DOE/PC/92521--T268

TECHNICAL REPORT
December 1, 1994 through February 28, 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
Principal Investigator:	J. W. Wilson, Department of Mining Engineering, University of Missouri-Rolla
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 they create problems in coal transportation as well as in its storage and handling at utility plants. The objective of this research project is to combine 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, two types of coal samples have been tested for use in the dewatering and briquetting processes. These tests were carried out using Orimulsion as the dewatering reagent. A ram extruder that can be operated continuously is used to fabricate dewatered pellets. The influence of compaction pressure, curing time, binder concentration (2% to 5%), particle size, and compacting time on the performance of coal pellets have been evaluated in terms of their water resistance and wear vulnerability.

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 wet physical coal cleaning process (column flotation). Because of the large surface area created by the ultrafine grinding operation, these ultrafine coal 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 coal 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.

Two types of coal samples, Illinois #6 (Arch Mineral) Coal and Western Kentucky coal, were used in this reporting quarter for the dewatering and briquetting process. The Illinois #5 coal from the Galatia Mine (Kerr McGee Co.) that was projected for use has been received from SIU-Carbondale and is currently being tested. These test results will be provided in the next quarterly report.

The Western Kentucky TVA coal was coal filter cake which had a moisture content of 28% and a particle size of 22.2% passing a 400 mesh screen. In order to prepare the coal for the dewatering and briquetting tests, a certain amount of water and Orimulsion was added into the coal sample to produce a coal-binder mixture that had a moisture content of 35%, which is equivalent to the moisture content of ultrafine coal filter cake normally obtained from a coal preparation plant. The Illinois #6 coal was ground to -100 mesh and mixed with Orimulsion to produce a coal-binder mixture with 33% moisture content.

The dewatering and briquetting process was completed using a lab-scale ram extruder. In order to evaluate the influence of compaction pressure on the dewatering efficiency and coal pellet strength, compaction pressures of 2,000 to 6,000 psi were applied in this process. For TVA coal, the coal pellet moisture content was reduced to between 19.5% and 12.2% (35% moisture content in the original coal-binder mixtures). Tests were also conducted at various compacting times ranging from 5 to 30 seconds. Pellets fabricated with the smaller particle size Illinois #6 coal were tested in a similar fashion. These pellets (-100 mesh particle size) performed better than similar pellets of larger particle size.

Tumbling tests were conducted at various pellet curing times (0, 2, 4, 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

OBJECTIVES

The objectives of this research project are to combine ultrafine coal dewatering and briquetting processes into a single stage operation using an hydrophobic binder as the dewatering and briquetting agent, and with the aid of 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 (-400 mesh) 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 products have a moisture content of less than 15% and possess high strength and water resistance that satisfies 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 particle size on the performance of coal pellets. Therefore, it was ground to -100 mesh before mixing with Orimulsion. The prepared sample which was used for pelletizing had a 33% moisture content.

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 repeated handling during their transportation, and handling at a utility plant. After 6 minutes in the tumbler, the percentage weight loss of the coal pellets were found to be between 10.9% and 4.6% as the compaction pressure was increased from 2,000 to 6,000 psi.

Water absorption tests were also conducted on pellets cured over various time periods (0, 2, 4, 8, 16, and 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 has shown that a curing period is required to build up the strength of coal pellets and to evaporate more water from the pellets, when bitumen emulsion is used as the binding agent. Thus, the moisture content of coal pellets made at various compaction pressures was measured at various time intervals, up to 24 hours. It was found that the moisture content of the coal pellets was reduced from 16% to 6% after 24 hours of curing period at ambient room temperature. In addition, coal pellets cured up to 24 hours absorbed lesser amounts of water when subsequently submerged for 24 hours.

Tested coal pellets were produced using a lab scale ram extruder. This dewatering and briquetting machine can be operated continuously using an hydraulic pump to provide the compaction pressure for 2" coal pellet fabrication. This machine will be further tested to optimize its operating parameters for the manufacture of ultrafine coal of acceptable moisture content and in a strong briquette form. A search for commercially available compacting and pelletizing machines is being conducted, in order to extend this process into production operation. Several commercial pelletizing machines, such as ram extruders, rotary presses, and roller presses, were found to have capacities that would handle a large scale operation. This search will be continued throughout this project period.

