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TECHNICAL REPORT
March 1 through May 31, 1995

Project Title: **ULTRAFINE COAL SINGLE STAGE DEWATERING AND BRIQUETTING PROCESS**

DOE Cooperative Agreement Number: DE-FC22-92PC92521(Year 3)
ICCI Project Number: 94-1/1.1A-2P
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Other Investigator: R. Q. Honaker, Department of Mining Engineering, Southern Illinois University
Project Manager: K. Ho, Illinois Clean Coal Institute

ABSTRACT

It is well known that a large portion of the pyrite particles in the coal seams of the Illinois Basin are finely disseminated within the coal matrix. In order to liberate these micron size pyrite particles, one must use a fine grinding operation. The ultrafine coal particles that are produced are difficult to dewater and create problems in coal transportation, as well as in storage and handling at utility plants. The objective of this research project is to combine the ultrafine coal dewatering and briquetting processes into a single stage operation. This will be accomplished by the use of bitumen based emulsions for dewatering and a compaction device for briquetting.

During this reporting period, several types of coal samples with various particle size distributions have been tested for use in the dewatering and briquetting processes. Furthermore, various bitumen emulsions have been tested to determine the optimum dewatering reagent. These dewatering and pelletizing tests were carried out using a lab-scale ram extruder. Discharge from the dewatering and briquetting processes was tested to determine compliance with current federal and state requirements. The influence of bitumen emulsion on the sulfur content of coal pellets made were also examined. In addition, a ram extruder which can be operated continuously to simulate a rotary press operation, has been built and is currently being tested for use in the fine coal dewatering and pelletizing process.

DISCLAIMER

EXECUTIVE SUMMARY

It is well known that mineral particles, including pyrite, are finely disseminated in the Illinois basin coal as micron size particles. In order to separate mineral matter from coal particles efficiently, the mineral matter must be liberated from the coal matrix by the use of an ultrafine grinding operation followed by a wet physical coal cleaning process (column flotation). Due to the large surface area created by the ultrafine grinding operation, these ultrafine particles entrap a large amount of water after they are recovered from the column flotation process, and make the dewatering of the filter cake much more difficult than moderately ground particles. Moreover, this ultrafine coal creates dust control problems during its transportation and results in storage and handling difficulty at coal-burning utility plants.

In order to overcome the above mentioned problems, efficient dewatering and briquetting of ultrafine coal needs to be developed at the downstream end of the process, following the coal cleaning process. In this research project, Orimulsion has been used as a dewatering and briquetting agent to expel water that exists between the coal particles, and to bond the coal particles into a strong and robust pellet with the help of a compaction device.

Samples of three types of coal, Illinois #5 coal from the Galatia Mine (Kerr McGee Coal Co.), Illinois #6 (Arch Mineral) coal, and Western Kentucky (TVA) coal, were used for sulfur testing this quarter. The Illinois #5 coal was used for extensive testing with regard to the effect of particle size on dewatering and pelletizing properties such as pellet durability and water resistance.

The Illinois #5 coal was received from SIU-Carbondale as filter cake of three particle size ranges. The -100M x 0 coal had a moisture content of 30%, the coal with particle size ranging 28M x 0 had a moisture content of 25%, and the coal with particle size 28M x 100M had a moisture content of 27%. In order to prepare the filter cake for the dewatering and briquetting tests, a calculated amount of water and Orimulsion was added into the sample to produce a coal-binder mixture that had a moisture content of 35%. The Illinois #6 coal (Arch Mineral) and Western Kentucky (TVA) coals were ground to -100M x 0 and mixed with Orimulsion to produce pellets for evaluating the influence of Orimulsion on the sulfur content of coal pellets.

The dewatering and briquetting processes were carried out using a lab-scale ram extruder. In order to evaluate the influence of particle size on dewatering efficiency and coal pellet strength, compaction pressures of 4,000 to 7,000 psi and binder concentrations from 2 to 5 percent, were utilized. Compaction time was between 5 and 7 seconds. Results for the three coal particle sizes were similar, although the coal pellets with particle size range of 28M x 0 performed slightly better than those pellets with size ranges of -100M x 0 and 28M x 100 M.

Tumbling tests were conducted on coal pellets made with the three different size ranges mentioned at various curing times (8, 16, and 24 hours), to determine the relative friability

of the coal pellets. This technique provides a means of measuring the likelihood of coal pellets to break into smaller pieces when subjected to repeated handling during their transportation and handling at a utility plant. In general, the percentage weight loss of the coal pellets tested were found to be similar (between 6% and 9%) for all three particle size ranges, after 6 minutes in the tumbler. As compaction pressure is increased, or curing time is increased, or binder concentration is increased, the percent weight loss decreased for nearly all pellets tested. The tumbling tests were carried out on all coal pellets that were subjected to 24 hours of water absorption tests.

