items during this quarter. With the ordering and purchasing of these equipment and services, the bulk of purchasing under Subtask 9.1 is complete.

Construction - Construction of the Selective Agglomeration PDU module by MEI continued during this reporting quarter. Work completed on the construction of Plant Area 300 was as follows:

- The completion of all equipment installation
- The completion of all clarified water, utility water, gas blanket, and relief system piping
- Continuation of process piping installation
- Installation of virtually all of the instrumentation items
- Continuation of the running of various conduits and wires to and from the MCC, DCS, equipment, and instrumentation locations
- The installation of the new roof, including a removable section for servicing of the agglomeration agitators
- Installation of ventilation system exhaust duct work
- Installation of used air handling unit and new exhaust blower
- Completion of all heat tracing and the bulk of the insulation

Outstanding work as of the end of this reporting quarter includes the following:

- Completion of fine grinding mill cooling water circuit process piping
- Completion of instrument and process air piping
- Completion of pump and mixer cooling water and lubricator piping
- Installation and wiring of several instruments and one sampler
- Completion of personnel protection insulation
- Completion of DCS panel wiring

- Completion of ventilation exhaust duct work and balancing of the ventilation system

The following summarizes the progress of the work completed as of the end of September 1996:

- Mobilization, excavation, concrete, and foundation work - 100% complete
- Structural steel & platework - 100% complete
- Equipment installation - 100% complete
- Piping Installation - 99% complete
- Electrical & instrumentation installation - 99% complete
- Ventilation and fire protection - 99% complete
- Sheeting and painting - 76% complete
- Overall construction effort - 94% complete

In addition, the building of the DCS system operator screens and the programming of the DCS logic, control, and database schemes are continuing towards the completion of Subtask 9.1. This work is being performed by two consultants, Control Technology, Inc. and AR Technologies.

Task 11 Project Final Report

The final project report will include an economic assessment of producing premium fuel from coal. The assessment will be based upon the results of the Tasks 4 and 6 laboratory and bench-scale testing and upon the Tasks 8 and 9 PDU operation of the advanced flotation and selective agglomeration modules. Capital and operating costs for the economic assessment will be based on the design of a conceptual plant located in the Ohio Valley Region which would produce 1.5 million short tons per year (dry basis) of clean coal marketed as a coal-water slurry fuel.

Bechtel has begun designing the flowsheet for the flotation plant and collecting the data needed for selecting and costing the equipment in the plant. Because of the high cost and low unit capacity of some pieces of equipment, special attention has been given to the clean coal dewatering and CWF preparation circuits. To reduced capital costs, centrifuges will be used for dewatering rather than filters. Also, the grinding mill specified in the initial conceptual flowsheet for particle-size adjustment has been dropped because recent Subtask 6.4 work has shown that the improvement in loading that can be achieved by adjusting the particle size distribution of the CWF is quite meager. The 62-percent loading specification will be retained for the finished product, though, since that loading was achieved during the test work on Taggart coal and approached for the Sunnyside and Hiawatha coals during the CWF formulation studies.

INTRODUCTION AND BACKGROUND

The main purpose of this project is the engineering development of advanced column flotation and selective agglomeration technologies for premium fuel applications. Development of these technologies is an important step in the Department of Energy program to show that an ultra-clean coal-water slurry fuel (CWF) can be produced from selected United States coals and that this fuel will be a cost-effective replacement for a portion of the oil and natural gas burned by electric utility and industrial boilers in this country, as well as for advanced combustors currently under development. Capturing even a relatively small fraction of the total utility and industrial oil-fired boiler fuel market would have a significant impact on domestic coal production and reduce national dependence on petroleum fuels. Significant potential export markets also exist in Europe and the Pacific Rim for cost-effective premium fuels prepared from ultra-clean coal.

The replacement of oil and natural gas with CWF can only be realized if retrofit costs and boiler derating are kept to a minimum. Also, retrofit boiler emissions must be compatible with national clean air goals. These concerns establish the specifications for the ash and sulfur levels and combustion properties of ultra-clean coal as discussed below.

This multi-year cost-shared contract effort began on October 1, 1992, and is scheduled for completion by September 30, 1997. This report discusses the technical progress made during the sixteenth quarter of the project, July 1 to September 30, 1996. Fifteen quarterly reports have been issued previously [1-15].

SPECIFIC OBJECTIVES OF THE PROJECT

The three main objectives of this project are discussed below.

The primary objective is to develop the design base for commercial prototype advanced fine coal cleaning facilities capable of producing ultra-clean coals suitable for conversion to stable, highly loaded coal-water slurry fuels. These slurry fuels should contain less than 2 lb ash/MBtu HHV (860 grams ash/gigajoule) and preferably less than 1 lb ash/MBtu HHV (430 grams ash/gigajoule), and less than 0.6 lb sulfur/MBtu HHV (258 grams sulfur/gigajoule). The advanced fine coal cleaning technologies to be employed are advanced column froth flotation and selective agglomeration. Operating conditions during the advanced cleaning processes should recover at least 80 percent of the heating value in run-of-mine source coals at an annualized cost of less than $2.50/MBtu ($2.37/gigajoule), including the cost of the raw coal.

A secondary objective of the work is to develop a design base for near-term commercial applications of these advanced fine coal cleaning technologies. These applications should be suitable for integration into new or existing coal preparation plants for the purpose of economically and efficiently processing minus 28-mesh coal fines. The design base will also include the auxiliary systems required to yield a shippable, marketable product such as a dry clean coal product.

A third objective of the work is to determine the distribution of toxic trace elements between clean coal product and refuse during the cleaning of various coals by advanced froth flotation and selective agglomeration technologies. Eleven toxic trace elements have been targeted. They are antimony, arsenic, beryllium, cadmium, chromium, cobalt, lead, manganese, mercury, nickel, and selenium. The results will show the potential for removing these toxic trace elements from coal by advanced physical cleaning.

APPROACH

A team headed by Amax Research & Development Center (Amax R&D) was formed to accomplish the project objectives. Figure 1 shows the project organization chart. Entech Global, Inc. is managing the project for Amax R&D and also performing laboratory research and bench-scale testing. Entech Global is also responsible for the operation and evaluation of the 2 t/hr process development unit (PDU). Cyprus Amax Coal Company is providing operating and business perspective, the site for the near-term testing, and some of the coals being used in the program. Bechtel Corporation is providing engineering and design capabilities, and the operating experience it gained while managing similar proof-of-concept projects for DOE. The Center for Applied Energy Research (CAER) at the University of Kentucky and the Center for Coal and Mineral Processing (CCMP) at the Virginia Polytechnic Institute and State University are providing research and operating experience in the column flotation area. Arcanum Corporation is providing similar experience in the selective agglomeration area. Dr. Douglas Keller of Syracuse University is serving as a consultant in the area of selective agglomeration and Dr. John Dooher of Adelphi University is serving as a consultant in the area of coal-water slurry formulation. Robert Reynouard was retained as a consultant to help with electrical and instrumentation systems in the PDU. Mech EL Contracting, Inc. is constructing the Selective Agglomeration Module of the PDU.

The overall engineering development effort has been divided into four phases with specific activities as discussed below. As shown in Table 1, Work Breakdown Structure, the four phases of the project have been further divided into tasks and subtasks, with specific objectives which may be inferred from their titles. Figure 2 shows the project schedule.

Phase I

Phase I encompassed preparation of a detailed Project Work Plan, selection and acquisition of the test coals, and laboratory and bench-scale testing. The laboratory and bench-scale work determined the cleaning potential of the selected coals and established design parameters and operating guidelines for a 2 t/hr PDU containing both advanced column flotation and selective agglomeration modules. A conceptual engineering design was prepared for a fully integrated and instrumented 2 t/hr PDU incorporating the features determined from the laboratory and bench-scale studies.

Additional activities during Phase I included:

- Production of ultra-clean coal test lots by bench-scale column flotation and selective agglomeration for end-use testing
- Determination of toxic trace element distribution during production of these test lots
- Evaluation of the rheological properties of slurry fuels prepared from ultra-clean coals
- Evaluation of methods for applying these advanced cleaning technologies to existing coal preparation plants in the near term

Phases II and III

Phases II and III cover the construction and operation of the 2 t/hr PDU. Phase II is for advanced column flotation while Phase III is for selective agglomeration. Process performance is to be optimized at the PDU-scale, and 100 ton lots of ultra-clean coal is to be produced by each process for each of the three test coals. The toxic trace element distribution is also to be determined during the production runs. The ultra-clean coals are to be delivered to DOE or a designated contractor for end-use testing.

Phase IV

Phase IV activities will include decommissioning of the PDU, restoration of the host site, and preparation of the final project report.

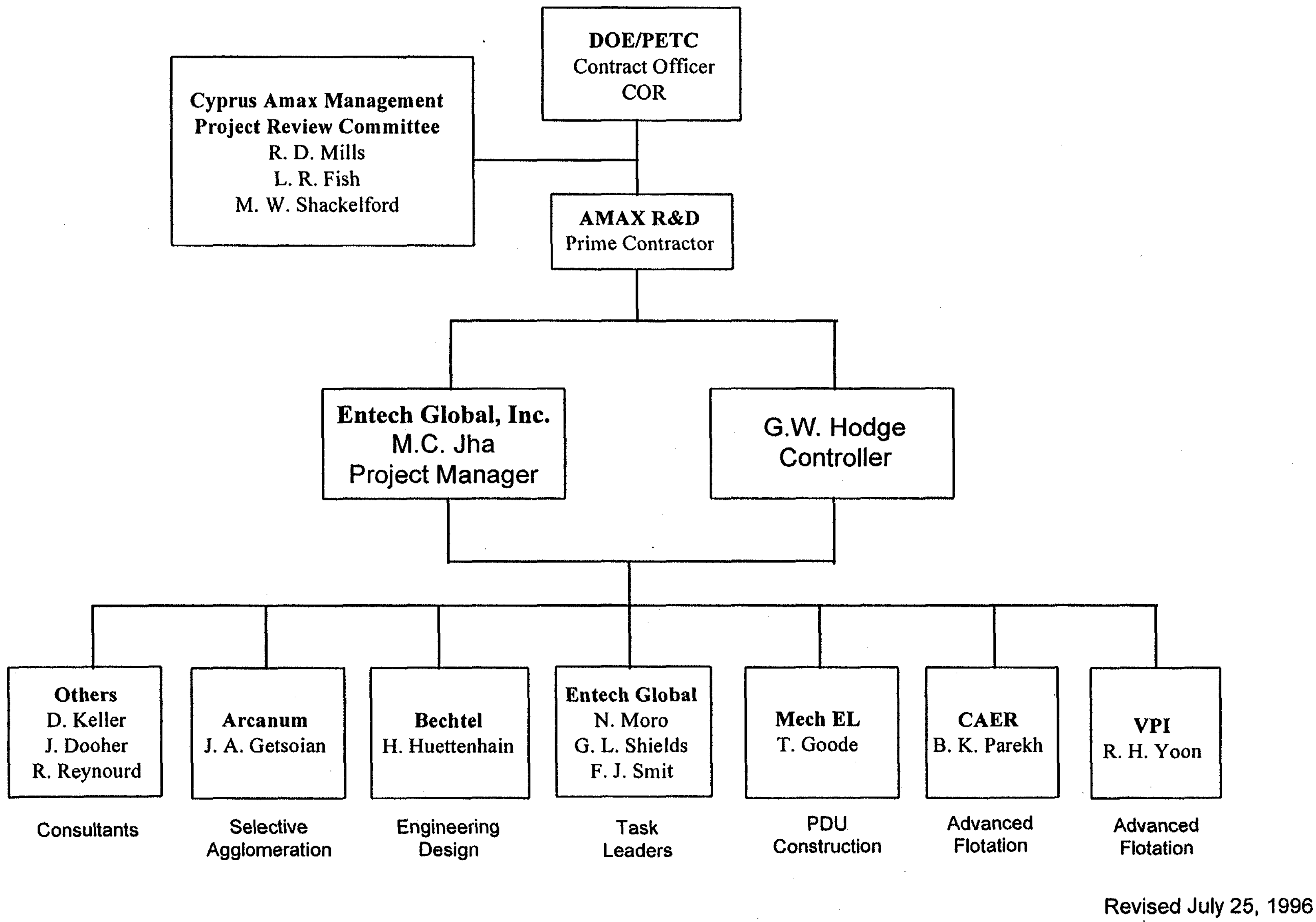
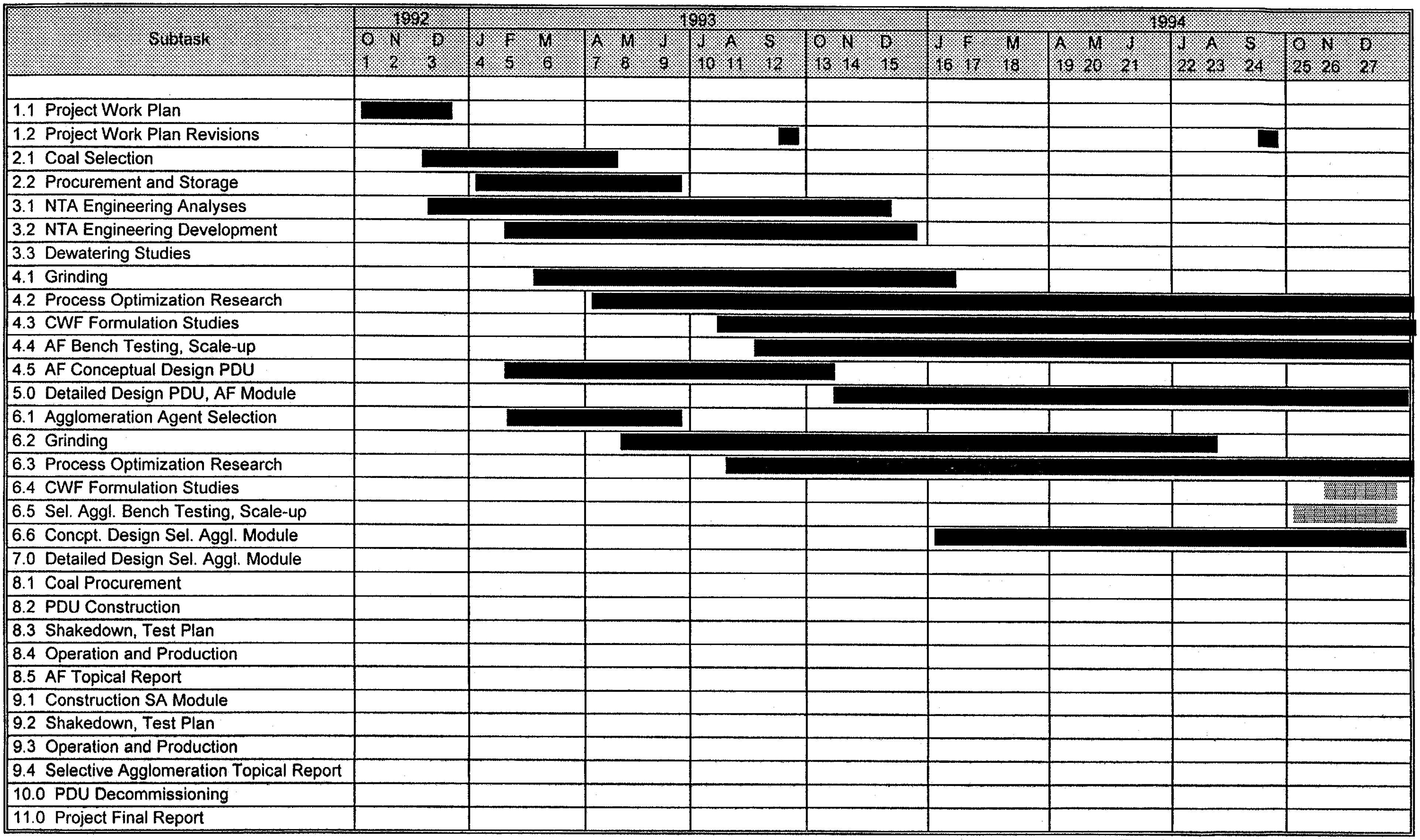