(5% of Orimulsion) by weight of dry coal was diluted with a certain amount of water. This diluted Orimulsion was then mixed with coal particles for 5 min. using a lab. scale mixer. This final coal-binder mixture has a moisture content of approximately 33%.

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 within the range of 2,000 to 6,000 psi. The setup of the dewatering and briquetting process is shown in Figure 1.

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 0, 2, 4, 8, and 24 hours.

The water absorption tests were carried out by submerging the coal pellets in water for 24 hours after a predetermined 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 weighed, the coal pellet is allowed to cure for between 0 and 24 hours. After curing, 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 jar 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 Compaction Pressure on Dewatering Efficiency:

In the previous reporting period, the effect of compaction pressure on the dewatering efficiency was evaluated over a range of 2,000 to 10,000 psi. For this reporting period, the lab scale ram extruder that can be operated continuously was used to compact the coal-binder mixtures at pressures varying from 2,750 to 5,500 psi. Due to a newly designed dewatering extruder gate valve, the coal-binder moisture content was reduced from 35% initially to nearly 15%, see Table 1.

2. Influence of Curing Time on Properties of Coal Pellets Produced Using Various Compacting Pressures:

TVA coal samples were pelletized at compaction pressures ranging from 2,750 to 5,500 psi and then allowed to cure for between 0 and 24 hours. As shown in Table 1, when the curing period increased from 0 to 24 hours at ambient room temperature the pellet moisture content was reduced from nearly 15% to under 5%.

Table 1 also includes information pertaining to the influence of curing time on water absorption. Pellets cured for less than 24 hours show a sizeable increase in moisture content when subsequently saturated. However, when allowed to cure for up to 24 hours, water absorption is not as prevalent.

Tumbling tests were carried out to evaluate the wear resistance of coal pellets by following the test procedures described in the Experimental Procedures section. The dewatered coal pellets were tumbled in the tumbler at a speed of 60 rpm. After 6 min. of tumbling, the percentage weight loss of the coal pellets was used to evaluate the wear resistance of the coal pellets. As shown in Table 2, the percentage weight loss of coal pellets was between 4% and 13 % as the curing time varied from 0 to 24 hours. The coal pellets tumbled immediately after pelletizing showed slightly better results. This may be a result of the higher plasticity of the moist, uncured pellets. Pellets which were allowed to cure for 2, 4, 8, and 24 hours showed approximately the same percentage of weight reduction regardless of compaction pressure.

3. Influence of Curing Time on Properties of Coal Pellets Produced Using Various Binder Concentrations:

The effect of curing time on the relative friability and water resistance of pellets was also examined for pellets fabricated at various binder concentrations. Table 3 shows the initial, cured, and saturated moisture contents of coal pellets made with binder concentrations ranging from 2% to 5%. Upon dewatering caused by pelletizing with the ram extruder, the moisture content of the coal-binder mixture was reduced from its initial 35% to less than 16%. Table 3 shows that a higher binder concentration results in coal pellets with lower initial moisture content.

When the coal pellets were allowed to cure for a period of 24 hours the pellet moisture content was reduced even further (less than 5%). Coal samples saturated after curing for 8 hours were found to have moisture contents of approximately 20%, while similar samples cured for 24 hours remained under 12% moisture after the absorption test. This indicates that a longer curing period can help increase the water resistance of coal pellets.

Table 4 shows the effect of curing time on the wear resistance of coal pellets made with various binder concentrations. From the tumbling test results, it can be seen that the percentage weight loss of coal pellets that were made at 2 to 5% binder concentration are all below 8%. The influence of curing time on these pellets was similar to that noticed on pellets compacted at various pressures. For coal pellets made without the addition of a binder, they completely disintegrated during the tumbling test. These test results show that the influence of binder concentration on the wear resistance of coal pellet is not as significant as its effect on water resistance.

4. Influence of Particle Size on Coal Pellet Characteristics:

In order to evaluate the influence of particle size distribution on the performance of coal pellets, Illinois #6 (-100 M x 0) coal were used to fabricate coal pellets for comparison with TVA (-30 M x 0) coal pellets. The resulting initial, cured, and saturated moisture contents are shown in Table 5. These pellets were allowed to cure for 12 hours prior to saturation. It can be seen from Table 5 that the initial and saturated moisture content of coal pellets made from -100 M x 0 coal sample are much lower than with the -30 M x 0 coal sample. This is believed to be due to the finer particle size have less void to entrap and absorb water. These test results suggest that a reduction in coal particle size can even further enhance the dewatering efficiency and water resistance of coal pellet.