Water absorption tests were also conducted on pellets cured over various time periods (8, 16, 24 hours) to evaluate the water resistance of coal pellets fabricated using Orimulsion. These tests were carried out by submerging the coal pellets in water for 24 hours. The amount of moisture gained was used as a measurement for evaluating the water resistance of the coal pellets. Research in this reporting period further substantiated previous experiments which showed that a curing time is required to build up the strength of coal pellets and to evaporate more water from pellets when using bitumen emulsion as a binding agent. The moisture content of coal pellets made at various compacting pressures, particle sizes and binder concentrations, were measured at time intervals of 8, 16 and 24 hours. It was found that the moisture content of the coal pellets was reduced by 10 percent during a 24 hour curing time. Furthermore, coal pellets that were cured up to 24 hours absorbed lesser amounts of water than coal pellets that were immediately submerged after they were made.

The sulfur analysis were carried out to evaluate the influence of Orimulsion on the total sulfur content of coal pellets that were made with 0, 2 and 5% Orimulsion. Illinois #5, Illinois #6, and Western Kentucky coal were used in this experiment. The standard testing procedure was observed, as stated by the operations manual of the LECO SC132 Sulfur Determinator. Test results showed that the sulfur content of coal pellets is only very slightly affected by the addition of Orimulsion as a binding agent. The increase in the amount of sulfur in coal pellets was found to be less than 0.2% as the Orimulsion concentration increased from 0 to 5%.

Water Discharge from the coal dewatering and briquetting process was tested for Biochemical Oxygen Demand (BOD) and Dissolved Oxygen (DO) values, as well as for the concentration of heavy metals. Levels for BOD and DO were well within required federal limits for untreated discharge. High levels of Fe and Mn were found in untreated discharge, however, samples treated separately with lime and sodium hydroxide tested were below the required levels for all heavy metals found in the discharge.

The coal pellets used in these tests were produced using a lab scale ram extruder. This dewatering and briquetting machine was operated continuously using a hydraulic pump to provide the compaction pressure for the fabrication of 2" pellets. While a search for commercially available compacting and pelletizing machines is still being conducted, several machines such as ram extruders, rotary presses, and roller presses have been identified that have capacities to handle large scale operation.

OBJECTIVES

The objectives of this research project are to combine ultrafine coal dewatering and briquetting processes into a single stage operation using a hydrophobic binder as the dewatering and briquetting agent, and using a compaction device. A laboratory scale ultrafine coal pelletizing machine has been built and tested to optimize the ultrafine coal dewatering efficiency, and at the same time, fabricate strong and robust coal pellets to meet coal transportation needs.

INTRODUCTION AND BACKGROUND

In the ultrafine coal cleaning process, small coal particles (-400M x 0) are produced during the pulverizing operation. After the coal cleaning process, these ultrafine particles are difficult to dewater and create problems in coal transportation, storage, and handling at utility plants.

Research work on ultrafine coal dewatering and briquetting has resulted in the development of a single stage operation that is potentially more effective and economic than conventional thermal drying and briquetting processes. The final coal pellets products have a moisture content of less than 15% and possess high strength and water resistance, that satisfy coal transportation, storage and handling requirements.

EXPERIMENTAL PROCEDURES

1. Sample Preparation:

    a. Coal Samples:

    The TVA coal was received from SIU. The coal samples are Jameson Cell flotation concentrates that were filtered using a lab. scale vacuum filter. These coal samples have a particle size of 52% less than 100 mesh and a moisture content of 28%. No further grinding was conducted on these TVA coals.

    Illinois #6 coal (Arch Mineral) was used to investigate the effect of binder concentration on sulfur characteristics. Therefore, it was ground to -100M x 0 using a ball and ring mill. The prepared samples which were used for pelletizing, had a 33% moisture content.

    Illinois #5 coal (Galatia Mine, Kerr McGee) was received from SIU. The coal samples were filter cake separated into three particle size fractions. The -100M x 0 had a moisture content of 30%, the 28M x 100M had a moisture content of 27%, and the 28M x 0 had a moisture content of 25%. These samples were used to determine the effect of particle size on coal pellet characteristics.

b. Coal-Binder Mixture Preparation:

Orimulsion (bitumen emulsion) was used as a binding agent for the dewatering and briquetting processes. Orimulsion contains 60 to 75% of solid (bitumen) material and 40 to 25% of water. When preparing the coal-binder mixture, 3% of bitumen (5% of Orimulsion) by weight of dry coal was diluted with an appropriate amount of water. This diluted Orimulsion was then mixed with coal particles for less than 5 min. using a lab. scale mixer. This final coal-binder mixture had a moisture content of approximately 35%.