Figure 1. Project Management Organization Chart

Table 1. Outline of Work Breakdown Structure

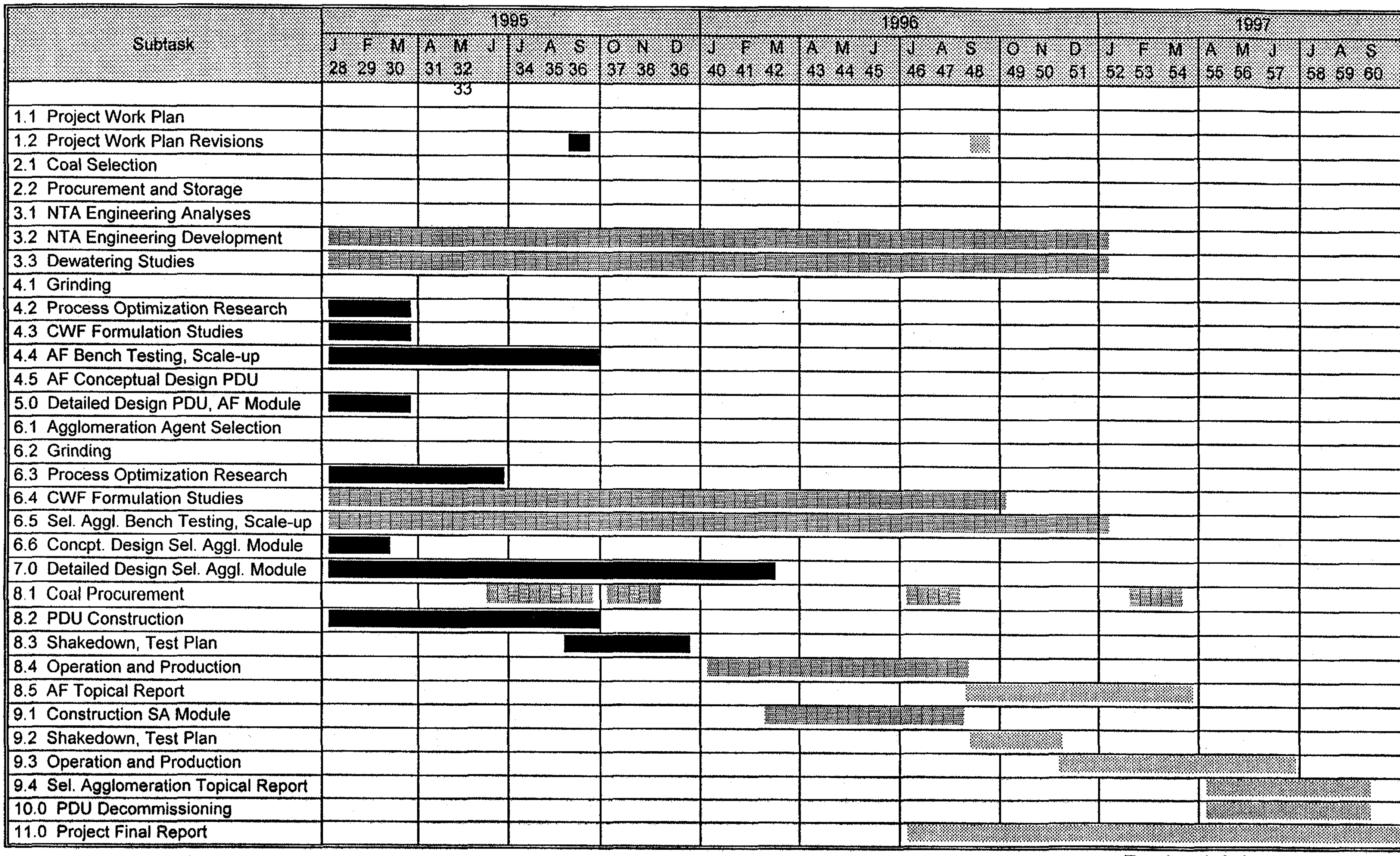
	Phase I. Engineering Analysis and Laboratory and Bench-Scale R&D
Task 1.	Project Planning
Subtask 1.1.	Project Work Plan
Subtask 1.2.	Project Work Plan Revisions
Task 2.	Coal Selection and Procurement
Subtask 2.1.	Coal Selection
Subtask 2.2.	Coal Procurement, Precleaning and Storage
Task 3.	Development of Near-Term Applications
Subtask 3.1.	Engineering Analyses
Subtask 3.2.	Engineering Development
Subtask 3.3	Dewatering Studies
Task 4.	Engineering Development of Advanced Froth Flotation for Premium Fuels
Subtask 4.1.	Grinding
Subtask 4.2.	Process Optimization Research
Subtask 4.3.	CWF Formulation Studies
Subtask 4.4.	Bench-Scale Testing and Process Scale-up
Subtask 4.5.	Conceptual Design of the PDU and Advanced Froth Flotation Module
Task 5.	Detailed Engineering Design of the PDU and Advanced Flotation Module
Task 6.	Selective Agglomeration Laboratory Research and Engineering Development for Premium Fuels
Subtask 6.1.	Agglomeration Agent Selection
Subtask 6.2.	Grinding
Subtask 6.3.	Process Optimization Research
Subtask 6.4.	CWF Formulation Studies
Subtask 6.5.	Bench-Scale Testing and Process Scale-up
Subtask 6.6.	Conceptual Design of the Selective Agglomeration Module
Task 7.	Detailed Engineering Design of the Selective Agglomeration Module
	Phase II. PDU and Advanced Column Flotation Module Testing and Evaluation
Task 8.	PDU and Advanced Column Froth Flotation Module
Subtask 8.1.	Coal Selection and Procurement
Subtask 8.2.	Construction
Subtask 8.3.	PDU and Advanced Coal Cleaning Module Shakedown and Test Plan
Subtask 8.4.	PDU Operation and Clean Coal Production
Subtask 8.5.	Froth Flotation Topical Report
	Phase III. Selective Agglomeration Module Testing and Evaluation
Task 9.	Selective Agglomeration Module
Subtask 9.1.	Construction
Subtask 9.2.	Selective Agglomeration Module Shakedown and Test Plan
Subtask 9.3.	Selective Agglomeration Module Operation and Clean Coal Production
Subtask 9.4.	Selective Agglomeration Topical Report
	Phase IV. PDU Final Disposition
Task 10.	Disposition of the PDU
Task 11.	Project Final Report

Revised April 25, 1995



Revised July 15, 1996

Figure 2. Project Schedule



Revised July 15, 1996

Figure 2. Project Schedule (Cont'd)

ACCOMPLISHMENTS DURING QUARTER

Work was carried out on Tasks 3, 6, 8, 9, and 11 during the sixteenth quarter (July 1 to September 30, 1996) reporting period. Good progress was made on these tasks as discussed below.

TASK 3 DEVELOPMENT OF NEAR-TERM APPLICATIONS

During 1993, Bechtel performed an engineering analysis evaluating potential applications for column flotation and selective agglomeration at three coal preparation plants operated by what is now Cyprus Amax Coal Company [16]. Economic projections favored column flotation over selective agglomeration and an application at the Lady Dunn Preparation Plant (Cannelton Coal Company) in West Virginia was found to be particularly attractive since the plant was being considered for a major capacity expansion. Because of the potential advantages of installing column flotation rather than mechanical flotation cells in the expanded fine coal cleaning circuit, Lady Dunn management was pleased to offer their plant as the study site for a near-term application of column flotation. The Microcel™ flotation column was selected for this study and the Center for Coal and Mineral Processing (CCMP) at Virginia Tech was assigned the responsibility for the on-site column testing under Subtask 3.2 "Engineering Development." Subtask, 3.3 "Dewatering Studies", investigating a novel dewatering process for advanced flotation products is also being performed by CCMP.

Subtask 3.2 Engineering Development

As described during previous Quarterly Progress Reports [11, 12, 13, 14, 15], an existing 30-inch diameter Microcel™ flotation column was refurbished and installed in the Lady Dunn Plant for this engineering development work. A high-quality product, containing about 8 to 10% ash was produced at approximately 80 to 85% combustible matter recovery during preliminary testing [13]. Based on these results, Cannelton included column flotation in its 1996 plant expansion. The three commercial size (4-meter) Microcel™ columns are now operating at Lady Dunn producing clean coal with ash contents below target and with a favorable recovery. Continuing assistance with the optimization and fine-tuning of the three production columns was provided to the Lady Dunn Preparation Plant during the quarter.

A portion of the clean coal from the May parametric testing was submitted to TraDet, Inc. (Triadelphia, WV) for binderless briquetting tests. High quality specimens of the briquette production were returned by TraDet, who reported that the briquetting was performed at near-ambient temperature on clean coal flotation product that had been air-dried to between 1.0 and 2.4 percent moisture. The clean coal, which was nominally minus 16 mesh (991 microns), contained 12 percent ash and 34.7 percent volatile matter.

A model B-100A Komarek laboratory roll-press machine with 5.1-inch diameter rolls was used for all testwork. The rolls were preheated to equilibrium operating temperature by briquetting waste material for about 10 minutes before switching to the test coal. Feed rates were between 74 and 168 lb/hr. Parametric tests were made at three roll speeds and at hydraulic roll pressures of 1,300, 1,600, 2,000, 2,400 and 2,800 psig. At the measured product temperatures of 128° to 178° F, these pressures deform coal particles and fuse them together. The tests were repeated on each of four batches of the flotation product that had been dried to differing moisture levels. The primary response considered was the average crush strength of 15 randomly selected briquettes produced during each set of test conditions. The densities, moisture reabsorption, degradation, and weathering of the briquettes were evaluated as well.

Average crush strengths between 50 and 200 lbs correlated well with the amount of energy transferred to the briquettes (between 8 and 29 kWh/ton). TraDet, Inc. considers any strength over 100 lbs to be acceptable for briquettes such as these. The hydraulic pressure holding the rolls together, in particular, had a significant impact on the energy transfer and resulting improvement in crushing strength. The effect is shown in Figure 3. The best briquettes were made from feed coal that had been dried the most, that is, to 1.0 percent moisture. The products from all 58 tests had acceptable moisture reabsorption, weathering and briquette degradation properties.

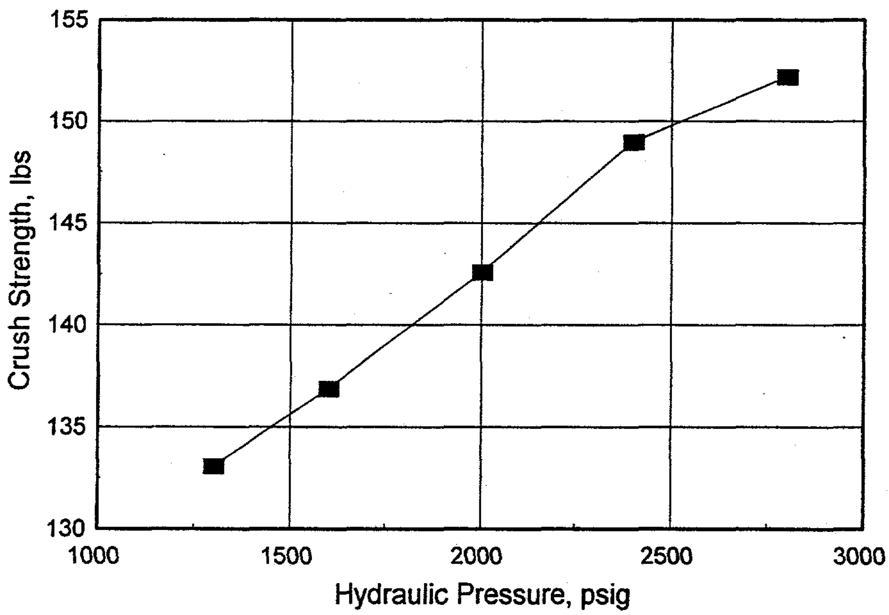


Figure 3. Effect of Pressure on Briquette Strength - Lady Dunn Flotation Product
Note: Values are averages across all roll speeds and moistures.

TraDet considered the B-100A briquetting results to be favorable indications of the potential for binderless briquetting of the flotation product from the Lady Dunn Preparation Plant. They suggested follow-up optimization testing in a larger, pilot-size machine (such as a Komarek Model DH-300 briquetter) to allow scale-up of briquetting performance to commercial/production units.

The performance data from the 30-inch column and the briquetting data are being organized for the subtask topical report. The report will also cover the Subtask 3.1 laboratory work done at the University of Kentucky and engineering analysis at Bechtel.

Subtask 3.3 Dewatering Studies

This work, being performed by Virginia Tech, is aimed at developing a novel hydrophobic dewatering (HD) process for efficiently removing moisture from clean coal fines without the expense and other related drawback associated with mechanical dewatering or thermal drying. During the HD process, a hydrophobic substance such as butane is added to a coal-water slurry to displace water from the surface of the coal. The hydrophobic substance is subsequently recovered and reused. Earlier testing revealed the ability of the HD process to reduce the moisture content of fine coal to a very low level and included a determination of the potential losses by adsorption of butane onto the coal. Work in the period covered by this report focused on the variations in the adsorbed amounts of butane and residual moisture contents as a function of the oxidation state of the coal sample.

Absorption losses were determined by tracking the loss in weight of dried coal with time after depressurization. To do this, small bottles containing known weights of coal were filled with liquid butane and held in a pressure chamber for one hour before release of the pressure. It was found that 80 minutes after depressurization, unoxidized coal retained 0.17 percent butane and oxidized coal retained only 0.10 percent butane. This suggests that the absorption is due to hydrophobic interaction between butane molecules and the carbonaceous surface of the coal. A striking difference between hydrophobic interactions was seen when comparing the dewatering effect of butane on unoxidized coal slurry with the dewatering effect of butane on a slurry of oxidized coal. The dewatered unoxidized coal contained only 1 to 2 percent moisture while the dewatered oxidized coal retained 40 percent moisture. Thus, it appears that the HD process will be applied most successfully to hydrophobic fine coal which can be recovered easily in a preparation plant or premium fuel production plant by froth flotation and may not be applicable to oxidized fines which do not float well.

TASK 6 ENGINEERING DEVELOPMENT OF SELECTIVE AGGLOMERATION

Task 6 is divided into six subtasks. Subtasks 6.1 Agglomerating Agent Selection, 6.2 Grinding Studies, 6.3 Process Optimization Research, and 6.6 Conceptual Design of the Selective Agglomeration PDU Module have been completed and were reported during previous quarters. There was activity on the two remaining subtasks, 6.4 and 6.5, during this quarter.

Subtask 6.4 Coal-Water-Fuel Formulation Studies

The primary objective of Subtask 6.4 is to evaluate the formulation of coal-water-fuel (CWF) slurries from selective agglomeration products. The clean coals used for this work were generated during Subtask 6.5, Selective Agglomeration Bench-scale Testing and Process Scale-up. The main thrust during the quarter was to update target specifications for CWF slurries. Published information was reviewed and telephone contacts made with representatives of Penn State, Penelec, Foster Wheeler, ABB Combustion Engineering, A. D. Little and Tecogen to determine current information. It appears from these discussions that Penn State and Penelec are the best-known groups in the US that are still actively engaged in the application CWF for firing boilers. A. D. Little, along with Cooper-Bessemer, remains part of a group that is developing coal-fueled diesel engines as part of a Clean Coal Technology project located in Alaska.

Development of Target CWF Slurry Specifications

The premium CWF being developed by this project is intended to be a retrofit fuel to replace oil and natural gas now fired in some large industrial and utility boilers. Such a retrofit market does not exist at this time. Consequently, specifications for such a premium fuel have not yet been established, and as a matter of fact, very little CWF is burned in the United States at the present time. However, during the early and mid 1980s some large combustion demonstrations were performed [17, 18, 19, 20], notably a successful 35-day EPRI-sponsored burn in Tennessee [18, 19] and similar utility station burns in Cape Breton, Canada [20]. In both instances the boilers originally had been designed for coal firing but had been converted later to oil and natural gas firing.

The CWF burned during the EPRI and Cape Breton demonstrations can be characterized as "boiler" grade, that is, the coal in the slurry was similar to the minus 0.3-mm pulverized coal commonly burned in large boilers. These slurries contained 70 to 75 percent coal cleaned to 5 to 7 percent ash on a dry basis. The major lot of CWF for the EPRI test arrived at a viscosity of 860 cP and the second lot at viscosities between 413 and 1150 cP [18]. It was found during the test program that atomization and combustion of the first slurry improved if it were diluted slightly to reduce its viscosity to 500 cP. Both lots of slurry were shipped to the test site in railroad tank cars and transferred to storage tanks without difficulty.

Interest in CWF declined after the mid 80s due a lack of any immediate economic incentive to switch to CWF from either oil or natural gas [20]. However, two groups known to be still active in the area were contacted regarding current specifications for CWF. The first group was the Energy and Fuels Research Center at Penn State University [21, 22] which is developing the technology to convert oil-fired boilers to CWF firing, and second group was at Penelec [23] where co-firing of CWF is being developed in order to utilize fine coal recovered from refuse ponds as a low-cost supplementary fuel in utility boilers. Both groups acknowledge that the cost of the CWF drives the formulation of the fuels that they have been burning. In particular, expensive reagent packages are difficult to justify even though they allow formulation of highly loaded slurries. In fact, both groups have permitted slurry loadings to drift down to the 50 to 60 percent range from the 70 to 75 percent range seen during the mid 80s because of cost considerations [22, 23].