5. Influence of Compacting Time on Coal Pellet Characteristics:

An initial study of the influence of compacting time on pelletizing was completed during this period for Illinois #6 Coal (-100 mesh). The amount of time in which the ram extruder applied a load was varied from 5 to 30 seconds. Pellets were then measured for their moisture content after a 20 hour curing period. As shown in Table

6, the moisture content of the coal pellets decreased from 17% to 11% as the compacting time increased from 5 to 30 seconds. After 20 hours of curing, the moisture content was reduced to less than 4%, regardless of compaction time. The tumbling test results show that the percentage weight loss of coal pellets decreased from 11.5% to 3% as the compaction time increased from 5 to 30 seconds.

5. Cost of Orimulsion used as the Dewatering and Briquetting agent:

As mentioned above, the Orimulsion used as the dewatering and briquetting agent possesses a high heating value. The actual binder cost must be calculated on the basis of the heating value of the coal pellet produced. The calculation of the actual binder costs are summarized in Table 7. The cost of Orimulsion increases from $0.76 to $1.90 as the Orimulsion concentration increase from 2 to 5%. This binder cost is acceptable when considering the overall process economics.

6. Design of a Dewatering and Briquetting Machine:

Over the previous reporting period, all coal pellets tested were fabricated using a lab type hydraulic press that can only provide an intermittent operation. In order to apply the continuous dewatering and briquetting process in practice, an hydraulic ram extruder has been designed and built for continuous operation. The setup and major components of this machine are illustrated in Figure 1. During this reporting period all pellets tested were produced using the lab scale ram extruder.

Several companies have been contacted in regard to the availability of production machines that are able to dewater and briquette ultra fine coal. These companies produce a variety of machines, from ram extrusion presses (Loomis Corporation) to rotary presses (Vector Corporation). Information is being collected from companies involved in other various pelletizing methods. Further information will be given in the next quarterly report and this study will continue to be updated throughout the project period.

CONCLUSIONS AND RECOMMENDATIONS

1. In addition to compaction pressure and binder concentration, pellet curing time is one of the most important factors to affect the dewatering efficiency of coal pellets fabricated when Orimulsion is used as a binding agent. During the curing period additional water can be evaporated from the coal pellets. Furthermore, a curing time of at least 24 hours results in a more water resistant coal pellet than those cured for less time.

2. Particle size also affects dewatering and briquetting results. Smaller particle sizes have resulted in stronger, more water resistant pellets. These smaller particle sizes allow

for a tighter particle interlock which gives the pellet its robust characteristics.

3. Curing time is also relevant in the determination of wear resistance. Although compaction pressure and binder concentration seem to have more importance with regard to coal pellet wear resistance, the effect of curing time can not be disregarded.

4. Further investigation will focus on optimizing the compaction machine design for manufacturing ultrafine coal pellets of acceptable moisture content. In addition, research will be carried out on the technical and economic feasibility of production scale equipment

DISCLAIMER STATEMENTS

Ultrafine Coal Dewatering and Pelletizing Procedure

1. Load coal sample into dewatering cylinder. At this point the dewatering gate (12 micron retention) is fastened to the discharge end of the dewatering cylinder.

2. With dewatering gate closed, apply compacting pressure with the ram piston to the coal sample. In this model a hydraulic pump and cylinder acts on the piston, applying pressures up to 10,000 psi to the coal sample. Water is expelled through the dewatering gate and pelletizing occurs.

3. The dewatering gate is opened and the piston ejects the coal pellet. The hydraulic cylinder is then used to retreat the piston and the dewatering gate is closed. The machine has now been returned to its initial station.