2. Dewatering and Briquetting Process:

After complete mixing, the coal-binder mixture was fed into a lab-scale ram extruder. The compaction pressure was increased to within the range of 4,000 to 7,000 psi. Current research involves modifying this design by replacing the dewatering gate with a second hydraulic piston. The new design of the compaction device is operated by acting two pistons against each other to produce coal pellets which closely parallel the operation of a commercial rotary press, see Figure 1. While the application of compacting forces is identical in both the rotary press and the lab-scale ram extruder, the only difference is the method of generating the compacting force. The rotary press uses a mechanical method to produce the pelletizing force, whereas the lab-scale ram extruder uses hydraulics as a means of creating the compacting force.

3. Moisture Content Determination of Dewatered Coal Pellets:

The initial weight of coal pellets was measured at the same time as they were fabricated. These coal pellets were oven dried at 110°C until the weight of the coal pellets reached a constant weight. The moisture content of the coal pellets was then determined by the following equation:-

Moisture content of coal pellet = [(initial weight of coal pellet - oven dried weight of coal pellet) / initial weight of coal pellet] x 100%

4. Water Absorption Test:

The water absorption test was carried out in order to examine the effect of binder curing time on water resistance of the coal pellet. The water evaporation test evaluates the rate of water evaporation from the coal pellet. The amount of water absorbed and the rate of water evaporation can be used as an index to evaluate the hydrophobicity of the coal pellet. Saturation tests were conducted at curing times of 8, 16, and 24 hours.

The water absorption tests were carried out by submerging the coal pellets in water for 24 hours after being exposed to a determined curing period. The percentage weight gained by the coal pellets was used to evaluate the water resistance of the coal pellets.

5. Tumbling Test:

In order to determine the strength and abrasion resistance of coal pellets, a tumbling test is considered to be a good technique to make this evaluation. The tumbling test is derived from a modification of the "ASTM Standard Test Method of Tumbler Test for Coal D441-45". The test procedure is described as follows:

- After the coal pellet is made and cured, the coal pellet is allowed to soak in water for up to 24 hours. After saturation, the pellet is placed in a tumbler and the tumbler is rotated at 60 rpm for up to 6 minutes.

- After tumbling, the coal pellet is removed from the tumbler and re-weighed. The percentage weight loss is then calculated and used as the coal pellet abrasion resistance index.

RESULTS AND DISCUSSION

1. Influence of Particle Size on Dewatering Efficiency:

Illinois #6 (Galatia Mine, Kerr McGee) coal was used to determine the effect of particle size on dewatering efficiency. To compare data collected this quarter with existing data, pellets were fabricated at various compaction pressures and again at various binder concentrations. Table 1 shows the results of the performance of coal pellets within the particle size range of -100M x 0. The initial moisture content of these pellets was between 18 and 20%, however when cured for 24 hours, a moisture content of below 5% was achieved.

The test results obtained from coal pellets made with 28M x 100M coal samples are shown in Table 2. The initial moisture content for these pellets was near the target moisture content of 15% when using compaction pressures of greater than 6,000 psi (3% Orimulsion) or binder concentrations of greater than 2% (6,000 psi compaction pressure). The moisture content of coal pellets were even further reduced to under 5% moisture when they were cured for 24 hours.

The initial moisture content for pellets with particle sizes within the range of 28M x 0 can be found in Table 3. For coal pellets compacted at 4,000 to 7,000 psi (3%

Orimulsion) the initial moisture content of coal pellets was about 15% and further reduced to less than 8% after 24 hours of curing. As the binder concentration of these pellets increases to 5% (6,000 psi compaction pressure), the initial moisture content drops below 13%. In addition, the curing and saturation of these pellets did not exceed the target moisture content of 15%.

2. Influence of Particle Size on Wear Resistance:

Illinois #6 (Galatia Mine, Kerr McGee) coal was used to determine the effect of particle size on the friability of coal pellets. For all three particle size ranges tested (-100M x 0, 28M x 100M, and 28M x 0) the results were similar to those described in previous reporting periods. Tumbling times of 6 minutes produced a weight reduction of less than 10%, with a decrease in weight loss as the compacting pressure and binder concentration increased. Under the same pelletizing conditions, coal pellets made with 28M x 0 coal particles performed better than the other size fractions. This is believed to be due to the better packing characteristics of 28M x 0 particles than the other two particle size distributions. As shown in Table 3, the average weight loss for a 6 minutes tumbling time, did not exceed 5%.

3. Water Discharge Characteristics:

The discharge collected from the pelletizing of coal samples was tested during this period for Biochemical Oxygen Demand (BOD), Dissolved Oxygen (DO) and heavy metal concentrations. BOD and DO were monitored using standard testing equipment and procedures, and were calculated to be well within legislative guidelines. High concentrations of Fe and Mn were discovered in untreated coal pellet discharge water. Existing levels of Cu, Cr, and Zn were below the acceptable limits. In addition, the pH level of the coal pellet water discharge was monitored at 1.78.

Two methods were used to treat the water discharged from the coal pelletizing process. Sodium hydroxide was first used to successfully reduce Fe and Mn to levels in compliance with government regulations. The use of lime was also successful in reducing all metal concentrations to below required limitations. These two treatment techniques also raised the discharge pH from 1.78 to 7. The results of the water analyses of the discharge are shown in Table 4.