Penn State prefers burning CWF with viscosities around 200- 400 cP at 100 s^{-1} but has had satisfactory results with slurry viscosities over a wider range as long as the loading is high enough to sustain combustion [22]. The minimum loading for satisfactory combustion has not been defined and probably is closely related to the design of the specific burner and boiler. Penn State prefers CWF containing 60 percent coal (which will have heating values between 7500 and 8400 Btu/lb CWF, depending upon the rank and ash content of the coal) for their equipment. Particle size distributions below 0.20 or 0.18 mm (about 80 mesh) are best with their combustion system. Ash accumulation in the boiler and around the burner area is a major concern. It is best if as much of the ash as possible is entrained by the combustion gas and carried over to the bag house for collection [22].

Penelec ordinarily co-fired slurries with viscosities between 150 and 450 cP but could use 500-cP slurries as well [23]. Penelec was not much concerned about keeping the solids loading high since sustaining combustion is not an issue when co-firing slurry along with the usual pulverized coal. Cost is a vital concern, though, so the CWF slurries being considered for use at Penelec are prepared without the use of dispersant.

Based upon the information gleaned from the accounts of previous testing and the thoughts of those currently engaged in utilizing CWF in the U. S., working specifications were adopted as targets for formulation of premium CWF from coal cleaned by selective agglomeration. These working specifications were as follows:

Table 2. CWF Working Specifications

Attribute	Value
Ash Content	<2 lb/MBtu HHV
Sulfur Content	<0.6 lb/MBtu HHV
Source Coal	High volatile bituminous
Particle Size Distribution:	100% minus 0.20 mm >98% minus 0.15 mm >80% minus 0.075 mm
Higher Heating Value	>7,500 Btu/lb CWF
Viscosity at 100 s^{-1} shear rate	200 to 500 cP
CWF Slurry Loading	High, yet meeting viscosity and HHV specifications
Rheology	Newtonian or pseudoplastic
Stability	Easily resuspended

The ash and sulfur content and the slurry loading specifications are based on the DOE contract objectives. The source coal and particle size distributions are based primarily on the requirements of the coal cleaning operations (advanced flotation and/or selective agglomeration) but are strongly influenced by combustion requirements as well. The heating value, viscosity and rheology specifications are based on atomization and combustion properties, and the stability specification is based upon expected storage and handling scenarios. Utilization of the fuel shortly after production is an important feature of these scenarios as well as automatic flushing of lines upon shutdown and continuous or periodic remixing strategies in surge tanks and temporary storage vessels.

Advanced combustion heating systems and large coal-fired diesel engines may represent additional markets for premium CWF. The fuel specification for one advanced coal-fired heating system [24-26] was a heating value greater than 8000 Btu/lb slurry loaded to more than 55 percent minus 45-μm coal. The desired slurry viscosity was 200 cP at 100 s^{-1} shear rate. Specifications of fuel for the coal-fired diesel engines proposed for a Clean Coal Technology program in Alaska are similar to the advanced heating system specification [27]. Originally, both programs specified that the coal contain less than 1 percent ash, but over time the specification for diesel engine fuel, at least, has been relaxed to allow up to 2 percent ash in the coal (about 1.5 lb/MBtu) [28] Thus, there is a good possibility that the specifications outlined above for retrofit boiler fuel applications may be applicable to other advanced combustion systems as well.

Properties of CWF Prepared From Test Coals

As described in the last quarterly report, a method was developed for projecting the viscosity of slurries in cases where wall slip interfered with normal measurements. Wall slip occurs when testing slurry containing a high concentration of solid material because liquid may segregate at the surfaces of the cup and/or bob. The procedure devised for use in such cases was to project the viscosity of such a slurry by extrapolating the measured viscosities of diluted portions of the slurry upward to the loading of the concentrated slurry. Dr. John Dooher has since reported that such projections from Subtask 6.4 data generally agree with the projections made when using his mathematical model which is calculated directly from coal properties and particle size distributions. The following comparisons show the loadings at which the CWF slurry samples were prepared and the projected loadings at 500 cP viscosity for the same samples:

Table 3. CWF Loadings and Viscosities		
	Percent Coal in Slurry	
Coal	As - Prepared	Projected to 500 cP
Taggart	62.2	61.9
Sunnyside	61.9	61.4
Hiawatha	59.7	59.5
Indiana VII	52.0-52.5	51.4-52.1
Elkhorn No. 3	60.0	59.6
Winifrede	48.8	not available

These samples were formulated with 0.5 to 1.0 percent dispersant and diluted visually to provide acceptable fluidity. Loadings were little changed by increasing the amount of dispersant added. Adjustment of the particle size distributions by regrinding a portion of each agglomeration product to provide a more bimodal distribution improved the loadings of the Taggart, Sunnyside and Hiawatha coals by 1 to 3 percentage points but did not improve the loading of the Elkhorn No. 3. No attempts were made to adjust the particle size distributions of the Indiana VII and Winifrede coals since those coals had been ground to very fine mesh sizes ahead of selective agglomeration.

Slurry Preparation Without Dispersant

As noted above, cost is a major concern of prospective users of CWF. Since the dispersants used to prepare high slurry loadings represent such a large portion of the total cost of preparing CWF, several slurry preparation tests were conducted without the use of A-23M dispersant. In the case of Taggart clean coal, a slurry loading of 53.9 percent was achieved without PSD manipulation and a disappointing 50.7 percent with PSD manipulation. Similarly, a 52.0-percent coal slurry was prepared from Hiawatha filter cake when the A-23M was omitted from the formulation. The 53.9-percent and 52.0 percent coal slurries have heating values around 7,800 to 8,000 Btu/lb, that is, heating values approaching the heating values of some Powder River Basin coals. It was also found that omission of dispersant from the CWF formulation greatly improved the stability of the slurries over the stability of slurries prepared with A-23M.

Subtask 6.5 Bench-Scale Testing and Process Scale-up

During previous testing with the 25 lb/hr bench-scale unit, evaluation of both the original and new Taggart coals, as well as the Sunnyside, Elkhorn No. 3, and Winifrede coals were completed. It should be noted that the Sunnyside coal has since been replaced with the Hiawatha coal for PDU operations.

Recent work has focused on two of the three project coals of primary interest - Indiana VII and Hiawatha (Sunnyside replacement). This work has indicated that for the Indiana VII coal, the 2 lb/MBtu product ash specifications could be met at the selected 325-mesh topsize grind. More testing with the Indiana VII coal, ground during Subtask 8.4 PDU operations, was carried out this reporting quarter.

Using Hiawatha coal feedstock closed-circuit ground to a 150-mesh topsize, the 2 lb ash/MBtu product specification was met during previous testing. During this quarter, evaluation of the Hiawatha coal ground to a 100-mesh topsize was carried out.

Hiawatha Coal

During previous testing, agglomeration of the Hiawatha coal at a 150-mesh topsize (d_{80} of 47 microns) was evaluated, with results indicating that this grind size was sufficiently fine to achieve the desired 2 lb/MBtu product ash specification. Also during the previous quarter, four tests were completed at a coarser (100 mesh) topsize grind with a d_{80} of 65 microns. This grind also proved sufficiently fine to achieve the 2 lb/MBtu product ash specification.

During this reporting quarter, ten more agglomeration tests were completed using the same 100-mesh topsize feedstock of the Hiawatha coal. The results for these tests, along with the four previous tests are shown in Figure 4, as well as presented in Appendix A.

Most of these tests were performed at 7 or 13% solids concentration, with one test carried out at 10% solids. As can be seen in Figure 4, generally, lower product ash contents were achieved at 7% solids than at 13% solids. Other variables changed during this test work included:

- High-shear tip speed (6.7 to 15 m/s)
- High-shear residence time (0.5 to 1.4 min)
- Low-shear tip speed (3 and 4.8 m/s)
- Low-shear residence time (1.5 to 3.7 min)
- Coal feed rate (17.5 to 75 lb/hr)
- Heptane concentration (20 to 24%, dry ash free coal basis)

All of these tests were successful in that they met the 2 lb ash/MBtu product specification at Btu recoveries ranging from 96.6 to 99.6%. Tailings ash values for these tests ranged from 56.5 to 86.4%. While some variation in product ash content (1.74 to 1.96 lb/MBtu) was observed, the data indicates that as with all previous testing, the primary influences on product ash are solids concentration in the feed slurry and agglomerate size.

It is also noted form this data that the highest Btu recoveries, with associated high tailings ash values, were generally achieved when a fast (15 m/s) high-shear impeller tip speed was utilized.

The one repeat test carried out (H2A4R) utilized approximately 2% less heptane than its original test (H2A4). The lower heptane level resulted in slightly smaller agglomerates (2 vs. 3 mm), lower Btu recovery (96.6 vs. 98.3%), and slightly higher product ash content (1.83 vs. 1.76 lb/MBtu).

No additional continuous agglomeration test work utilizing the Hiawatha coal is planned at this time.

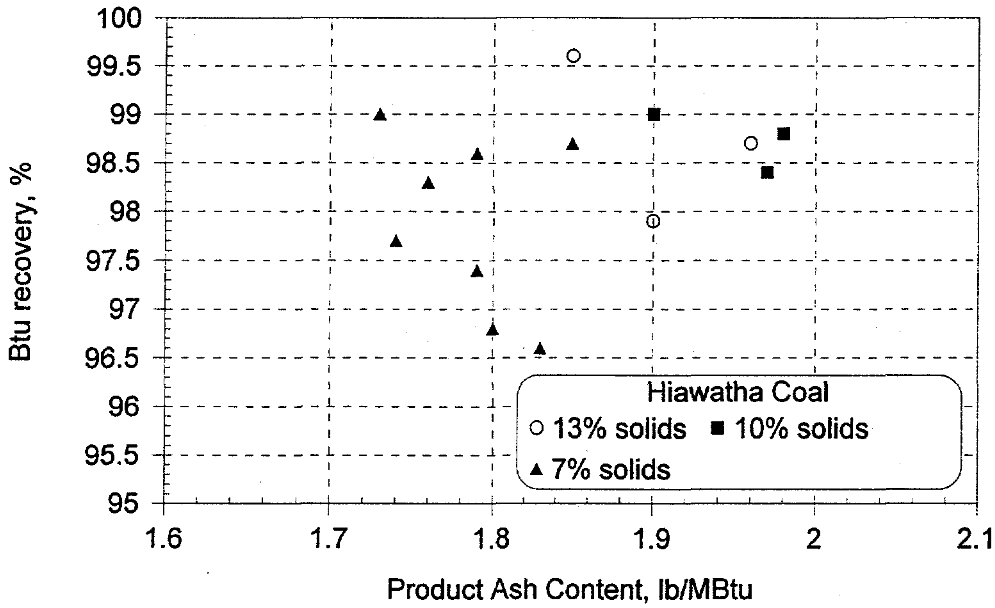


Figure 4. Hiawatha Coal Agglomeration Results

Indiana VII Coal

Continuous agglomeration testing of the Indiana VII coal continued during this quarter. The feedstock used for this work was a new batch of Indiana coal ground in the PDU under Subtask 8.4. This coal was ground in closed-circuit with the fine grinding mill and 270-mesh screens.

Four test were completed with this feedstock and conditions evaluated were as follows:

- Coal feed rates of 12.5, 17.5, and 25 lb/hr
- Feeds solids concentration of 7 and 10%
- High-shear tip speeds of 15 and 18 m/s
- Low shear tip speed of 4.8 m/s

- Asphalt concentration of 20 lb asphalt/ton of coal
- Heptane concentrations in the 32 to 35 % on a dry ash free basis

The test conditions and results for these four tests are shown in Appendix B.

Btu recoveries for these tests were in the 96 to 98% range with product ash contents in the 2.9 to 3.7% range, or approximately 2.2 to 2.7 lb ash/MBtu. As such, the target ash content of 2 lb/MBtu was not met with this grind. This, however, was not unexpected since this grind was tailored to achieve project goals utilizing advanced flotation, which generally results in lower Btu recoveries and, therefore, corresponding lower product ash contents.

Limited additional work will be carried out with this feedstock in an attempt to improve process performance, i.e., achieve lower product ash contents.

Continuous Steam Stripper Testing

One continuous agglomeration and steam stripping test utilizing the Hiawatha coal was carried out this quarter. The results of this test will be presented when the final analytical results become available. In addition, steam stripping of agglomerated coal was carried out as required for disposal.

TASK 8 PDU AND ADVANCED COLUMN FLOTATION MODULE

The Task 8 work completed this reporting quarter focused on Subtask 8.1 Coal Selection and Procurement and Subtask 8.4 PDU Operation and Clean Coal Production as discussed in the next sections of this report.

Subtask 8.1 Coal Selection and Procurement

Approximately 450 tons of Hiawatha seam coal are on hand to begin the selective agglomeration module testing in the PDU. Approximately 300 tons of Taggart coal and 200 tons of Indiana VII coal also are in storage at a Denver coal yard.

Subtask 8.4 PDU Operation and Clean Coal Production

Operation of the PDU Flotation Module was completed during the third quarter of 1996. Parametric testing, optimization, and extended production runs were completed for both Indiana VII and Hiawatha coals. Each production run lasted 72 hours and was completed without any unscheduled downtime.

Parametric Testing of PDU Flotation Module - Indiana VII Coal

Parametric testing of Indiana VII coal in the PDU Flotation Module concluded during the quarter. A total of 15 tests were conducted which utilized approximately 73 tons of feed coal. The results of these tests (I-17 through I-32), as well as the previous four tests completed last quarter, are shown in Table 4.

Table 4. Parametric Testing of PDU Flotation Module - Indiana VII Coal

Test #	Fuel Oil lb / ton	Frother lb / ton	% Sol	Air CFM	Wash GPM	Recirc GPM	Feed lb / hr	Column d80	PDU Yield	Energy Recov	Sulfur lb/MBtu	Ash lb/MBtu
I-7	4.97	2.53	8.99	55	142	800	3,200	22	87.8	94.7	0.42	3.04
I-14	4.97	0.73	5.70	55	142	800	3,200	21	11.9	13.2	N/A	1.81
I-15	4.97	1.13	6.29	55	142	800	3,200	22	57.2	62.3	N/A	1.95
I-16	5.04	0.94	6.57	55	111	800	2,500	18	19.8	21.7	N/A	1.93
I-17	4.97	2.53	7.30	55	142	800	3,200	22	86.9	94.3	N/A	2.54
I-18	2.97	2.53	7.11	55	142	800	3,200	20	86.0	92.9	N/A	2.29
I-19	6.97	2.53	7.04	55	142	800	3,200	23	87.5	94.6	N/A	2.50
I-20	4.97	1.53	7.10	55	142	800	3,200	23	53.5	58.6	N/A	1.89
I-21	4.97	2.99	7.21	55	142	800	3,200	22	86.9	94.4	N/A	2.39
I-22	4.97	2.53	4.14	55	142	800	3,200	23	65.9	71.9	N/A	1.90
I-23	4.97	2.53	7.40	75	142	800	3,200	22	88.6	94.8	N/A	3.25
I-24	4.97	2.53	7.52	35	142	800	3,200	22	78.4	85.0	N/A	2.49
I-25	Abort	Abort	Abort	Abort	Abort	Abort	Abort	Abort	Abort	Abort	Abort	Abort
I-26	4.97	2.53	7.09	55	100	800	3,200	22	87.8	94.5	N/A	2.54
I-27	4.97	2.53	7.28	55	142	990	3,200	21	89.7	96.4	N/A	2.57
I-28	4.97	2.53	7.25	55	142	600	3,200	22	65.8	71.9	N/A	2.07
I-29	5.04	2.47	5.89	55	142	800	2,500	21	79.5	86.3	N/A	2.43
I-30	5.04	2.47	4.67	55	111	800	2,500	19	83.7	91.3	N/A	2.59
I-31	4.98	2.51	7.94	55	142	800	3,900	27	84.1	91.6	N/A	2.65
I-32	4.98	2.51	7.79	55	173	800	3,900	25	83.1	88.8	N/A	3.01
MAX	6.97	2.53	8.99	75	173	990	3,900	27	89.7	96.4	0.42	3.25
MIN	2.97	0.73	4.14	35	100	600	2,500	18	12.0	13.2	0.42	1.81

Observation of the data shows that the overall quality goal of 2.00 lb/MBtu of ash was achieved on five occasions (parametric tests I-14, I-15, I-16, I-20, and I-22). Unfortunately, the overall PDU yield and energy recovery suffered significantly during these tests. Test I-25 was aborted due to insufficient wash water availability.

Overall, the clean coal yield varied from 12.0% to 89.7% while the energy recovery and product ash varied from 13.2% to 96.4% and 1.81 lb/MBtu to 3.25 lb/MBtu, respectively. Though the Microcel™feed d80 varied from 18 to 27 microns, the large d80 values found in Tests I-31 and I-32 are the result of lower retention time in the ball mills (high feed rates). The results of these parametric tests are compared to the release analysis (d80=22 microns) in Figures 5 and 6. Observation of the graphs in these figures reveal that the desired clean coal ash quality goal of 2.0 lb/MBtu can be achieved at a theoretical yield and energy recovery of 73% and 81%, respectively.