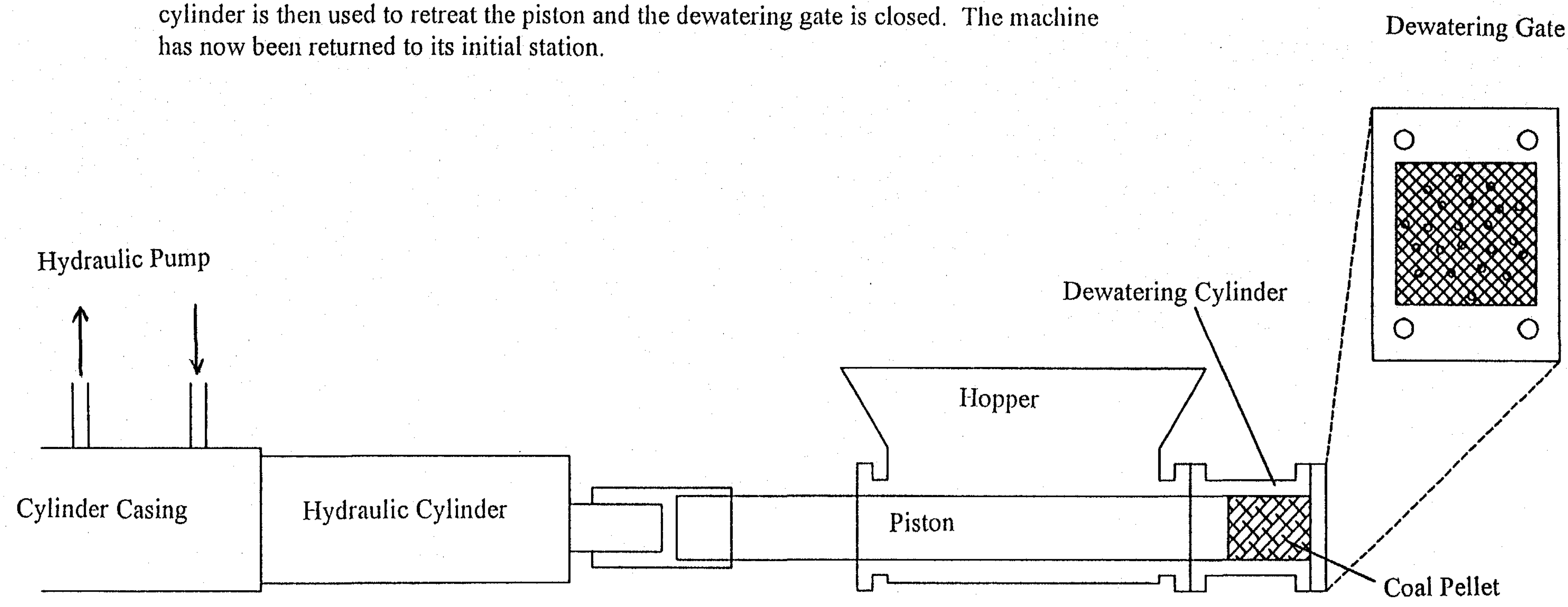

Figure 1. Lab Scale Ram Extruder Illustrating Dewatering and Pelletizing Procedure

Table 1. Influence of Compaction Pressure on Water Resistance

Test Conditions: Ram Extruder
2,756 - 5,513 psi compaction pressure
3% Orimulsion
30 sec. Compaction time

Compaction Pressure, psi	Curing Time, hr.	Initial Moist. Content, %	Cured Moist. Content, %	Saturated Moist. Content, %
2756	0	17.89	17.89	24.13
	2	18.09	15.81	23.21
	4	17.72	12.80	23.09
	8	17.58	9.21	22.80
	24	17.26	4.55	11.90
3675	0	16.17	16.17	22.56
	2	15.59	14.04	22.22
	4	15.70	11.22	22.05
	8	16.17	8.25	21.55
	24	15.88	4.51	11.31
4594	0	15.14	15.14	22.17
	2	14.84	13.03	21.97
	4	15.18	11.27	21.95
	8	15.76	8.55	20.91
	24	15.07	4.34	10.14
5513	0	14.75	14.75	21.80
	2	15.22	12.13	21.70
	4	14.80	10.38	21.22
	8	14.81	7.83	19.98
	24	14.77	3.95	9.64

Table 2. Influence of Compaction Pressure on Weight Reduction

Test Conditions: Ram Extruder
2,756 - 5,513 psi compaction pressure
3% Orimulsion
30 sec. Compaction time

Compaction Pressure (psi)	Curing Time (hours)	Weight Reduction (percent)
2756	0	4.56
	2	9.34
	4	11.31
	8	12.79
	24	9.17
3675	0	2.27
	2	11.12
	4	12.17
	8	7.19
	24	8.66
4594	0	7.29
	2	3.14
	4	7.53
	8	7.12
	24	9.87
5513	0	5.69
	2	4.83
	4	7.42
	8	7.08
	24	7.89