4. Effect of Binder Charge on Pelletizing Characteristics:

Several types of available bitumen emulsions were tested for dewatering and pelletizing fine coal particles. The test results were then compared with those obtained when Orimulsion was the dewatering and binding agent. All coal samples were cured for 24 hours after pelletizing, and subsequently saturated for 24 hours and then tumbled for 6 minutes. The anionic binders such as the MS-2H (medium set) and SS-1H (slow set) performed better than the cationic binders such as CRS-2 (cationic rapid set) and CRS-2P (cationic rapid set). The use of anionic emulsions produced cured pellets with moisture contents of only 2% less than cationic emulsions, however, they gained 10% less moisture upon saturation. As shown in Table 5, Orimulsion produces similar results as the anionic emulsions. However, the bitumen emulsions tested cost about $130 per ton more than Orimulsion ($50/ton). Therefore, from the economic and coal pellet performance points of view, the Orimulsion is considered as the best choice for use in the dewatering and pelletizing process.

5. Influence of Binder Concentration on Sulfur and Vanadium Contents:

   Illinois #5, Illinois #6, and Western Kentucky (TVA) coal were used to determine the effect of binder concentration on sulfur and vanadium content of coal pellets. As expected, the use of Orimulsion did not substantially increase the sulfur content of the coal pellets, see Table 6.. Even at binder concentrations of 5%, the sulfur concentration was increased by less than two tenths of one percent. According to the source information, Orimulsion has a vanadium concentration of 300ppm. When 5% Orimulsion was used for fine coal pelletizing, a 15ppm of vanadium concentration increase in the coal pellet was calculated. It is noteworthy that Orimulsion has being used as a fuel for power generation in the state of Florida and no environmental problems have been reported. Therefore, it is believed that less than 5% of Orimulsion usage will not cause environmental problems.

CONCLUSIONS AND RECOMMENDATIONS

1. Particle size only slightly affects the fine coal dewatering and pelletizing results. While smaller particle sizes offer a tightly interlocking internal structure, particle size gradation is also important.

2. Through the inexpensive treatment of coal pellets water discharge with lime additive, full compliance with all legislative guidelines can be achieved. This includes heavy metal concentrations, BOD, DO, and pH.

3. Coal particle charge plays an important role in the success of the dewatering and briquetting processes, when using bitumen emulsions as binding agent. In general, anionic binders give better pellet characteristics than cationic binders. Orimulsion produces results comparable to anionic emulsions and is recommended for use due to its cost effectiveness as explained in the previous reporting period.

4. The use of Orimulsion as a binding agent does not significantly increase the sulfur and vanadium contents of coal pellets. This is due to the small percentage by weight of Orimulsion used with respect to the amount of coal.

5. Further research will focus on optimizing the compaction machine design for manufacturing ultrafine coal pellets of acceptable moisture content. In addition, research will continue to explore the economic and technical feasibility of production scale equipment.