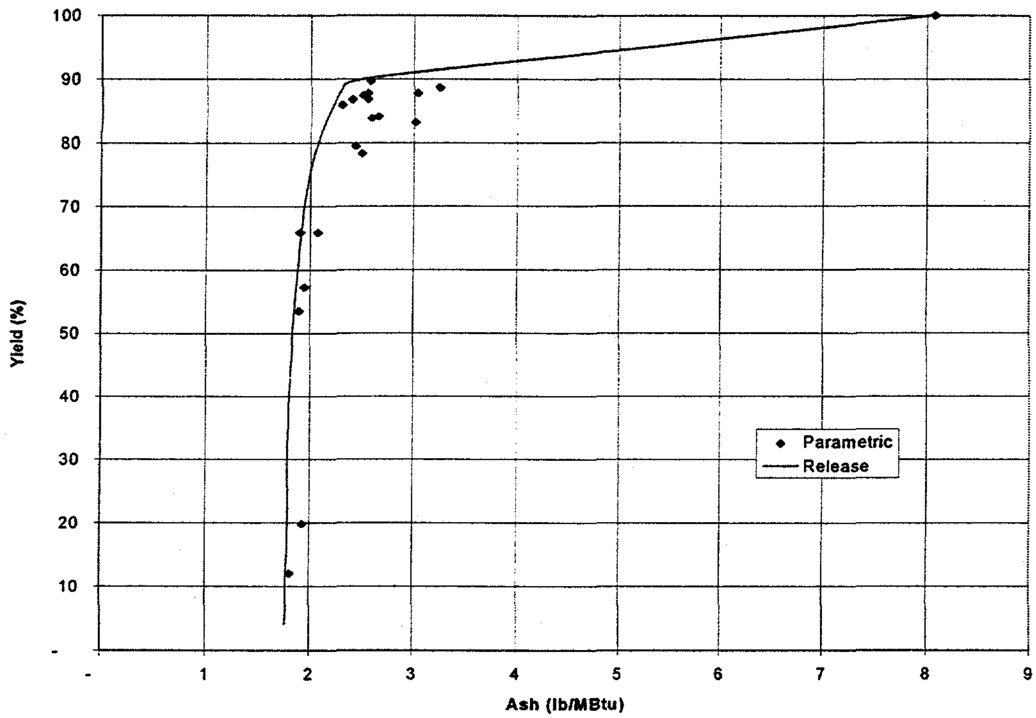


Figure 5. Parametric Testing of Indiana VII Coal - Yield vs. Ash

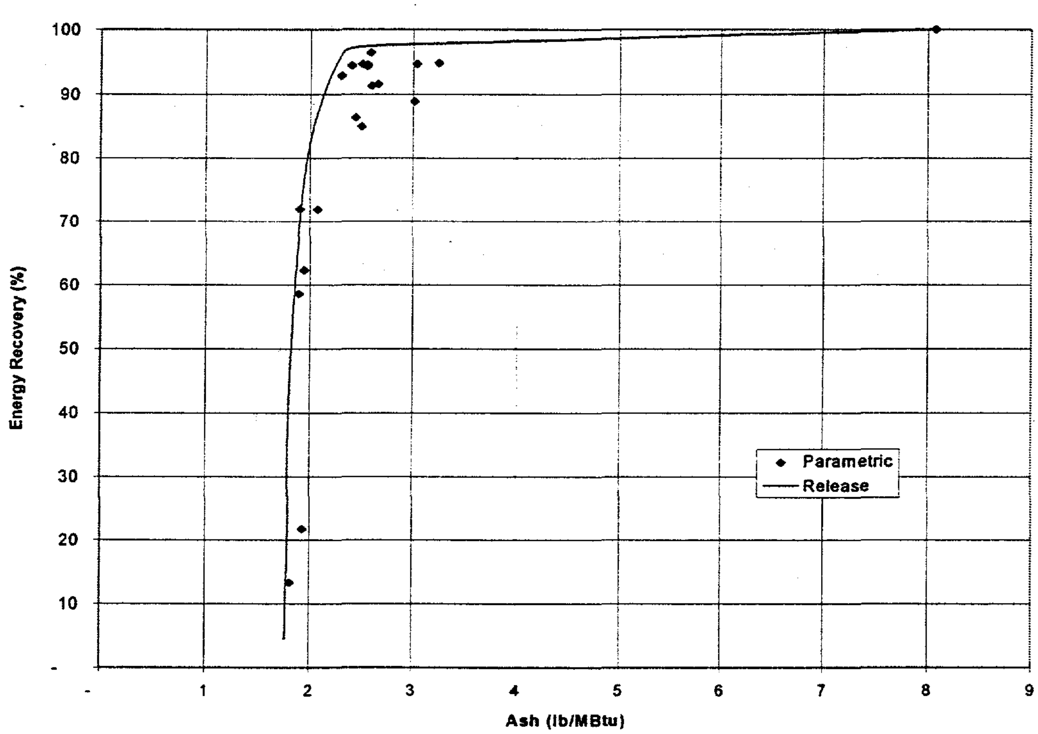


Figure 6. Parametric Testing of Indiana VII Coal - Energy Recovery vs. Ash

Development of Flotation Regression Equations - Indiana VII Coal

Data from PDU Flotation Module parametric testing was compiled and multiple regression models (equations) were generated. Forward stepwise regression produced equations which link output variables such as yield and clean coal quality to input variables such as feed rate, wash water rate, air rate, collector addition, and frother addition. The equation term coefficients for the two main response variables are listed in Tables 5 and 6

Table 5. Regression Analysis of Indiana VII Yield (%)

Input Variable	Coefficient	t-Statistic
Intercept	8,269.0	11.52
Collector lb/ton	7.3089	12.69
% Solids	-1.1019	-2.23
1 / Feed Rate lb/hr	-226370	-8.48
1 / (Frother lb/ton)	-69.336	-52.46
1 / (Air Rate CFM)	-8566.4	-9.56
ln (Air Rate CFM)	-159.60	-8.73
$(\text{Recirculation GPM})^{1/2}$	-18.088	-10.87
1 / Recirculation GPM	-229961	-13.60
$(\text{Feed Ash \%})^2$	-15.034	-8.18
1 / Feed Ash %	-32216	-7.99
$(\text{d80})^2$	-1.52448	-20.10
1 / d80	-23211	-20.87
Coefficient of Determination (R^2)	0.989	
Adjusted R^2	0.987	

Table 6. Regression Analysis of Indiana VII Clean Coal Ash (lb/MBtu)

Input Variable	Coefficient	t-Statistic
Intercept	11.963	5.44
1 / Feed Rate lb/hr	2505	2.23
$(\text{Collector lb/ton})^2$	0.006314	2.57
$(\text{Frother lb/ton})^2$	-0.10371	-1.69
1 / (Frother lb/ton)	2.1090	2.43
ln (Frother lb/ton)	2.4188	2.64
$(\text{\% Solids})^2$	0.04262	5.93
ln (% Solids)	-2.4218	-3.91
$(\text{Air Rate CFM})^2$	0.00058226	9.65
ln (Air Rate CFM)	-2.3263	-6.58
ln (Wash Water GPM)	-0.3158	-1.88
1 / (Recirculation GPM)	-729.5	-4.87
$(\text{Feed Ash \%})^2$	-0.002247	-0.46
$(\text{d80})^2$	-0.000163	-0.26
Coefficient of Determination (R^2)	0.905	
Adjusted R^2	0.889	

The Coefficient of Determination (R^2) and Adjusted Coefficient of Determination (Adjusted R^2) both show that the each equation fits the data quite well. In addition, observation of the t-statistic, which indicates the relative importance of each independent variable to the response equation, shows that the most important variable that affects yield and product ash is frother dosage and air rate, respectively. It is also important to note that though the yield and product ash are also dependent on the feed coal ash content, the ash content itself is not a controllable variable and thus considered a covariant.

Optimization of PDU Flotation Module - Indiana VII Coal

Optimization testing of Indiana VII coal in the PDU Flotation Module was completed during the quarter. A total of four tests were performed to determine the optimum Microcel™ setpoints needed to achieve the process development goals of 2.00 lb/MBtu of ash and 80 percent energy recovery with maximum yield.

Equations were first developed to estimate the effects of tested input variables on Microcel™ outputs such as yield and quality. The equations were developed by evaluating the input and output variables of parametric tests I-14 through I-32 as well as I-7 by multiple linear regression. The resulting equations were then used to determine optimum Microcel™ setpoints. A unique function found in the Microsoft Excel software package called "Solver" was used to determine the proposed optimal setpoints for testwork. The results of the optimization testwork is shown in Table 7.

Table 7. Optimization Testing of PDU Flotation Module - Indiana VII Coal

Test #	Fuel Oil lb / ton	Frother lb / ton	% Sol	Air CFM	Wash GPM	Recirc GPM	Feed lb / hr	Column d80	PDU Yield	Energy Recov	Sulfur lb/MBtu	Ash lb/MBtu
I-O-1	4.97	1.60	N/A	55	142	800	3,200	23	79.0	85.8	N/A	2.34
I-O-2	4.97	1.73	7.61	55	142	800	3,200	24	79.4	85.9	N/A	2.63
I-O-3	4.97	1.93	7.52	55	142	800	3,200	22	84.9	91.5	N/A	2.48
I-O-4	4.97	1.26	7.55	55	142	800	3,200	22	65.8	71.3	N/A	2.36
MAX	4.97	1.93	7.61	55	142	800	3,200	24	84.9	91.5	N/A	2.63
MIN	4.97	1.26	7.52	55	142	800	3,200	22	65.8	71.3	N/A	2.34

The results indicate that the product ash goal of 2 lb/MBtu was not achieved. It is suspected that a buildup of frother in the clarified water circuit resulted in higher recovery of unwanted middlings material which in turn increased the clean coal yield and ash content. The frother buildup was visible as white foam on the clarified water tank surface and also at screen sprays.

The hypothesis is partially supported by comparing the results of two tests that were conducted at similar conditions. Except for a small difference in the metered frother dosage, Test 1-20 (Table 4) and optimization Test 1-0-1 (Table 7) were performed at similar conditions. Though similar performance values would be expected, the yield of optimization Test 1-0-1 was over 25 points higher than 1-20 while the product ash was 0.45 lb/MBtu higher.

Extended Run of PDU Flotation Module - Indiana VII Coal

An extended production run of the PDU Flotation Module was successfully completed during the month of July, 1996. The effort commenced Monday, July 22 and concluded the evening of Wednesday, July 24. Like the Taggart production run, a failed belt splice was the only operational difficulty. Due to the extremely poor filtering characteristics of this coal, 16 hours each day was dedicated to operation of the PDU while the remaining 8 hours were used for filtering accumulated clean coal slurry. Though the operating parameters were changed during the first day, the resulting setpoints are listed as follows:

- Coal: Indiana VII
- Nominal Feed Rate: 3,200 lb/hr
- Sizetec Screen Cloth 270 mesh
- Grinding Circuit: 2" Cyclones / Screens / Netzsch Mill
- Primary Water: 8 GPM
- Cyclone Water: 12 GPM
- Ground Product H_2O: 40 GPM
- Collector: 5.00 lb/ton (72 cc/min)
- Frother: 1.375 lb/ton (21 cc/min)
- % Solids Setpoint: 5.50
- Microcel Dilution H_2O: 10 GPM
- Air Rate: 49 CFM
- Microcel Level SP: 55 inches
- Spray Water: 142 GPM
- Microcel Recirculation: 800 GPM
- Operating Hours: 48 hours
- Pounds Processed: 154,170
- Tons Processed: 77

A breakdown of the production run by time interval is shown in Table 8. Observation of the data shows that the clean coal ash quality, yield, and energy recovery increased during the second half of the production run. This increase is most likely attributable to the steady growth of the d80 values (reduced liberation of mineral matter) coupled with an apparent buildup of frother in the clarified water system.

Table 8. Extended Production Run - Indiana VII Coal

Date	From	Until	Total Hours	Feed lb/hr	Feed Solids	Feed Ash%	Tails Ash%	Prod d80	PDU Yield	BTU Rec %	lb Ash / MBtu
7/22/96	07:00	11:00	4	3,200	N/S	N/S	N/S	N/S	N/S	N/S	N/S
7/22/96	11:00	15:00	8	3,200	6.96	10.80	41.94	25	80.6	88.0	2.38
7/22/96	15:00	19:00	12	3,200	6.96	9.95	28.26	17	72.5	78.6	2.17
7/22/96	19:00	23:00	16	3,200	7.34	10.89	25.65	18	65.1	71.4	2.13
7/23/96	07:00	11:00	20	3,200	N/S	N/S	N/S	N/S	N/S	N/S	N/S
7/23/96	11:00	15:00	24	3,200	4.40	10.67	33.06	N/S	74.6	81.6	2.21
7/23/96	15:00	19:00	28	3,200	4.52	10.34	28.41	19	71.1	77.5	2.17
7/23/96	19:00	23:00	32	3,200	4.61	10.74	27.81	18	69.0	75.6	2.22
7/24/96	07:00	11:00	36	3,200	4.39	10.58	33.46	28	77.5	83.8	2.87
7/24/96	11:00	15:00	40	3,200	4.38	10.41	37.55	26	79.0	86.0	2.32
7/24/96	15:00	19:00	44	3,200	4.47	10.66	41.98	28	80.9	88.2	2.36
7/24/96	19:00	23:00	48	3,200	4.42	10.60	42.72	27	81.7	88.9	2.46
AVG					5.25	10.56	34.08	23	75.2	82.0	2.33
MAX					7.34	10.89	42.72	28	81.7	88.9	2.87
MIN					4.38	9.95	25.65	17	65.1	71.4	2.13

Delivery of Hiawatha Coal to Amax PDU Site

Delivery of crushed Hiawatha coal to the Amax PDU site occurred during the quarter. Diamond Trucking, Inc. delivered twenty one (21) loads of crushed coal as follows:

Table 9. Delivery of Hiawatha Coal to Amax PDU Site

Date	Truck Loads	Tons / Truck	Tons Received
8/5/96	2	24	48
8/15/96	1	24	24
8/20/96	2	24	48
8/27/96	2	24	48
9/10/96	4	24	96
9/12/96	2	24	48
9/24/96	3	24	72
9/25/96	5	24	120
Total	21	24	504

Release Analysis - Hiawatha Coal

To better define the theoretical grade-yield curves associated with different feed size distributions, laboratory release analysis test work was performed on the Hiawatha coal during the quarter. Two Microcel™ feed slurries, one having a size distribution with 80% passing 54 microns and a second with 80% passing 49 microns, were evaluated. The results of the flotation test work are shown in Figures 7, 8, 9, and 10.