Table 3. Influence of Orimulsion Concentration on Water Resistance

Test Conditions: Ram Extruder
5,513 psi compaction pressure
2 -5% Orimulsion
30 sec. Compaction time

Orimulsion Conc., %	Curing Time, hr.	Initial Moist. Content, %	Cured Moist. Content, %	Saturated Moist. Content, %
2	0	15.91	15.91	23.19
	2	16.63	13.80	22.60
	4	15.75	12.60	22.05
	8	15.74	8.35	20.34
	24	15.88	4.83	12.05
3	0	14.75	14.75	21.80
	2	15.22	12.13	21.70
	4	14.80	10.38	21.22
	8	14.81	7.83	19.98
	24	14.77	3.95	9.64
4	0	13.94	13.94	20.51
	2	13.89	11.61	19.95
	4	13.99	9.86	19.49
	8	14.37	8.63	19.21
	24	13.90	4.07	9.39
5	0	13.64	13.64	20.73
	2	14.24	11.90	20.34
	4	13.33	8.74	19.28
	8	13.71	7.45	17.67
	24	13.88	4.01	9.34

Table 4. Influence of Orimulsion Concentration on Weight Reduction

Test Conditions: Ram Extruder
5,513 psi compaction pressure
2 -5% Orimulsion
30 sec. Compaction time

Orimulsion Concentration (percent)	Curing Time (hours)	Weight Reduction (percent)
2	0	4.55
	2	6.66
	4	6.22
	8	5.81
	24	3.91
3	0	5.69
	2	4.83
	4	7.42
	8	7.08
	24	7.89
4	0	2.78
	2	3.74
	4	5.31
	8	5.79
	24	2.48
5	0	1.82
	2	2.43
	4	2.85
	8	2.62
	24	2.41

Table 5. Influence of Particle Size on Water Resistance

Test Conditions: Ram Extruder
2,756 - 5,513 psi compaction pressure
3% Orimulsion
30 sec. Compaction time

Compaction Pressure, psi	Curing Time, hr.	Initial Moist. Content, %	Cured Moist. Content, %	Saturated Moist. Content, %
Arch #6 -100M x 0				
5513	12	10.97	6.70	9.06
4594	12	11.17	7.10	9.96
3675	12	12.31	8.50	10.86
2756	12	13.84	9.14	11.35
TVA -30M x 0				
5513	12	14.87	6.75	18.10
4954	12	15.18	7.20	19.05
3675	12	15.70	7.45	20.95
2756	12	17.72	7.50	22.43

Table 6. Influence of Compaction Time on Water Resistance

Test Conditions: Ram Extruder
5,513 psi compaction pressure
3% Orimulsion
5-30 sec. Compaction time

Compaction Time, seconds	Curing Time, hr.	Initial Moist. Content, %	Cured Moist. Content, %	Tumbling Wt. Loss, %
5	20	16.80	3.60	11.54
10	20	14.87	3.90	8.24
15	20	12.86	3.64	5.88
20	20	12.09	2.64	4.23
25	20	11.36	3.10	2.91
30	20	10.97	3.05	2.85

Table 7. Influence of Binder Concentration on Actual Binder Cost

Assume the heating value of Illinois coal to be 11,600 BTU/lb, that is, 23.2 MBTU/ton
Mining cost: $20/ton, or, $0.862/MBTU
Heating value of Orimulsion: 18,000 BTU/lb
Cost of Orimulsion: $70/ton (solid)
2% Orimulsion coal pellet: 23.46MBTU/ton at $21/ton, that is, $0.895/MBTU
Therefore, the actual binder cost will be $0.895-$0.862 = $0.033/MBTU

Binder Conc., %	0	2	3	4	5
Coal pellet, $/MBTU	0.862	0.895	0.911	0.928	0.944
Binder cost, $/MBTU	0.000	0.033	0.049	0.066	0.082
Coal pellet, $/ton	20.00	20.76	21.15	21.53	21.90
Binder cost, $/ton of coal	0.000	0.76	1.15	1.53	1.90

PROJECT MANAGEMENT REPORT

December 1, 1994 through February 28, 1995

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DOE Cooperative Agreement Number:	DE-FC22-92PC92521(Year 3)
ICCI Project Number:	91-1/1.1A-2P
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Project Manager:	K. Ho, Illinois Clean Coal Institute

COMMENTS

The projected cost for materials and supplies was $7,500 for the first and second quarter of this project. Only minor adjustments have been made to the lab scale ram extruder, therefore the cost for materials and supplies was only $725. The cost saved thus far has been set aside for future use.