DISCLAIMER STATEMENTS

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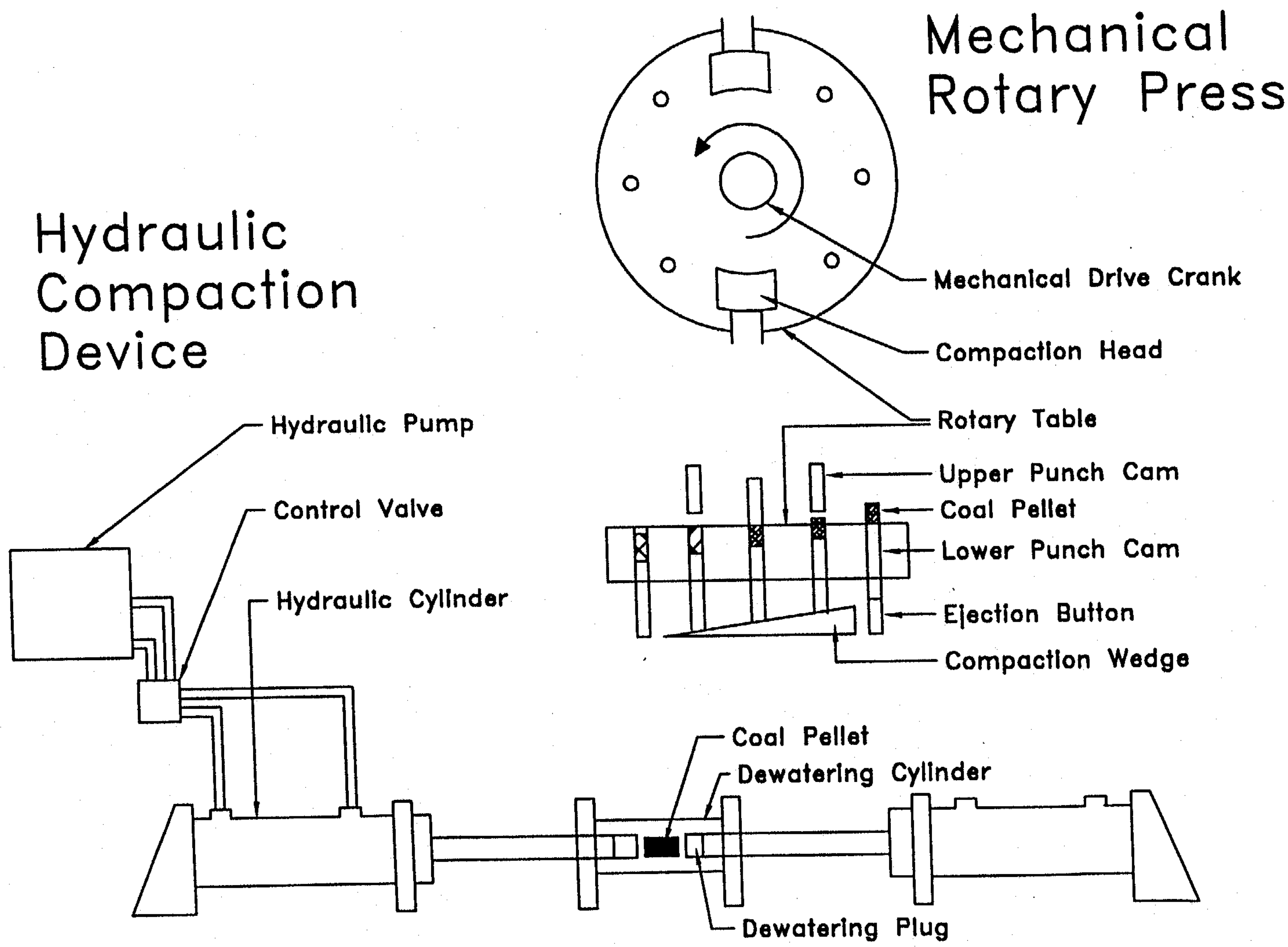

Figure 1. Comparison of Lab Scale Compaction Device and Rotary Press

Table 1. Influence of Particle Size on Coal Pellet Characteristics

Test Conditions: Ram Extruder
4,000-7,000 psi compaction pressure (3% Orimulsion)
2-5% Orimulsion (6,000 psi compaction pressure)
5-7 second compaction time
- 100M x 0 particle size

Compaction Pressure, psi	Curing Time, hr.	Init. Moist. Content, %	Cur. Moist. Content, %	Sat. Moist. Content, %	Wt. Loss 6-min, %
4000	8	20.1	11.1	21.9	13.7
	16	19.3	6.6	17.7	6.4
	24	19.1	5.2	14.5	5.2
5000	8	19.5	10.5	20.3	9.2
	16	19.8	6.8	15.8	5.0
	24	19.2	4.8	8.3	1.3
6000	8	19.1	10.0	19.5	7.1
	16	18.1	6.5	13.9	6.9
	24	18.9	4.9	9.1	2.0
7000	8	19.2	10.2	20.0	7.0
	16	18.0	7.7	12.0	4.9
	24	18.3	4.3	8.4	1.9

Binder Conc.,%	Curing Time, hr.	Init. Moist. Content, %	Cur. Moist. Content, %	Sat. Moist. Content, %	Wt. Loss 6-min, %
2	8	20.4	11.1	23.0	2.8
	16	20.0	9.7	17.8	5.5
	24	20.8	6.3	9.8	9.9
3	8	19.1	10.0	19.5	7.1
	16	18.1	6.5	13.9	6.9
	24	18.9	4.9	9.1	2.0
4	8	19.4	12.2	20.9	9.9
	16	19.1	8.8	16.6	6.9
	24	19.1	5.1	8.3	4.9
5	8	19.0	11.7	21.9	9.9
	16	18.8	7.7	14.3	4.4
	24	18.3	4.8	7.9	2.2

Table 2. Influence of Particle Size on Coal Pellet Characteristics

Test Conditions: Ram Extruder
4,000-7,000 psi compaction pressure (3% Orimulsion)
2-5% Orimulsion (6,000 psi compaction pressure)
5-7 second compaction time
28M x 100M particle size

Compaction Pressure, psi	Curing Time, hr.	Init. Moist. Content, %	Cur. Moist. Content, %	Sat. Moist. Content, %	Wt. Loss 6-min, %
4000	8	18.2	9.5	21.6	10.1
	16	18.1	8.6	15.7	17.5
	24	18.8	7.3	11.6	8.4
5000	8	16.7	10.2	21.6	9.7
	16	16.6	8.1	16.4	6.9
	24	17.7	6.6	11.5	4.7
6000	8	15.1	10.2	20.9	8.5
	16	16.0	8.3	17.4	8.5
	24	15.6	4.7	9.9	6.3
7000	8	15.3	10.4	21.4	13.3
	16	15.3	7.7	17.2	9.8
	24	14.6	2.9	9.4	4.1