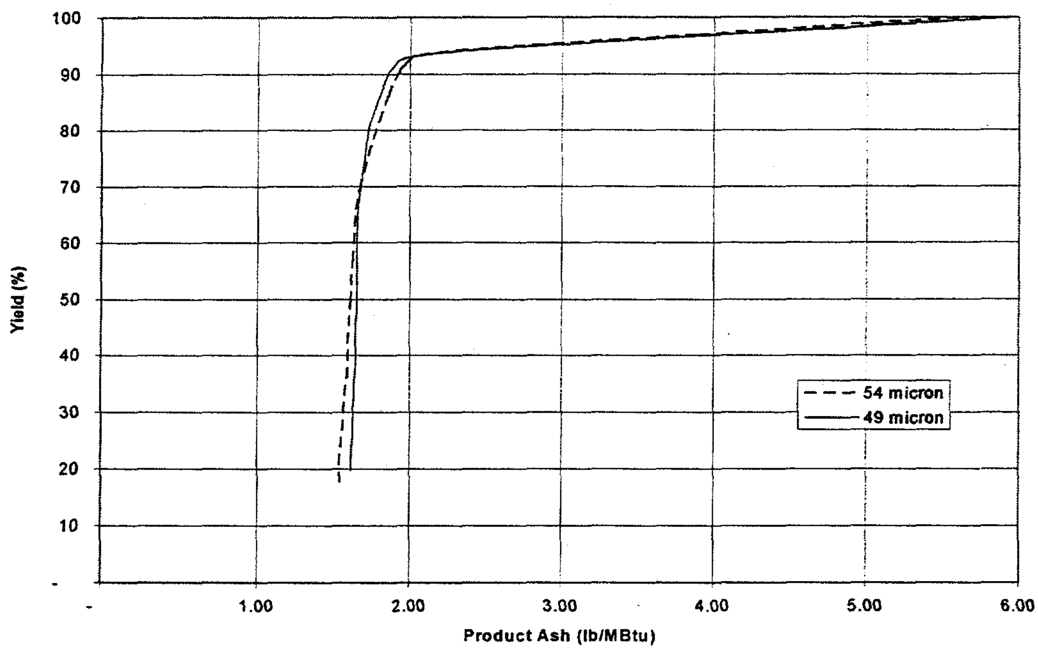


Figure 7. Hiawatha Release Analysis - Yield vs. Ash

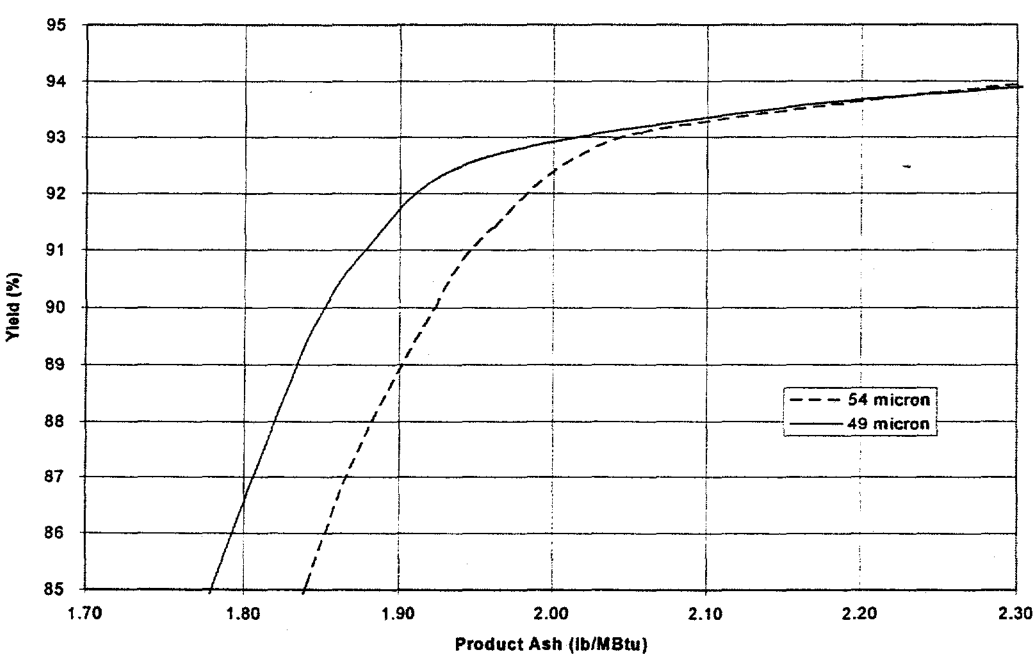


Figure 8. Hiawatha Release Analysis - Yield vs. Ash (Enlarged)

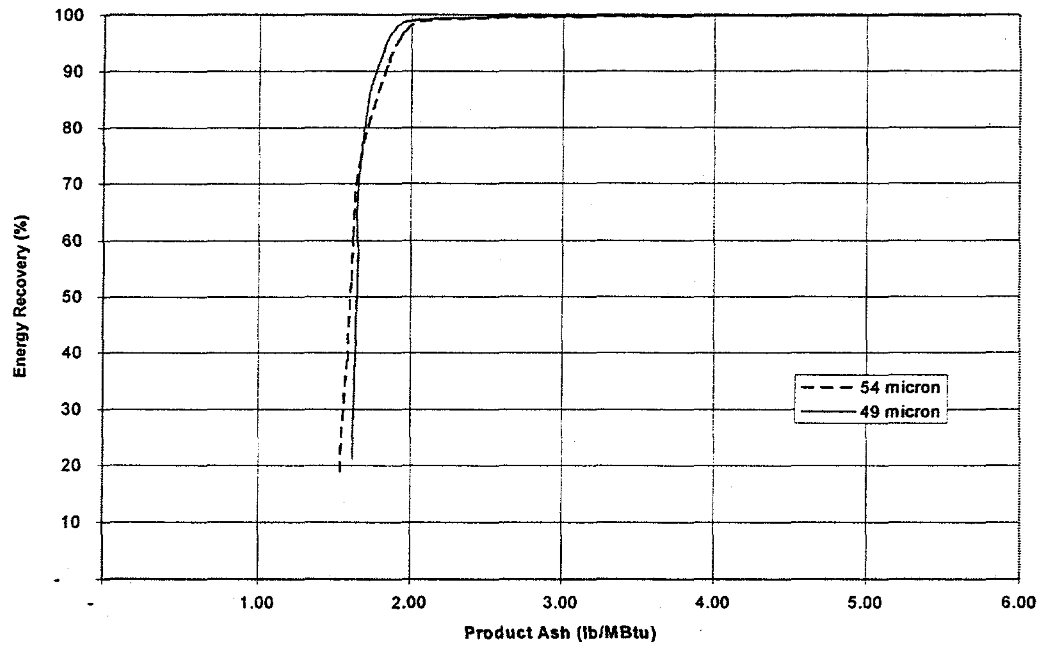


Figure 9. Hiawatha Release Analysis - Energy Recovery vs. Ash

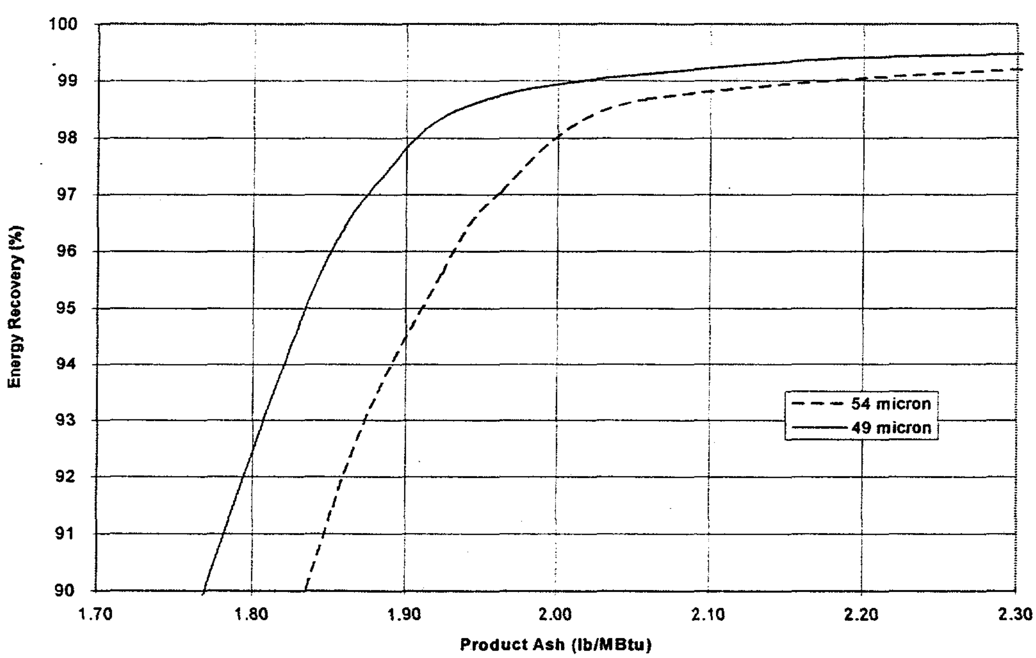


Figure 10. Hiawatha Release Analysis - Energy Recovery vs. Ash (Enlarged)

Observation of the data shows that though the ash goal of 2.00 lb/MBtu can be achieved at both particle size distributions, there is a subtle change in the flotation characteristics when the d80 is reduced from 54 microns to 49 microns. At a product ash value of 2.00 lb/MBtu, the yield improves from about 92% to 93% while the Energy Recovery rises from 98% to about 99%. However, at a product ash of 1.90 lb/MBtu, the yield increases from 89% to 92% while the Energy Recovery improves from about 94% to 98%.

Overall, it can be concluded that grinding the Hiawatha coal to a d80 of 49 microns typically improves the yield and energy recovery when operating near the "knee" of each curve.

<u>Parametric Testing of Grinding Circuit - Hiawatha Coal</u>

Parametric testing of the PDU grinding circuit was completed during the third quarter of 1996. The testing was performed to determine the optimum grinding circuit arrangement needed to achieve adequate mineral liberation for the Hiawatha coal. Because the Hiawatha coal was not evaluated in the 12-inch Microcel™ during Subtask 4.4 (Hiawatha replaced Sunnyside), no data was available for indicating expected performance.

Release analysis of the Hiawatha coal suggests that the product ash quality goal of 2.00 lb/MBtu can be achieved with size distributions having d80 values of 54 and 49 microns, respectively. As a result, the two objectives of the grinding circuit testwork were:

- Determine optimum conditions to achieve a size distribution with d80 of 54 microns;
- Determine optimum conditions to achieve a size distribution with d80 of 49 microns;

Nineteen (19) tests, aimed at optimizing the grinding circuit, were conducted during the quarter. The results of the testwork, which utilized approximately 125 tons of coal, are presented in Table 10.

Table 10. Parametric Testing of Grinding Circuit - Hiawatha Coal

Test #	Date	Feed Rate	Prim Ball Load	Sec Ball Load	Screen Cloth Size	4-inch Cyclone	3-inch Cyclone	2-inch Cyclone	Wet Screen d80	Microtrac d80
H-1	8/5/96	4,300	8,100	8,100	100M	X	X			54
H-2	8/7/96	4,300	8,100	8,100	100M	X	X			58
H-3	8/8/96	4,300	8,100	8,100	100M		X			61
H-4	8/8/96	4,300	8,100	8,100	100M		X			59
H-5	8/12/96	4,300	8,100	8,100	100M		X			60
H-6	8/12/96	4,300	8,100	8,100	100M		X			62
H-7	8/13/96	4,300	8,100	8,100	100M		X			57
H-8	8/13/96	4,300	8,100	8,100	100M		X			59
H-9	8/13/96	4,300	8,100	8,100	100M		X			61
H-10	8/14/96	4,300	8,100	8,100	100M		X			57
H-11	8/14/96	4,300	8,100	8,100	100M		X			56
H-12	8/14/96	4,300	8,100	8,100	100M		X			59
H-13	8/21/96	4,300	8,100	8,100	100M		X		53	58
H-14	8/22/96	4,300	8,100	8,100	100M		X			
H-15	8/26/96	4,300	8,350	8,350	145M		X		54	
H-16	8/26/96	4,300	8,350	8,350	145M		X		53	
H-17	8/26/96	4,300	8,350	8,350	145M		X		52	
H-18	8/27/96	4,300	8,350	8,350	145M		X		51	
H-19	8/28/96	4,300	9,100	9,083	145M			X	45	
Avg									51	58
Max									54	62
Min									45	54

Observation of the data shows that the grinding circuit was evaluated under four (4) general conditions:

- Mill loads at 8,100 lbs, 100 mesh screens, 4-inch cyclone and 3-inch cyclones;
- Mill loads at 8,100 lbs, 100 mesh screens, 3-inch cyclones only;
- Mill loads at 8,350 lbs, 145 mesh screens, 3-inch cyclones only;
- Mill loads at 9,100 lbs, 145 mesh screens, 2-inch cyclones only.

Condensing the tabular data to reflect these four conditions gave the results presented in Table 11.

Table 11. Parametric Testing of Hiawatha Grinding Circuit - Condensed

Test #	Feed Rate	Prim Ball Load	Sec Ball Load	Screen Cloth Size	4-inch Cyclone	3-inch Cyclone	2-inch Cyclone	Average d80	Maximum d80	Minimum d80
H1 - H2	4,300	8,100	8,100	100 M	X	X		56	58	54
H3 - H14	4,300	8,100	8,100	100 M		X		59	62	56
H15 - H18	4,300	8,350	8,350	145 M		X		52	54	51
H19	4,300	9,100	9,083	145 M			X	45	45	45

Observation of the data in Table 11 shows that each of the four conditions produced a ground product with varying d80 values. Maximum d80 values were obtained during tests H-3 through H-14 while a minimum d80 value was achieved during test H-19.

Because the release analysis indicates improved yield and energy recovery at a d80 of 49 microns, and to ensure adequate liberation, the grinding conditions used in test H-19 was used for all parametric testwork of the Microcel™ flotation column.

Loading of Primary and Secondary Ball Mills

Parametric testing and optimization of the PDU grinding circuit resulted in the addition of grinding media to both ball mills. A current distribution of balls by size is shown in Table 12.

Table 12. Distribution of Grinding Media in Ball Mills

	Primary Ball Mill				Secondary Ball Mill			
Ball Size (in)	Begin	8/26/96	8/28/96	Final	Begin	8/26/96	8/28/96	Final
2	2,700		333	3,033				
1-1/2	2,700	250	84	3,034	2,700		316	3,016
1	2,700		333	3,033	2,700	250	84	3,034
1/2					2,700		333	3,033
Total	8,100	250	750	9,100	8,100	250	733	9,083

The addition of grinding media to each ball mill resulted in acceptable d80 values in the Microcel™ feed.

Ground Product d80 Evaluations - Microtrac vs. Wet Screening

It is important to note that all d80 values for tests H-1 through H-13 were determined by Microtrac while the remainder were determined by wet screening. Observed variations in the Microtrac results led to an evaluation and comparison of the two size determination methods.

Four hourly samples were collected during test H-13 for evaluation by both methods. The results are shown in Figure 11.

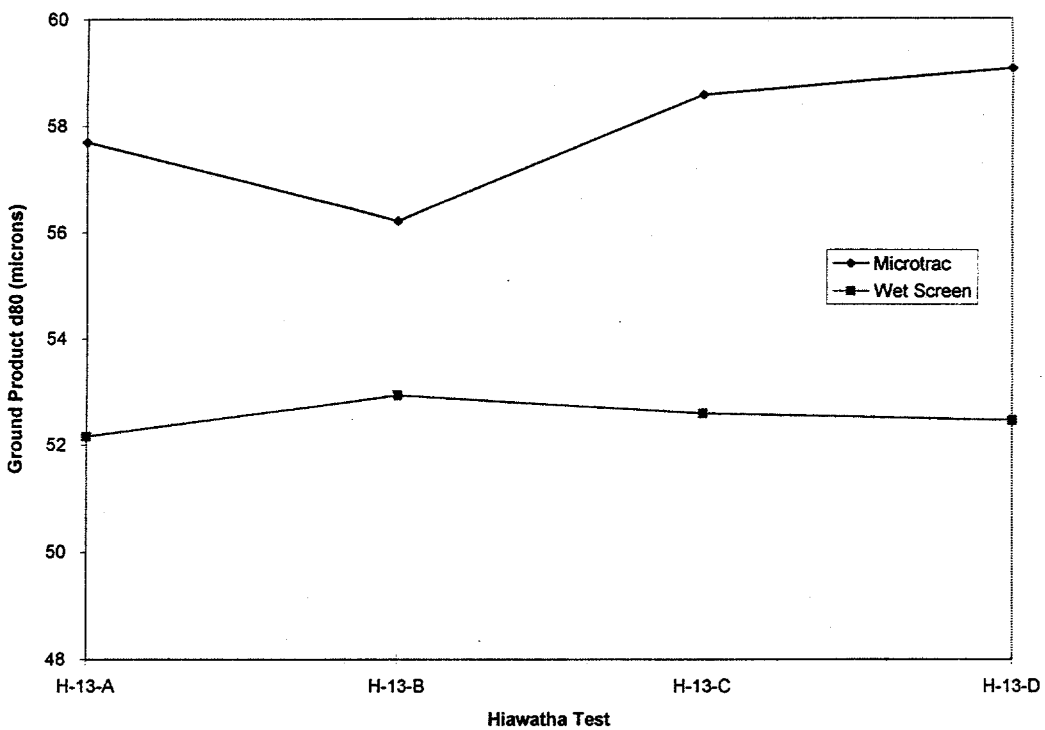


Figure 11. Comparison of Wet Screening and Microtrac Results

Observation of the data reveals that wet screening gave lower d80 values (5 micron average difference) and was more consistent than the Microtrac unit. As a result of this test work, use of the Microtrac was temporarily abandoned until repairs can be made. A Microtrac technician is scheduled to repair the unit during the first week of October, 1996.

Parametric Testing of PDU Flotation Module - Hiawatha Coal

Parametric testing of Hiawatha coal in the PDU Flotation Module concluded during the quarter. A total of 20 tests were conducted which utilized approximately 124 tons of feed coal. The results of the these tests are presented in Table 13.