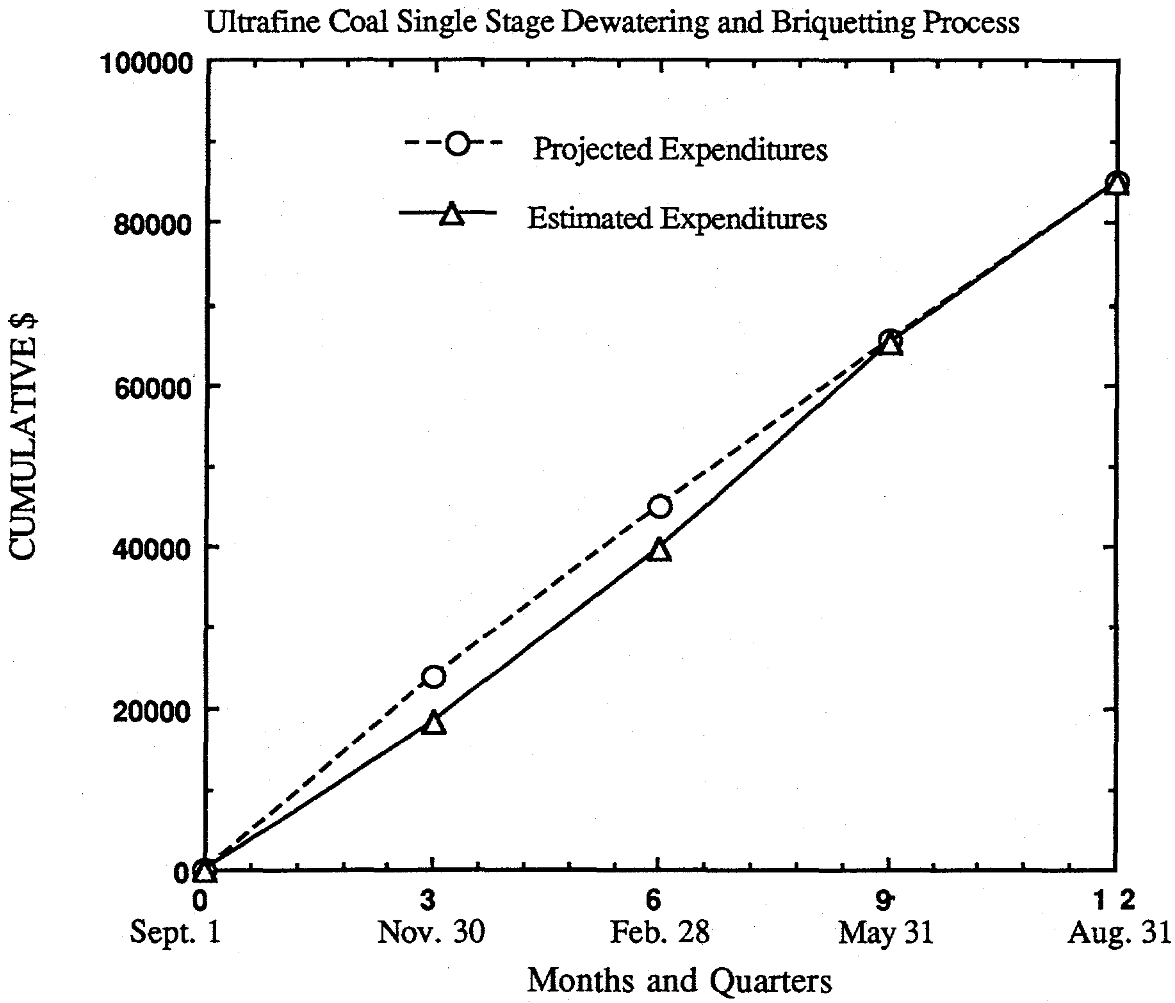
The remainder of the budget for materials and supplies will be spent on a more sophisticated dewatering and briquetting machine. The construction of this new machine will involve retooling of an existing production device and be based on the prototype ram extruder. Therefore a large part of the budget will be used in the following quarter.