Binder Conc.,%	Curing Time, hr.	Init. Moist. Content, %	Cur. Moist. Content, %	Sat. Moist. Content, %	Wt. Loss 6-min, %
2	8	15.1	11.0	21.5	9.3
	16	15.8	8.7	16.8	9.1
	24	15.1	4.1	9.0	7.9
3	8	15.1	10.2	20.9	6.3
	16	16.0	8.3	17.4	8.5
	24	15.6	4.7	9.9	8.5
4	8	14.2	10.9	19.7	4.1
	16	13.7	7.8	14.7	3.7
	24	13.3	5.4	9.1	2.1
5	8	12.5	9.4	18.6	2.8
	16	12.2	6.6	13.6	0.8
	24	12.4	1.5	7.1	0.8

Table 3. Influence of Particle Size on Coal Pellet Characteristics

Test Conditions: Ram Extruder
4,000-7,000 psi compaction pressure (3% Orimulsion)
2-5% Orimulsion (6,000 psi compaction pressure)
5-7 second compaction time
28M x 0 particle size

Compaction Pressure, psi	Curing Time, hr.	Init. Moist. Content, %	Cur. Moist. Content, %	Sat. Moist. Content, %	Wt. Loss 6-min, %
4000	8	15.9	9.3	15.9	3.2
	16	15.5	6.6	10.2	4.2
	24	15.4	6.7	9.3	3.8
5000	8	15.7	8.1	15.1	6.1
	16	15.3	6.9	10.6	4.6
	24	15.6	6.9	9.2	2.5
6000	8	15.2	9.7	16.0	5.0
	16	15.4	6.8	10.6	4.2
	24	15.2	6.9	9.6	3.6
7000	8	14.3	7.3	15.1	4.2
	16	14.1	6.7	10.8	3.2
	24	14.3	5.7	9.2	2.7

Binder Conc.,%	Curing Time, hr.	Init. Moist. Content, %	Cur. Moist. Content, %	Sat. Moist. Content, %	Wt. Loss 6-min, %
2	8	15.7	8.8	13.3	3.2
	16	15.2	5.9	14.1	6.4
	24	15.9	4.5	10.4	4.1
3	8	15.2	9.7	16.0	5.0
	16	15.4	6.9	10.6	3.6
	24	15.2	6.8	9.6	4.2
4	8	14.5	7.6	17.0	2.9
	16	14.5	7.2	14.0	2.5
	24	13.7	5.2	10.5	2.2
5	8	13.6	7.0	14.9	2.5
	16	13.4	4.6	13.2	2.5
	24	14.4	4.3	10.0	2.5

Table 4. Water Discharge Characteristics

	Federal Limits (mg/L)	Untreated Discharge (mg/L)	Lime Treated Discharge (mg/L)	Sodium Hydroxide Treated Discharge (mg/L)
BOD	<30			
DO	>5			
pH	6-9	1.8	7	7
Fe	<3.5	7000	3.3	3.0
Mn	<2.0	100	2.0	2.0
Cu	<1	9.0	trace	trace
Cr	<0.2	1.0	trace	trace
Zn	<1	1.2	trace	trace

Table 5. Pelletizing Characteristics of Anionic and Cationic Bitumen Emulsion Binders

Test Conditions:
Ram Extruder
6,000 psi compaction pressure
3% Orimulsion
5-7 second compaction time

Emulsion Type	Curing Time, hr.	Init. Moist. Content, %	Cur. Moist. Content, %	Sat. Moist. Content, %	Wt. Loss 6-min, %
Orimulsion	24	19.1	4.9	9.1	2.0
CRS-2	24	22.0	4.8	22.4	17.5
CRS-2P	24	22.0	5.2	22.7	15.3
MS-2M	24	19.8	3.2	12.6	9.2
SS-1H	24	18.6	3.7	6.7	5.7

Table 6. Effect of Binder Concentration on Sulfur Content

Test Conditions: Orimulsion contains 3.68% sulfur
Calculated value based on percents by weight

Calculated Values:

Orimulsion Conc.(%)	West. Kentucky(TVA)	Sulfur Content, % Illinois #5	Illinois #6
0	1.55%	1.42%	1.63%
2	1.59%	1.47%	1.67%
5	1.65%	1.53%	1.73%

Tested Values:

Orimulsion Conc.(%)	West. Kentucky(TVA)	Sulfur Content, % Illinois #5	Illinois #6
0	1.55	1.42	1.63
2	1.63	1.47	1.68
5	1.74	1.51	1.76

PROJECT MANAGEMENT REPORT
March 1 through May 31, 1995

Project Title: **ULTRAFINE COAL SINGLE STAGE DEWATERING AND BRIQUETTING PROCESS**

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Project Manager:	K. Ho, Illinois Clean Coal Institute