Table 13. Parametric Testing of PDU Flotation Module - Hiawatha Coal

Test #	Feed lb/hr	Fuel Oil lb / ton	Frother lb / ton	% Solids	Air CFM	Wash GPM	Recirc GPM	Column d80	PDU Yield	Energy Recov	Ash lb/MBtu
H-19	4,304	0.25	0.30	4.27	55	140	800	45	12.3	13.8	1.43
H-20	4,304	0.50	0.30	4.50	55	140	800	49	74.5	80.2	1.69
H-21	4,304	0.50	0.50	6.38	55	86	800	49	89.8	96.5	2.40
H-22	4,306	0.25	0.75	3.78	55	86	800	52	90.8	97.2	2.40
H-23	4,306	0.75	0.75	6.60	55	86	800	52	91.5	98.0	2.51
H-24	4,306	0.50	1.00	6.67	55	86	800	49	90.3	97.6	2.31
H-25	4,302	0.50	0.75	9.99	55	86	800	54	91.1	97.8	2.74
H-26	4,302	0.50	0.75	4.44	55	86	800	47	91.8	97.6	2.30
H-27	4,308	0.50	0.75	7.17	75	86	800	50	92.7	98.4	2.63
H-28	4,305	0.50	0.75	7.50	30	86	800	52	90.6	96.7	2.54
H-29	4,295	0.50	0.75	7.42	55	140	800	53	89.0	96.5	2.17
H-30	4,295	0.50	0.75	7.04	55	55	800	47	94.0	98.7	2.87
H-31	4,305	0.50	0.75	7.71	55	86	990	54	90.7	97.4	2.37
H-32	4,305	0.50	0.75	7.35	55	86	600	48	89.8	95.3	2.14
H-33	4,308	0.50	0.35	7.07	55	86	800	51	90.3	96.3	2.16
H-34	4,308	0.50	0.40	7.15	55	86	800	46	90.6	96.8	2.30
H-35	4,308	0.50	0.45	7.43	55	86	800	45	90.5	96.6	2.38
H-36	5,973	0.50	0.75	8.63	55	86	800	61	92.5	97.2	2.41
H-37	5,333	0.50	0.75	6.14	55	86	800	56	90.4	96.6	2.35
H-38	3,307	0.50	0.75	6.02	55	86	800	49	91.8	97.5	2.39
MAX	5,973	0.75	1.00	9.99	75	140	990	61	94.0	98.7	2.87
MIN	3,307	0.25	0.30	4.27	30	55	600	45	12.3	13.8	1.43

Observation of the data shows that the overall quality goal of 2.00 lb/MBtu of ash was achieved on two occasions (parametric tests H-19 and H-20). Unfortunately, the overall PDU yield and energy recovery suffered significantly during one of these tests.

Overall, the clean coal yield varied from 12.3% to 94.0% while the energy recovery and product ash varied from 13.8% to 98.7% and 1.43 lb/MBtu to 2.87 lb/MBtu, respectively. The Microcel™ feed d80 values averaged 50 microns with a standard deviation of 3 microns. The results of these parametric tests are compared to the release analysis (d80=49 microns) in Figures 12 and 13.

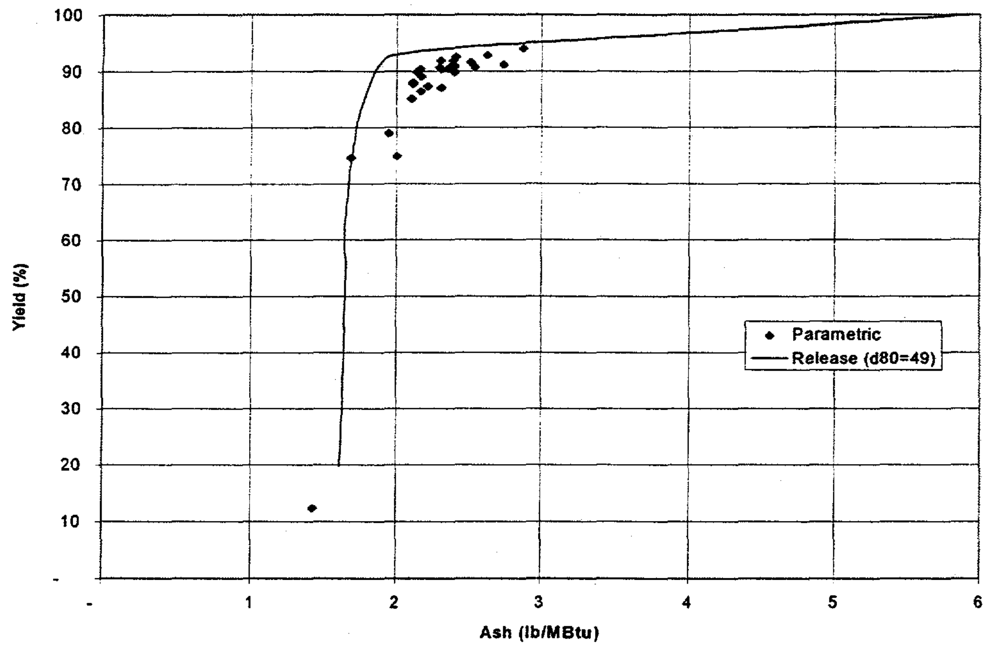


Figure 12. Parametric Testing of Hiawatha Coal - Yield vs. Ash

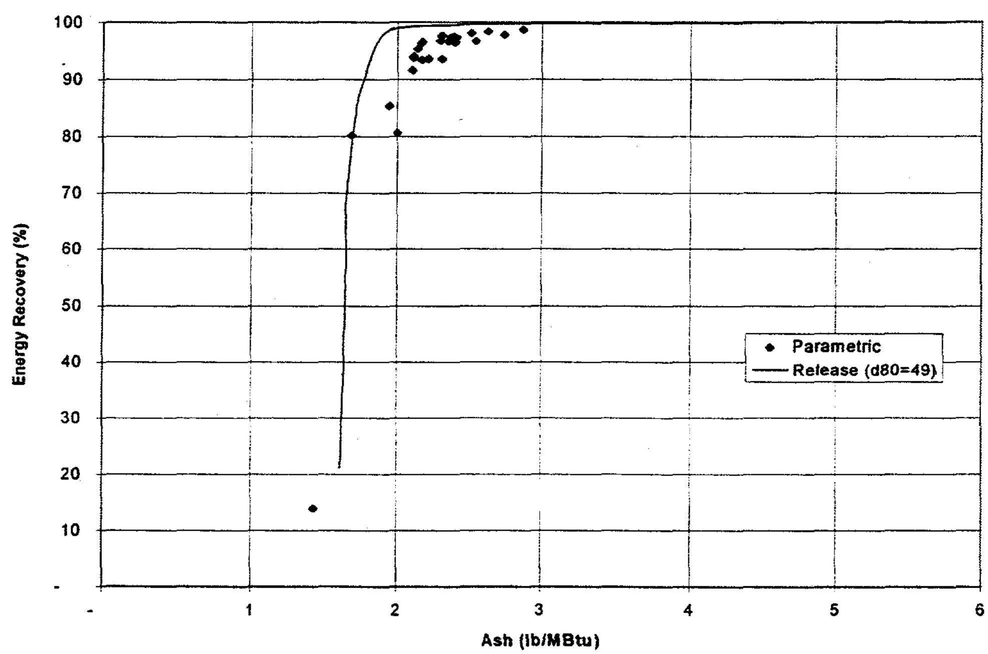


Figure 13. Parametric Testing of Hiawatha Coal - Energy Recovery vs. Ash

Development of Flotation Regression Equations - Hiawatha Coal

Data from PDU Flotation Module parametric testing was compiled and multiple regression models (equations) were generated. Like the Taggart and Indiana VII coals, forward stepwise regression produced equations which link output variables such as yield and clean coal quality to input variables such as feed rate, wash water rate, air rate, collector addition, and frother addition. The equation term coefficients for the two main response variables are shown in Tables 14 and 15.

Table 14. Regression Analysis of Hiawatha Clean Coal Ash (lb/MBtu)

Input Variable	Coefficient	t-Statistic
Intercept	80.106	21.63
% Solids	0.075829	17.26
$(\text{Frother lb/ton})^2$	-1.8928	-10.28
$(\text{Air Rate CFM})^2$	0.00002260	4.24
$(\text{Wash Water GPM})^{1/2}$	-0.144977	-21.27
1 / (Collector lb/ton)	-0.062601	-7.43
1 / (Frother lb/ton)	0.7819	5.53
1 / (Recirculation GPM)	-7896.6	-21.50
1 / (Feed Ash %)	1.8427	2.27
ln (Frother lb / ton)	3.0606	7.91
ln (Recirculation GPM)	-9.8943	-20.32
Coefficient of Determination (R^2)	0.991	
Adjusted R^2	0.989	

Table 15. Regression Analysis of Hiawatha Coal - Yield (%)

Input Variable	Coefficient	t-Statistic
Intercept	-442.10	-10.40
Feed Ash %	152.092	20.45
$(\text{Feed Ash \%})^2$	-8.8689	-22.10
$(\text{Air Rate CFM})^{1/2}$	-8.694	-4.13
1 / (Collector lb/ton)	-1.8587	-3.41
1 / (Frother lb/ton)	-5.9086	-12.78
1 / (% Solids)	-75.07	-7.26
1 / (Air Rate CFM)	-1485.3	-4.82
Coefficient of Determination (R^2)	0.987	
Adjusted R^2	0.985	

The Coefficient of Determination (R^2) and Adjusted Coefficient of Determination (Adjusted R^2) both show that the each equation fits the data quite well. In addition, observation of the t-statistic, which indicates the relative importance of each independent variable to the response equation, shows that the most important controllable variables that affect clean coal ash are Recirculation Rate (affects bubble size) and Wash Water. However, the variables that have the most significant impact on yield are Feed Ash % and Frother Dosage.

It is important to note that though the yield and product ash are dependent on the feed coal ash content, the ash content itself is not a controllable variable and thus considered a covariant.

Optimization of PDU Flotation Module - Hiawatha Coal

Optimization tests for Hiawatha coal in the PDU Flotation Module were completed during the quarter. A total of eight tests were performed to determine the optimum Microcel™ setpoints needed to achieve the process development goals of 2.00 lb/MBtu of ash and 80 percent energy recovery with maximum yield.

Equations were first developed to estimate the effects of test input variables on Microcel™ outputs such as yield and quality. The equations were developed by evaluating the input and output variables of parametric tests H-19 through H-38 by multiple linear regression. The resulting equations were then used to determine optimum Microcel™ setpoints. A unique function found in the Microsoft Excel software package called "Solver" was used to determine the proposed optimal setpoints for testwork. The results of the optimization testwork is shown in Table 16.

Table 16. Optimization Testing of PDU Flotation Module - Hiawatha Coal

Test #	Feed lb / hr	Fuel Oil lb / ton	Frother lb / ton	% Solids	Air CFM	Wash GPM	Recirc GPM	Column d80	PDU Yield%	Energy Recov%	Ash lb/MBtu
H-OP-39	4,280	0.45	0.35	4.50	51	117	810	50	87.3	93.5	2.21
H-OP-40	4,280	0.45	0.40	4.37	51	117	810	52	88.0	94.0	2.11
H-OP-41	4,301	0.45	0.45	5.04	51	117	810	56	87.6	93.8	2.11
H-OP-42	4,301	0.45	0.45	5.09	51	140	810	51	86.4	93.4	2.17
H-OP-43	4,301	0.45	0.40	5.09	51	140	810	50	87.0	93.6	2.31
H-OP-44	4,306	0.45	0.30	5.37	51	140	810	52	78.9	85.4	1.95
H-OP-45	4,306	0.45	0.35	5.20	51	140	810	52	85.1	91.6	2.11
H-OP-46	4,292	0.45	0.25	5.01	51	140	810	49	74.8	80.6	2.00
MAX	4,306	0.45	0.45	5.37	51	140	810	56	88.0	94.0	2.31
MIN	4,280	0.45	0.25	4.37	51	117	810	49	74.8	80.6	1.95

Observation of the data shows that the product ash goal of 2.00 lb/MBtu was achieved on two occasions (H-0P-44 and H-OP-46). Because test H-OP-46 used a lower frother dosage, the setpoints used during this test were used for the extended production run.

Extended Run of PDU Flotation Module - Hiawatha Coal

An extended production run of the PDU Flotation Module on Hiawatha coal was successfully completed during September 1996. The effort commenced Monday, September 23 and concluded the morning of Thursday, September 26. The PDU operated 72 continuous hours without interruption. Though the operating parameters were changed during the first day, the resulting setpoints are listed as follows:

- Coal: Hiawatha
- Nominal Feed Rate: 4,300 lb/hr
- Sizetec Screen Cloth 145 mesh
- Grinding Circuit: Closed / 2" Cyclones / Sizetec Screens
- Primary Water: 8 GPM
- Cyclone Water: 20 GPM
- Ground Product H_2O: 20 GPM
- Collector: 0.45 lb/ton (9 cc/min)
- Frother: 0.35 lb/ton (7 cc/min)
- % Solids Setpoint: 5.24
- Microcel Dilution H_2O: 20 GPM
- Air Rate: 51 CFM
- Microcel Level SP: 55 inches
- Spray Water: 140 GPM
- Microcel Recirculation: 810 GPM
- Operating Hours: 72 hours
- Pounds Processed: 310,270
- Tons Processed: 155
- Clean Filter Cake Bags: 131

A breakdown of the production run by time interval is shown in Table 17.

Table 17. Extended Production Run - Hiawatha Coal

Date	From	Until	Feed lb/hr	% Solid	Feed Ash %	Clean Ash %	Tails Ash %	Feed d80	PDU Yield	Energy Recov	Sulfur lb/MBtu	ASH lb/MBtu
9/23/96	7 AM	11 AM	4,309	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S
9/23/96	11 AM	3 PM	4,309	4.78	8.16	2.44	16.25	48	58.6	62.8	0.44	1.70
9/23/96	3 PM	7 PM	4,309	4.67	8.39	2.58	25.68	51	74.9	80.4	0.44	1.80
9/23/96	7 PM	11 PM	4,309	4.73	8.57	2.92	43.89	52	86.2	92.4	0.45	2.05
9/23/96	11 PM	3 AM	4,309	5.68	8.09	2.28	20.68	46	68.4	73.5	0.45	1.59
9/24/96	3 AM	7 AM	4,309	5.76	8.32	2.41	26.15	50	75.1	80.7	0.43	1.68
9/24/96	7 AM	11 AM	4,309	5.87	10.56	2.63	35.99	47	76.2	84.1	0.45	1.84
9/24/96	11 AM	3 PM	4,309	5.16	8.82	2.87	38.53	47	83.3	89.7	0.44	2.01
9/24/96	3 PM	7 PM	4,309	5.22	7.82	3.08	36.57	50	85.9	91.0	0.45	2.16
9/24/96	7 PM	11 PM	4,309	5.47	8.88	2.69	39.31	46	83.1	89.7	0.44	1.88
9/24/96	11 PM	3 AM	4,309	5.29	7.68	2.65	37.17	48	85.4	90.8	0.44	1.85
9/25/96	3 AM	7 AM	4,309	5.31	8.71	2.78	44.21	50	85.7	92.2	0.45	1.95
9/25/96	7 AM	11 AM	4,309	5.61	9.34	2.75	46.22	46	84.8	92.0	0.45	1.92
9/25/96	11 AM	3 PM	4,309	5.07	8.93	2.75	45.53	50	85.6	92.3	0.43	1.92
9/25/96	3 PM	7 PM	4,309	5.26	8.80	2.71	42.71	50	84.8	91.4	0.43	1.90
9/25/96	7 PM	11 PM	4,309	5.34	9.10	2.57	33.98	48	79.2	85.8	0.44	1.79
9/25/96	11 PM	3 AM	4,309	5.24	8.27	2.66	40.06	44	85.0	91.1	0.45	1.86
9/26/96	3 AM	7 AM	4,309	5.12	9.04	2.75	43.65	51	84.6	91.4	0.45	1.92
AVG #1				5.27	8.68	2.69	33.22	48	80.4	86.5	0.44	1.88
AVG #2				5.30	8.71	2.70	35.63	48	81.8	88.0	0.44	1.89
MAX				5.87	10.56	3.08	46.22	52	86.2	92.4	0.45	2.16
MIN				4.67	7.68	2.28	16.25	44	58.6	62.8	0.43	1.59

Except for % Solids and d80, the average values shown are weighted averages based on feed rate and yield. Values listed as AVG #1 do not include the first four hours of operation while AVG #2 values do not include the first eight hours of operation.

Based on the fact that some parameters were varied during the first eight hours of the production run, the resulting values obtained during this time period should be omitted. As a result, the Hiawatha production run produced a clean coal product with the following average values:

- Ash: 1.89 lb/MBtu
- Sulfur: 0.44 lb/MBtu
- Yield: 81.8 %
- Energy Recovery: 88.0 %

Electric Power Usage - Hiawatha Extended Run

To provide the energy consumption data for the design of the commercial plant, electric power usage related to the Hiawatha Extended Production Run in the PDU has been determined. Mr. Martin, Consumer Representative with Public Service Company of Colorado, was very helpful in this regard. The total power usage is summarized in Table 18.