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	$11,158	$3,491	$250	$148	$ -	$325	$2,773	$18,147
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	$22,317	$6,984	$722.55	$148.70	$ -	$875	$8,693.30	$39,740.55
Sept. 1, 1994 to May 31, 1995	Projected	$34,387	$5,109	$9,000	$1,875	$ -	$2,251	$12,780.25	$65,402.25
	Estimated	$33,476	$10,474	$8,000	$1,002	$ -	$1,425	$10,876	$65,253
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**

COSTS BY QUARTERS

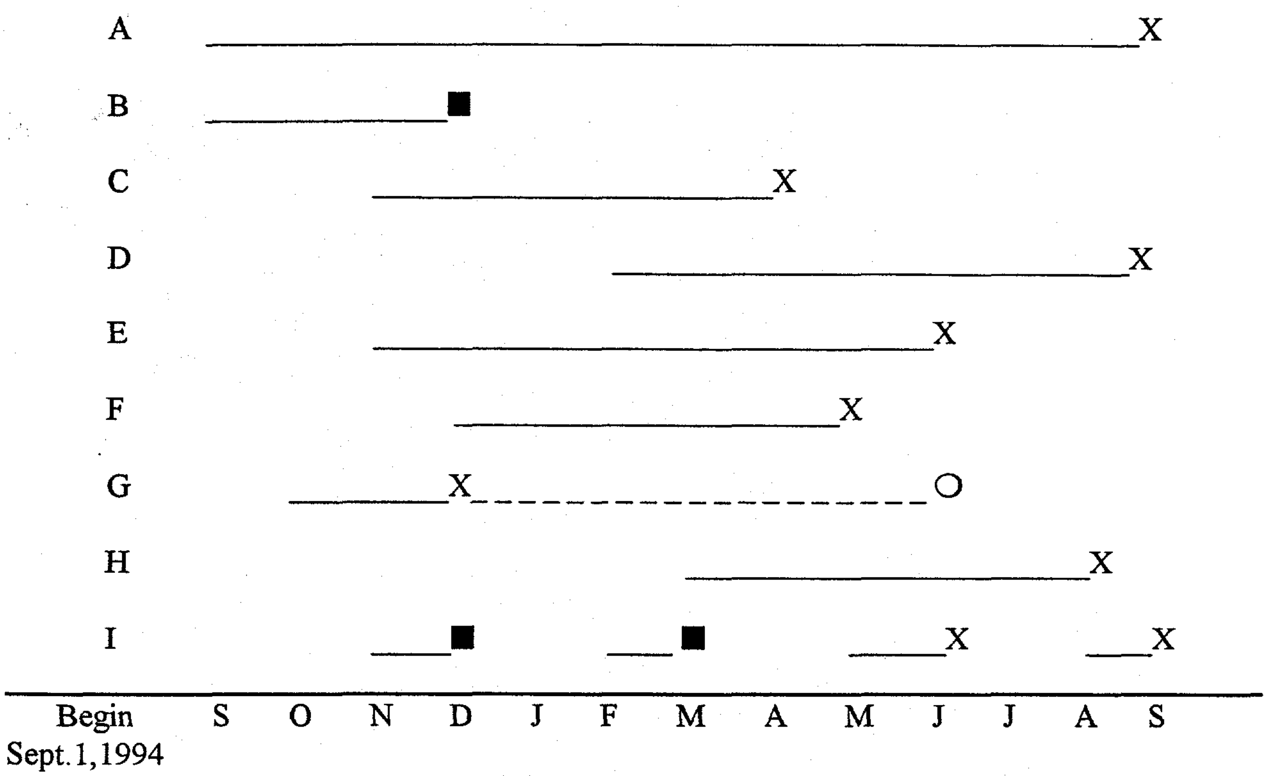


—O— = Project Expenditures

—△— = 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 the possible impact of the proposed process on coal transportation methods, storage, handling, and combustion at the destination utility plant.
I. Technical and project management reports prepared and submitted.

Comments:

Evaluation of coal surface properties on dewatering and briquetting of ultrafine coal has been delayed due to the reconstruction of the preparation plant at the Galatia Mine. Pending arrival, Illinois Harrisburg No. 5 coal will be tested in regard to surface properties.