COMMENTS

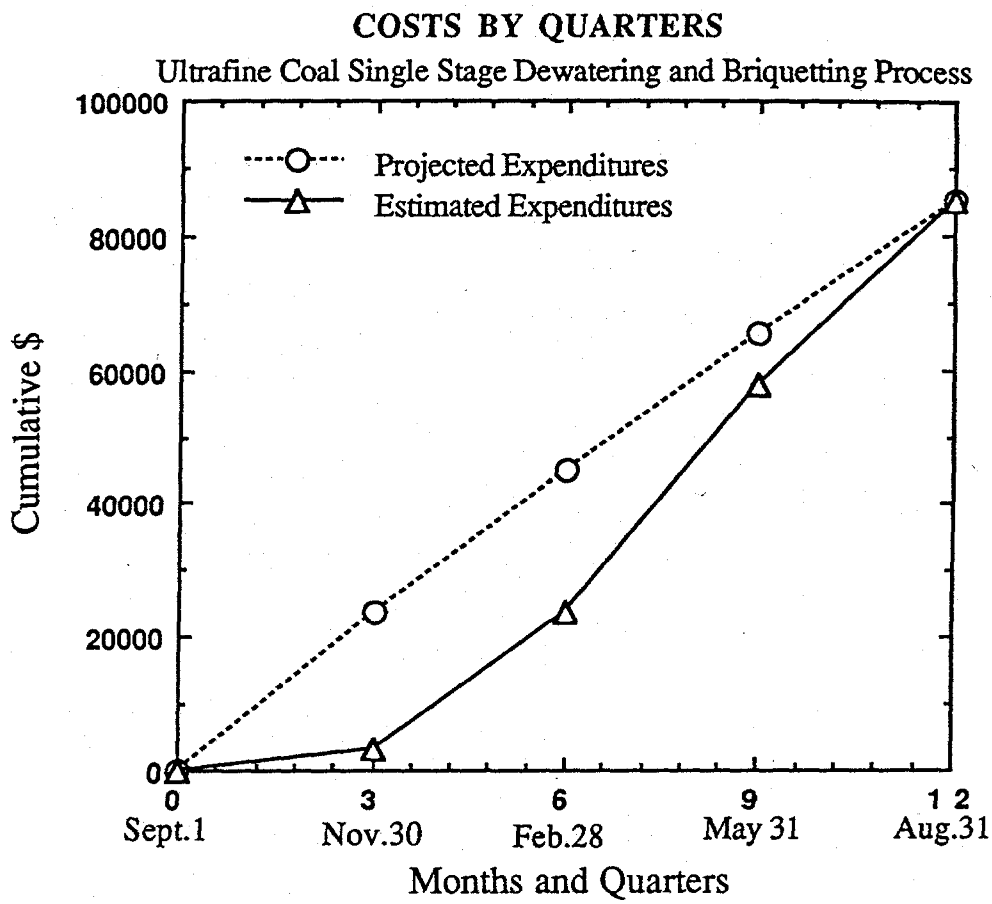
The projected and estimated expenditures for this project have been reevaluated and slightly redistributed. While this does not alter the overall budget, some changes have been made to the Projected and Estimated Expenditures by Quarter sheet found in this report. This is due in large part to the $13,374.54 subcontract payment made to SIU-Carbondale during this period.

In addition, a large portion of the Materials and Supplies budget was spent to construct a more sophisticated dewatering and briquetting machine. The resulting expenditures include a 15 horsepower Bosch motor and hydraulic pump, two directional control valves, two check valves, two hydraulic manifolds, a hydraulic cylinder, and dewatering cylinder. Several parts were salvaged from the existing lab scale dewatering and briquetting machine and were used for the new device. The remainder of the budget for materials and supplies will be spent on optimizing the new dewatering and briquetting machine.

Projected and Estimated Expenditures by Quarter

Quarter*	Types of Cost	Direct Labor	Fringe Benefits	Materials & Supplies	Travel	Major Equipm.	Other Direct Costs	Indirect Costs	Total
Sept. 1, 1994 to Nov. 30, 1994	Projected	$11,462	$1,703	$5,000	$625	$ -	$750	$4,260.75	$23,800.75
	Estimated	$ 2,035.61	$210.37	$94.86	$148.70	$ -	$17.15	$851.42	$ 3,391.94
Sept. 1, 1994 to Feb. 28, 1995	Projected	$22,925	$3,406	$7,500	$1,250	$ -	$1,500	$8,520.50	$45,101.50
	Estimated	$16,463.66	$1635.03	$698.27	$400.70	$ -	$39.19	$4,306.26	$23,543.21
Sept. 1, 1994 to May 31, 1995	Projected	$34,387	$5,109	$9,000	$1,875	$ -	$2,225	$12,780.25	$65,402.25
	Estimated	$27,924.65	$3,271.96	$4,862.20	$1,556.35	$ -	$111.15	$6,606.22	$57,707.07**
Sept. 1, 1994 to Aug. 31, 1995	Projected	$45,850	$6,812	$10,000	$2,500	$ -	$3,000	$17,041	$85,203
	Estimated	$44,634	$13,967	$9,000	$1,427	$ -	$1,975	$14,200	$85,203