Table 18. Electric Power Usage - Hiawatha Extended Production Run

Attribute	Kilowatt Hours	Peak Kilowatts
Begin Reading	1833	1.149
End Reading	1902	1.149
Meter Usage	69	1.149
Factor	240	31.12
Actual Usage	16,560 kWh	35.76 kW
Feed Tons (AR)	155.14	155.14
kWh / Feed Ton (AR)	106.74	

Disposal of Clean Coal Filter Cake

Fifty bags (supersacks) of Taggart filter cake as well as one bag of Indiana VII filter cake were shipped to The Pennsylvania State University on Tuesday, August 13, 1996. Though 200 bags of Taggart product were initially scheduled for delivery to Penn State, difficulties in finding storage space resulted in a reduced delivery. The remaining bags of Taggart and Indiana VII filter cake were disposed as refuse.

During the extended production run, 131 bags (supersacks) of Hiawatha filter cake were produced. So far, 75 bags have been disposed to date with 53 sent to landfill and

22 transported to the Western Aggregate facility near Golden, Colorado. Currently, 56 bags remain on site.

Since the flatbed trucks used for transport hold a maximum of 22 bags, two truckloads (44 bags) are tentatively scheduled for delivery to The Pennsylvania State University during the upcoming quarter. Two bags will be stored for possible future use by Amax R&D and the remaining 10 bags will be sent to Western Aggregate.

Miscellaneous Accomplishments

The following miscellaneous accomplishments were made during the quarter:

- Installed new check valve ball in east Netzsch filter charge pump.
- Emptied Indiana VII coal from feed bin.
- Moved excess Indiana VII coal to Ralston site for storage.
- Precision Mechanical, Inc. installed 4-inch classifying cyclone on discharge of primary ball mill. Cyclone to remove unwanted undersize material from secondary mill feed. Use of cyclone abandoned due to high d80 values produced when in use.
- Repaired / modified drum filter discharge chute;
- Performed general plant cleanup;
- Repaired faulty activator on clean coal sampler;
- Installed splash guard on tailings sampler;
- Replaced damaged floor drain grating in Area 400 (lower level);
- Applied silicone to west Sizetec screens to stop leaking from stress cracks;
- Disassembled thickener underflow pump casing and removed foreign debris;
- Drained and cleaned filtrate sump;
- Added hydraulic fluid to Netzsch press pumps;
- Replaced damaged filter cloth on east Eimco filter press
- Prepared 2-inch classifying cyclones for service;
- Precision Mechanical, Inc. installed a bypass line between the discharge of each Netzsch piston pump to aid in pumping flexibility;
- Compiled and updated MSDS listing of PDU materials.
- Removed worn mixer shaft from Microcel™ feed sump.
- Drained and filled Microcel™, thickener, and clarified water tank with fresh water to alleviate suspected frother buildup. This procedure was performed several times during the quarter.

- Transferred archived files from full disk drive on SCAN system to WIPS station hard drive. Determined that system was archiving data every 5 seconds instead of every minute.
- Installed LaserJet III printer on CADS WIPS station.
- Precision Mechanical, Inc. installed thickener underflow bypass line to Netzsch filter feed sump.
- Repaired / spliced torn belting on elevating conveyor.
- Repaired discharge screen retainer on secondary ball mill.
- Crushed coal at Ralston Development.
- Precision Mechanical, Inc. repaired cracks on east Sizetec screen frame.

TASK 9 SELECTIVE AGGLOMERATION MODULE

Phase III of this project involves the construction and operation of a 2 t/hr selective agglomeration (SA) PDU module. This SA module will be integrated with the existing PDU facility constructed during Subtask 8.2 and currently being operated under Subtask 8.4.

During operation of the SA module, the existing coal handling and grinding circuits (Plant Area 100) will be used to produce ground coal slurry feed for the selective agglomeration process. Similarly, the existing product and tailings dewatering circuits (Plant Area 400) will also be used. As such, the SA module (Plant Area 300) will essentially replace the Microcel™ flotation column (Plant Area 200), with the remainder of the plant remaining intact.

Just like the advanced flotation PDU, selective agglomeration process performance will be optimized at the 2 t/hr scale, and 100 ton lots of ultra-clean coal will be produced for each of the three test coals. Toxic trace element distributions will also be determined during the production runs. The ultra-clean coals will be delivered to DOE or some other user for end-use testing.

Subtask 9.1 Selective Agglomeration Module Construction

Construction of the PDU selective agglomeration module by Mech El Contracting, Inc. (MEI) of Aurora, Colorado, began on March 11, 1996. MEI is constructing the SA Module based on the detailed design prepared by Bechtel. MEI is providing all the labor and materials for the construction except the major pieces of equipment which are provided by Amax R&D.

The overall scope of work being performed by MEI includes:

- Excavation and concrete foundation work for equipment as required
- Structural steel installation and modifications
- Installation of equipment, piping, and valves

- Installation of MCC and electrical from existing switchgear to equipment
- Installation of various instruments and expanded process control system
- Sheeting and painting
- Assistance during plant shakedown testing

Equipment Purchasing

Orders were placed and Purchase Orders issued for a number of different equipment items and services as well as other miscellaneous electrical, instrumentation, and Distributive Control System (DCS) items during this quarter. A complete listing of all equipment and services purchased and/or rented to date for the selective agglomeration module construction, along with the status of delivery is presented in Appendix C. Items and services ordered and/or received during this quarter are as follows:

- One (1) flowmeter for flare fuel gas purge
- One (1) level switch for floor sump pump
- One (1) "S" section pipe, mounting plate, and mounting cover for relocation of existing nuclear density gauge
- One (1) insert holder and three (3) rupture discs for gas holder
- Five (5) combustible gas detectors with associated accessories
- Two (2) oxygen detectors with associated accessories
- One (1) natural gas regulator
- Two (2) two-speed combination starters for air handling and exhaust fan units
- One (1) two-speed exhaust fan for air handling system
- Parts and service to upgrade existing air handling unit to desired air flow capacity with two-speed capability
- One (1) display builder for Windows software package for DCS system
- One (1) pressure control orifice union for asphalt feed line
- One (1) Ethernet card for DCS system
- One (1) LAN Workplace software package for DCS system
- One (1) 17-inch monitor for DCS system
- Services for fabrication of the DCS panel
- Spare parts for various pumps
- Consulting services for development of SA module DCS system
- Consulting services for the development of DCS system process screens
- Various miscellaneous hoses and fittings
- Miscellaneous electrical components

- Miscellaneous DCS components
- Rock salt for boiler feed water treatment
- Chemicals for boiler feed water treatment
- Replacement belt for elevating conveyor 100-T-03

With the purchase of these equipment and services, the bulk of purchasing under Subtask 9.1 is complete.

Construction

Construction of the Selective Agglomeration PDU module by MEI continued during this reporting quarter. Work completed on the construction of Plant Area 300 was as follows:

- The completion of all equipment installation
- The completion of all clarified water, utility water, gas blanket, and relief system piping
- Continuation of process piping installation
- Installation of virtually all of the instrumentation items
- Continuation of the running of various conduits and wires to and from the MCC, DCS, equipment, and instrumentation locations
- The installation of the new roof, including a removable section for servicing of the agglomeration agitators
- Installation of ventilation system exhaust duct work
- Installation of used air handling unit
- Installation of new exhaust blower
- Completion of the electrical heat tracing
- Completion of the bulk of the required insulation

Outstanding work as of the end of September includes the following:

- Completion of fine grinding mill cooling water circuit process piping
- Completion of instrument and process air piping
- Completion of pump and mixer cooling water and lubricator piping
- Installation and wiring of several instruments
- Installation and wiring of one sampler
- Completion of personnel protection insulation
- Completion of DCS panel wiring
- Completion of ventilation exhaust duct work, installation of one hydrocarbon detector, and balancing of ventilation system

- Other various small miscellaneous items

Based on the work completed as of the end of this reporting period, Table 19 presents the percent completion of each construction milestone and the overall project.

Table 19. SA Module Construction Progress by Milestone

Item	Milestone	Percent Complete
1	Mobilization, excavation, concrete, and foundation work	100
2	Structural Steel & Platework	100
3	Equipment Installation	100
4	Piping Installation	99
5	Electrical & instrumentation installation	99
6	Ventilation & fire protection installation	99
7	Sheeting & Painting	76
8	Shakedown testing, cleanup, & demobilization	--
	Total Contract	**96**

In addition, the building of the DCS system operator screens and the programming of the DCS logic, control, and database schemes are continuing towards the completion of Subtask 9.1. This work is being performed by two consultants, Control Technology, Inc. and AR Technologies.

TASK 11 PROJECT FINAL REPORT

The final project report will include an economic assessment of the production of premium fuel from coal. The assessment will be based upon the results of the Tasks 4 and 6 laboratory and bench-scale testing and upon the Tasks 8 and 9 PDU operation of the advanced flotation and selective agglomeration circuits. Capital and operating costs for the economic assessment will be based on conceptual plants tentatively located in the Ohio Valley Region for producing 1.5 million short tons per year (dry basis) of clean coal to be marketed as coal-water fuel.

Bechtel has begun designing the process flowsheet for the flotation plant and collecting the data needed for selecting and costing the equipment in the plant. Because of the high budget quotes and comments being received from prospective vendors, special attention has been given to the clean coal dewatering and CWF preparation circuits. In particular, filters have been replaced by solid-bowl centrifuges since fewer pieces of equipment would be needed. This change, in turn, drastically reduces the amount of floor space required and simplifies the feeding and product gathering system. The overall effect is a significant reduction in capital costs.

Also, recent Subtask 6.4 work has shown that the improvement in loading that can be achieved by adjusting the particle size distribution of the CWF is quite meager. For this reason, the grinding mill specified in the initial conceptual flowsheet for particle-size adjustment has been dropped from the flowsheet. The 62-percent loading specification will be retained for the finished product, though, since that loading was achieved for the Taggart coal and is close to the loadings achieved for Sunnyside and Hiawatha coals during the CWF formulation studies.

PLANS FOR NEXT QUARTER

The following activities are planned for the seventeenth quarterly reporting period, October - December, 1996:

- Subtask 3.2 - The Topical Report will be prepared and distributed for DOE review. The report will combine the work done by Virginia Tech at Lady Dunn with the earlier laboratory studies and will also include the dewatering, briquetting and slurry preparation studies on the clean coal produced by the column flotation.
- Subtask 3.3 - A flowsheet of a continuous bench-scale unit for the hydrophobic dewatering process will be developed and the economics of the process will be reviewed.
- Subtask 6.4 - The subtask Topical Report will be issued during the quarter.
- Subtask 6.5 - Selective Agglomeration Bench-scale Testing will be completed as will a draft of the Subtask 6.5 report.
- Subtask 8.4 - Efforts will be directed toward the following:
    - Complete backlog of lab analyses for Hiawatha coal
    - Complete backlog of lab analyses for Indiana VII coal
- Subtask 8.5 efforts will be directed toward the following:
    - Review and compile operating data for Taggart coal
    - Review and compile operating data for Indiana VII coal
    - Review and compile operating data for Hiawatha coal
- Subtask 9.1 - The PDU Selective Agglomeration Module construction will be completed.
- Subtask 9.2 - Selective Agglomeration Module shakedown testing and test plan development will be completed.
- Task 11 - Bechtel will continue costing a CWF premium fuel plant based on flotation recovery of the clean coal and performing an economic analysis of the process.

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APPENDIX A

Hiawatha Coal Agglomeration Results

Appendix A - Hiawatha Coal - 25 lb/hr Agglomeration Test Conditions and Results

		System Configuration										Feed						Screen Product		W/out Froth Skim					With Froth Skim						ROM Perfrom		
		Top	High Shear			Low Shear			Vibrat. Screen			Solids		%		Heptane		%	Size	Prod	Tails		Agg Perform		Prod		Tails		Agg Perform				
		Size	Imp	Tip	RT	Imp	Tip	RT	Size	Incl	H20									%	%	Yield	Btu	AR	%	#ash/	%	Yield	Btu	AR	Yield	Btu	AR
Run	Date	Mesh	in	m/s	min	in	m/s	min	Mesh	deg	lb/hr	%	lb/hr	ash	Btu/lb	%.db	%.daf	Sol	mm	ash	ash	%	Rec.%	%	ash	MBtu	ash	%	Rec.%	%	%	Rec.%	%
H2A1	6/14	100	2.4	15.0	1.4	4.8	4.8	3.4	48	42	52.3	9.9	25.0	7.97	13548	23.6	25.6	49.5	.5-1	2.8	61.3	91.2	96.7	68.0	2.84	1.98	78.9	93.3	98.8	66.8	73.9	89.0	91.2
H2A2	6/19	100	2.4	7.3	1.4	4.8	4.8	3.3	48	42	52.3	9.8	25.2	7.63	13597	21.9	23.7	46.1	1	2.81	53.4	90.5	95.6	66.7	2.83	1.97	73.1	93.2	98.4	65.5	73.8	88.7	90.8
H2A3	6/19	100	2.4	15.0	1.0	4.8	4.8	2.4	48	42	52.3	6.9	25.0	7.65	13594	24.3	26.3	53..9	.5-3	2.44	69.1	92.2	97.8	70.6	2.50	1.73	80.4	93.4	99.0	69.5	74.0	89.2	91.9
H2A3R	6/19	100	2.4	15.0	1.0	4.8	4.8	2.3	48	42	52.3	6.9	25.3	7.62	13598	24.0	26.0	46.3	1	2.63	58.3	91.0	96.4	68.6	2.66	1.85	76.6	93.3	98.7	67.5	73.9	88.9	91.3
H2A4	7/9	100	2.4	8.9	1.0	4.8	4.8	2.5	48	42	48.9	6.9	24.0	7.56	13607	22.3	24.2	53.2	.5-3	2.51	64.9	91.9	97.4	69.5	2.53	1.76	72.1	92.8	98.3	68.9	73.5	88.5	91.7
H2A4R	7/17	100	2.4	8.9	1.0	4.8	4.8	2.4	48	42	48.9	7.1	25.7	7.05	13683	20.4	22.0	44.4	.5-2	2.62	40.7	88.4	93.0	67.2	2.63	1.83	56.5	91.8	96.6	65.7	72.7	87.0	90.9
H2A5	7/10	100	2.4	7.0	1.4	4.8	4.8	3.4	48	42	48.9	6.9	17.5	7.56	13607	20.0	21.6	47.6	.5-3	2.55	46.5	88.6	93.8	70.1	2.59	1.80	60.9	91.5	96.8	68.7	72.4	87.2	91.7
H2A6	7/11	100	2.4	6.7	1.4	4.8	4.8	3.4	48	42	48.9	13.1	33.0	7.49	13618	20.4	22.0	53.9	<2	2.72	41.0	87.5	92.4	68.2	2.74	1.90	68.2	92.7	97.9	66.1	73.4	88.2	91.0
H2A7	7/11	100	2.4	15.0	0.6	4.8	4.8	1.5	48	42	48.9	12.9	75.8	7.33	13641	24.1	26.0	58.5	.5-2.5	2.65	83.7	94.2	99.4	65.9	2.66	1.85	86.4	94.4	99.6	65.8	74.8	89.7	90.9
H2A8	7/11	100	2.4	8.9	1.0	4.8	3.0	2.4	48	42	48.9	6.9	24.7	7.17	13665	22.0	23.8	40.9	<1.5s	2.57	44.3	89.0	93.8	68.1	2.58	1.79	63.0	92.4	97.4	66.8	73.2	87.7	91.1
H2A9	7/18	100	2.4	15.0	1.9	4.8	4.8	4.4	48	42	48.9	13.4	26.0	6.83	13716	21.6	23.2	51.2	<1.5	2.78	45.7	90.6	94.9	63.1	2.82	1.96	72.8	94.3	98.7	61.1	74.7	88.9	89.6
H2A10	7/30	100	2.4	15.0	1.0	4.8	3.0	2.4	48	42	48.9	7.0	25.2	6.82	13717	23.4	25.1	48.3	.5-2	2.56	52.3	91.4	96.0	65.7	2.57	1.79	72.7	93.9	98.6	64.6	74.4	88.9	90.6
H2A11	7/30	100	2.4	9.6	0.5	4.8	4.8	2.6	48	42	48.9	7.0	50.0	6.70	13735	22.1	23.7	48.4	<2	2.49	51.7	91.4	96.0	66.0	2.50	1.74	63.2	93.1	97.7	65.2	73.7	88.0	90.7
H2A12	7/30	100	2.4	15.0	0.7	4.8	4.8	3.7	48	42	48.9	10.0	49.8	6.65	13743	21.5	23.0	47.3	<2	2.73	57.3	92.8	97.1	61.9	2.74	1.90	76.1	94.7	99.0	61.0	75.0	89.2	89.6