***Cumulative by Quarter**
****Includes Payment of $13,374.54 to SIU for Subcontract**

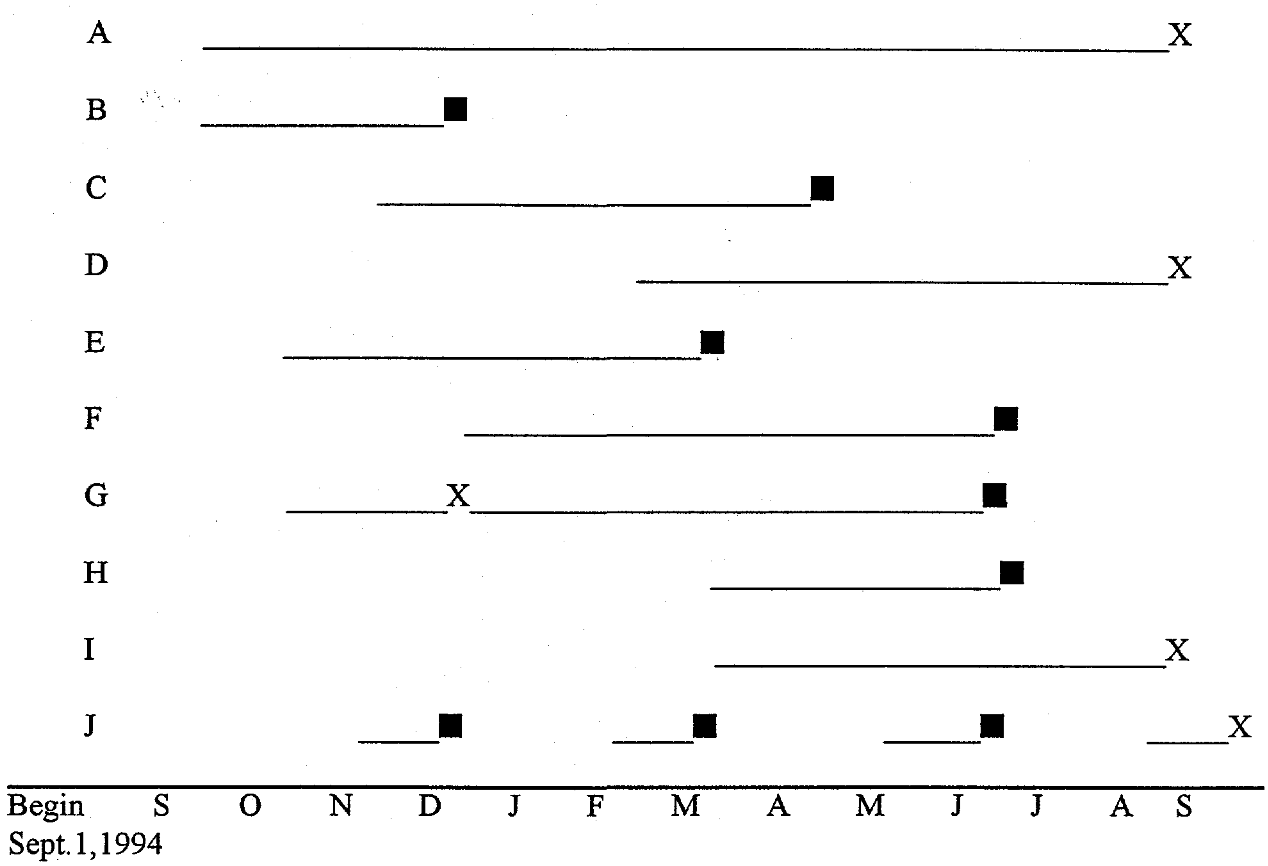


—O— = Project Expenditures

—Δ— = Estimated Expenditures

Total Illinois Clean Coal Institute Award = $85,203

SCHEDULE OF PROJECT MILESTONES



Major Milestones of the Project:

A. Research assistant employed.
B. Design and construction of compaction mold.
C. Design and construction of lab scale compaction device.
D. Design and construction of production scale compaction device.
E. Evaluation of binder concentration and compaction pressure on dewatering and briquetting of ultrafine coal.
F. Evaluation of curing time and particle size on dewatering and briquetting of ultrafine coal.
G. Evaluation of bitumen emulsions and coal surface properties on dewatering and briquetting of ultrafine coal.
H. Evaluation of binder concentration on pellet sulfur content and environmental impact studies of process discharge.
I. Evaluation of the possible impact of the proposed process on transportation methods, storage, handling, and combustion at the destination utility plant.
J. Technical and project management reports prepared and submitted.