APPENDIX B

Indiana VII Coal Agglomeration Results

Appendix B - Indiana VII Coal 25 lb/hr Agglomeration Test Conditions and Results

	System Configuration					Feed							Product		No Froth Skim		With Froth Skimming							
	High Shear		Low Shear		Scm	Solids		%	Heptane		Asph		%	Size	Prod	Aggl	Product		Tails	Agg Perform		ROM Perform		
	RT	Tip	RT	Tip	Deck										%	Yield	%	#ash/	%	Yield	Btu	Yield	Btu	
Run	min	m/s	min	m/s	Mesh	%	lb/hr	ash	%, db	%, daf	lb/t		Sol	(mm)	ash	%	ash	MBtu	ash	%	Rec. %	%	Rec. %	
I2A1	1.44	18.0	3.41	4.8	48	10.0	25.1	9.93	30.1	33.4	20.0		35.1	.5-4	3.74	89.3	3.78	2.71	73.4	91.2	98.0	51.3	88.7	
I2A2	2.06	18.0	4.89	4.8	48	10.0	17.6	9.92	29.4	32.7	20.0		49.0	<2	3.12	89.6	3.16	2.25	75.4	90.6	98.1	51.0	88.8	
I2A3	2.04	18.0	4.84	4.8	48	6.9	12.3	9.82	31.4	34.8	20.0		52.0	1-7	2.94	86.3	3.08	2.19	64.8	89.1	96.4	50.1	87.2	
I2A4	2.03	15.0	4.82	4.8	48	7.0	12.5	9.87	29.6	32.8	20.0		42.5	1-6	3.13	86.5	3.27	2.33	65.4	89.4	96.6	50.3	87.4	

APPENDIX C

PDU Selective Agglomeration Module Purchasing

Appendix C - PDU Selective Agglomeration Module Purchasing

Equip #	Description	Status	Vendor
NEW EQUIPMENT PURCHASES			
300-C-02	HS Reactor-B	Rcv'd	PF Inc.
300-C-03	Low Shear Reactor	Rcv'd	PF Inc.
300-C-04	Froth skimmer tank	Rcv'd	PF Inc.
300-C-05	Steam stripper A	Rcv'd	PF Inc.
300-C-06	Steam stripper B	Rcv'd	PF Inc.
300-C-07	Oil/water separator	Rcv'd	PF Inc.
300-C-08	Heptane drum	Rcv'd	PF Inc.
300-C-10	Tailings surge drum	Rcv'd	PF Inc.
300-C-11	Slurry sampling pot	Rcv'd	PF Inc.
300-C-12	Emerg. slop tank	Rcv'd	PF Inc.
300-C-13	Stm. strip. feed sump	Rcv'd	PF Inc.
300-C-15	Relief K. O. Drum	Rcv'd	PF Inc.
300-E-01	Vap.cond chill H2O	Rcv'd	Fluid Tech
300-E-02	Water preheater	Rcv'd	Fluid Tech
300-E-03	Slurry cooler	Rcv'd	Fluid Tech
300-E-04	Blanket gas cooler	Rcv'd	Fluid Tech
400-E-01	Clarified water cooler	Rcv'd	Fluid Tech
300-E-05	Vap. cond, air cooler	Rcv'd	CS Group
600-E-01	Cool. water air cooler	Rcv'd	CS Group
300-F-02	Flare stack	Rcv'd	Flare Ind.
300-G-01	Agg feed pump	Rcv'd	Quadna
300-G-02	Stripper A feed pump	Rcv'd	Quadna
300-G-03	Stripper B feed pump	Rcv'd	Quadna
300-G-04	Cl. coal slurry pump	Rcv'd	Quadna
300-G-05	Heptane feed pump	Rcv'd	Centen.
300-G-06	Asphalt pump	Rcv'd	Centen.
300-G-07	Tailings pump	Rcv'd	Quadna
600-G-02	Cooling water pump	Rcv'd	Quadna
600-G-03	FGM Cool. H2O pump	Rcv'd	Quadna
300-G-08	Emerg. slop pump	Rcv'd	Quadna
300-G-12	Floor sump pump	Rcv'd	Canmac
300-Y-03	HSR A impellers (4)	Rcv'd	Daigler
300-Y-04	HSR impeller-B	Rcv'd	Daigler
300-Y-05	LSR impeller	Rcv'd	Daigler
300-Y-07	Froth skimmer	Rcv'd	Daigler
300-Y-08	Steam strip feed agit.	Rcv'd	Daigler
300-Y-09	Stm strip. A agitator	Rcv'd	Daigler
300-Y-06	Screen	Rcv'd	Sizetech
600-V-01	Water Chiller	Rcv'd	York
300-D-04-A	Gas holder - tank	Rcv'd	PF Inc.
300-D-04-B	Gas holder - liner	Rcv'd	Flexi-Liner
300-C-14	12 Carb.drums @ $625	Rcv'd	Fluid Tech
300-G-09	Carbon drum feed pu	Rcv'd	DIP
300-Y-10	Condi.tank agitator	Rcv'd	Indco
–	Heptane hand pump	Rcv'd	Grainger
300-Y-10	Asphalt drum mixer	Rcv'd	Grainger
–	3 Air motor filters, etc.	Rcv'd	Grainger
–	Hose and fittings		McMaster

Appendix C - PDU Selective Agglomeration Module Purchasing

Equip #	Description	Status	Vendor
RECONDITIONING COSTS			
300-Y-03	HS Reactor-A Seal	Rcv'd	Ekato
600-G-01	Refrig. unit feed pump	Rcv'd	DIP
100-T-03	Elevating conveyor belt		Midwest
INSTRUMENTATION			
FT-6023	3" chilled water flow	Rcv'd	PCI
	GPM digital indicator	Rcv'd	PCI
FT-3175	1" N2 flow	Rcv'd	PCI
	CFM digital indicator	Rcv'd	PCI
FIQ-6010	2" gas flow	Rcv'd	PCI
	CFM digital indicator	Rcv'd	PCI
FE/FT-3090	6" steam flow	Rcv'd	PCI
~~FE/FT-3168~~	~~6" steam flow~~	Rcv'd	PCI
FE/FT-3013	1.5" mag, HS feed reci	Rcv'd	M&V Co.
FE/FT-3102	1.5" mag, final produc	Rcv'd	M&V Co.
FE/FT-3014	2" mag, HS feed	Rcv'd	M&V Co.
FE/FT-3055	2" mag, tails flow	Rcv'd	M&V Co.
FE/FT-3065	2" mag, stripper A fee	Rcv'd	M&V Co.
FI-3053	1" pad., froth laun. H2	Rcv'd	Integrity
FI-6024	1.5"pad, H2O- gas co	Rcv'd	Integrity
FIT-3115	2" water to E-03	Rcv'd	J&C Inc.
FIQ-3119	3/4" water from grav s	Rcv'd	J&C Inc.
FIQ-3123	1/2" hep from grav se	Rcv'd	J&C Inc.
FIQ-3144	1" water to cond tank	Rcv'd	J&C Inc.
FIQ-6009	2" water to plant	Rcv'd	J&C Inc.
FIQ-6025	2" water to sewer	Rcv'd	J&C Inc.
FI-3146	3/4" N2 to C-11	Rcv'd	J&C Inc.
FIT-3037	1" water to LS	Rcv'd	J&C Inc.
FIT-3046	1" water to screen	Rcv'd	J&C Inc.
FIT-3084	1" water to 300-E-01	Rcv'd	J&C Inc.
FIT-3108	1" water to 300-E-03	Rcv'd	J&C Inc.
LV-3149	2" tails FCV	Rcv'd	Protech
FV-3090	4" FCV, steam to Strip	Rcv'd	ICS
PV-3092	4" FCV, steam from SS	Rcv'd	ICS
FV-3108	1" FCV, H20 to E-02	Rcv'd	ICS
TV-3110	2" FCV, H2O to E-03	Rcv'd	ICS
LV-3121	1" FCV, H2O from GS	Rcv'd	ICS
LV-3187	1" FCV, blnket gas reli	Rcv'd	ICS
LV-3188	1" FCV, N2 makeup	Rcv'd	ICS
PSV-3021	1.5 " x 2", HS A relief	Rcv'd	Protech
PSV-3029	1.5" x 2.5", HS B relief	Rcv'd	Protech
PSV-3039	2" x 3" LS relief	Rcv'd	Protech
PSV-3067	1.5" x 3" Strip A relief	Rcv'd	Protech
PSV-3095	1.5" x 2.5" Strip B relief	Rcv'd	Protech
PSV-3103	.75" x 1" E-02 relief	Rcv'd	Protech
PSV-3109	.75" x 1" E-03 relief	Rcv'd	Protech
PSV-3122	1.5" x 2.5" grv sep relief	Rcv'd	Protech
PSV-3127	3" x 4" hept tank relief	Rcv'd	Protech
PSV-3154	3" x 4" slop tank relief	Rcv'd	Protech

Appendix C - PDU Selective Agglomeration Module Purchasing

Equip #	Description	Status	Vendor
LV-3008	1.5" FCV, GB to HS	Rcv'd	Protech
FV-3074	2" FCV, feed to strip B	Rcv'd	Protech
FV-3094	4", 3-way, stm/stm/gb	Rcv'd	Winn-Mar
PI-3017	larif water to Area 30	Rcv'd	JMC
PI-3133	eptane to agg circui	Rcv'd	JMC
PI-6011	Natural gas	Rcv'd	JMC
PI-6021	hilled water to proce	Rcv'd	JMC
PI-3136	Condit to agg circuit	Rcv'd	JMC
PI-3153	Tails pump discharge	Rcv'd	JMC
PI-3176	N2 Supply	Rcv'd	JMC
PSL-3176	N2 Supply	Rcv'd	JMC
PI-6020	Utility cooling water	Rcv'd	JMC
PI-6008	Utility water	Rcv'd	JMC
TE/TW-3016	Agg feed	Rcv'd	JMC
TE/TW-3022	HS A	Rcv'd	JMC
TE/TW-3077	Striiper A vapor	Rcv'd	JMC
TE/TW-3080	Ambient air	Rcv'd	JMC
TE/TW-3082	Cond vap, E-05 disch	Rcv'd	JMC
TE/TW-3085	E-01 cw to sewer	Rcv'd	JMC
TE/TW-3088	ap to gas blank cool	Rcv'd	JMC
TE/TW-3086	ooled cond, E-01 disc	Rcv'd	JMC
TE/TW-3090	Steam to stripper B	Rcv'd	JMC
TE/TW-3105	E-02 slurry discharge	Rcv'd	JMC
TE/TW-3107	CW to 300-E-02	Rcv'd	JMC
TE/TW-3110	E-03 slurry discharge	Rcv'd	JMC
TE/TW-3111	CW from E-03 to sewer	Rcv'd	JMC
TE/TW-3112	Heated cw from E-02	Rcv'd	JMC
TE/TW-3030	HS B	Rcv'd	JMC
TE/TW-3038	LS	Rcv'd	JMC
TE/TW-3062	Stripper feed	Rcv'd	JMC
TE/TW-3071	Stripper A liquid	Rcv'd	JMC
TE/TW-3093	Stripper B vapor	Rcv'd	JMC
TE/TW-3096	Stripper B liquid	Rcv'd	JMC
TE/TW-3156	Slop tank liquid	Rcv'd	JMC
TE/TW-4000	CLW to 400-E-01	Rcv'd	JMC
TE/TW-4001	CW from 400-E-01	Rcv'd	JMC
TE/TW-4002	CLW from 400-E-01	Rcv'd	JMC
TE/TW-6013	Utility water	Rcv'd	JMC
TE/TW-6022	Chilled utility water	Rcv'd	JMC
TI/TW-3182	Condensate from E-04	Rcv'd	JMC
TI/TW-3184	CW from E-04	Rcv'd	JMC
TI/TW-6008	CW to 600-E-01	Rcv'd	JMC
TI/TW-6009	CW from 600-E-01	Rcv'd	JMC
TI/TW-3128	Heptane storage	Rcv'd	JMC
TI/TW-3183	Gas blamket to E-04	Rcv'd	JMC
LSH-3039	Low shear	Rcv'd	FIC
LSH-3155	Slop tank	Rcv'd	FIC
LG/LSH-3179	Knock-out drum	Rcv'd	FIC
LG/LT-3124	Heptane storage	Rcv'd	FIC
LG/LT-3149	Tails tank	Rcv'd	FIC

Appendix C - PDU Selective Agglomeration Module Purchasing

Equip #	Description	Status	Vendor
LT-3001	Slurry storage level	Rcv'd	FIC
LT-3002	Slurry storage level	Rcv'd	FIC
LT-3186	Gas holder position	Rcv'd	FIC
LG-3054	Froth skimmer	Rcv'd	PSI
LG-3061	Stripper feed sump	Rcv'd	PSI
LG-3120	Gravity separator	Rcv'd	PSI
LG-3155	Slop tank	Rcv'd	PSI
LT-3121	Gravity separator	Rcv'd	ICS
LT-3059	Stripper feed sump	Rcv'd	Fischer
LT-3073	Stripper A	Rcv'd	Fischer
LT-3097	Stripper B	Rcv'd	Fischer
PV-3087	Condensed vapor, 2"	Rcv'd	ICS
PIT-3090	Steam from boiler	Rcv'd	J&C
PIT-3087	Stripper A vapor out	Rcv'd	J&C
PIT-3015	Slurry to agg circuit	Rcv'd	J&C
PT-3092	Stripper B	Rcv'd	J&C
–	Flare purge flowmeter	Rcv'd	Key
DE-3012	Density gauge pipe	Rcv'd	Berthould
PSV-3190	Rupture disc	Rcv'd	Protech
–	Comb. gas det.	Rcv'd	ICS
–	Comb. gas det.	Rcv'd	ICS
–	Comb. gas det.	Rcv'd	ICS
–	Comb. gas det.	Rcv'd	ICS
–	Comb. gas det.	Rcv'd	ICS
–	Oxygen det.	Rcv'd	ICS
–	Oxygen det.	Rcv'd	ICS
–	omb gas samp. mod	Rcv'd	ICS
–	xygen gas samp. mo	Rcv'd	ICS
PCV-6011	Fuel gas regulator	Rcv'd	ACE
PCV-3135	Asphalt line press. red.	Rcv'd	Protech
SV-3158	Solenoid valve	Rcv'd	Lakeland
LS-3113	Floor sump float switc	Rcv'd	Winpump
ELECTRICAL EQUIPMENT			
	600A circuit breaker	Rcv'd	–
	6 Section MCC	Rcv'd	ons. Elec
	VFD - 30 hp	Rcv'd	Reliance
	VFD - 7.5 hp	Rcv'd	Reliance
	VFD - 5 hp	Rcv'd	Reliance
	VFD - 5 hp	Rcv'd	Reliance
	VFD - 3 hp	Rcv'd	Reliance
	VFD - 1 hp	Rcv'd	Reliance
	250 A circuit breaker	Rcv'd	CED
	100 A circuit breaker	Rcv'd	CED
	20 HOA switches	Rcv'd	Ryall
	One 2-speed starter	Rcv'd	CED
	One 2-speed starter	Rcv'd	CED
	60 overload heaters	Rcv'd	CED
	86 fuses	Rcv'd	CED
	Exhaust fan	Rcv'd	CS Group

Appendix C - PDU Selective Agglomeration Module Purchasing

Equip #	Description	Status	Vendor
	Air handling unit modi	Rcv'd	CS Group
	Push buttons	Rcv'd	Ryall
	Miscellaneous Elect.	Rcv'd	CED
	Miscellaneous Elect.	Rcv'd	Ryall
	Miscellaneous Elect.	Rcv'd	Ryall
	Miscellaneous Elect.	Rcv'd	QED
	Miscellaneous Elect.	Rcv'd	Grainger
DCS COMPUTER SYSTEM			
–	CS Pentium compute	Rcv'd	Honeywel
–	Series 9000 upgrade	Rcv'd	Honeywel
–	17" Monitor	Rcv'd	CEW
–	Ethernet Card	Rcv'd	CEW
–	LAN Software	Rcv'd	CEW
–	isplay builder softwar	Rcv'd	Honeywel
	Screen Development		AR Tech
	Consulting Services		Honeywel
DCS PANEL			
–	Series 9000 hardware	Rcv'd	Honeywel
–	DCS Panel	Rcv'd	Circle AW
–	30 Zener bar.@ 89.38	Rcv'd	ocky Mt
–	10 Zener bar. @ 59.04	Rcv'd	ocky Mt
	Miscell. bariers		Rocky Mt
	Panel Fabrication	Rcv'd	CCC
RENTAL EQUIPMENT			
300-V-01	N2 & 6m rental	Rcv'd	Gen. Air
30–F-01	Boiler, 10 month rental	Rcv'd	TM
MISCELLANEOUS			
	Water treatment salt		Cullig
	Water treatment chem		Diversey
SPARE PARTS			
	300-G-08		Quadna
	300-G-04		Quadna
	300-G-07 600-G-02/3		Quadna
	300-G-01/02/03		Quadna