DOE/PC/92521--T256

TECHNICAL REPORT
December 1, 1994 through February 28, 1995

Project Title: **A FINE COAL CIRCUITRY STUDY USING COLUMN FLOTATION AND GRAVITY SEPARATION**

DOE Cooperative Agreement Number: DE-FC22-92PC92521 (Year 3)
ICCI Project Number: 94-1/1.1A-1P
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ABSTRACT

Column flotation provides excellent recovery of ultrafine coal while producing low ash content concentrates. However, column flotation is not efficient for treating fine coal containing significant amounts of mixed-phase particles. Fortunately, enhanced gravity separation has proved to have the ability to treat the mixed-phased particles more effectively. A disadvantage of gravity separation is that ultrafine clay particles are not easily rejected. Thus, a combination of these two technologies may provide a circuit that maximizes both the ash and sulfur rejection that can be achieved by physical coal cleaning while maintaining a high energy recovery. This project is studying the potential of using different combinations of gravity separators, i.e., a Floatex hydrosizer and a Falcon Concentrator, and a proven flotation column, which will be selected based on previous studies by the principle investigator.

During this reporting period, an in-plant Box-Behnken test program of the Floatex hydrosizer has been conducted at Kerr-McGee's Galatia preparation plant. The results have shown that the Floatex hydrosizer can be successfully used to reject most of coarser (+100 mesh) pyrite and mineral matter in the coal stream to the plant. With a single operation, ash rejection of 63% and total sulfur rejection of 43% have been achieved while maintaining a combustible recovery as high as 90.5%. A long term duration test under the optimum operating conditions determined from Box-Behnken test results has also been conducted. The feed samples for the following enhanced gravity - column flotation studies, which will be carried out in the next reporting period, have been collected.

EXECUTIVE SUMMARY

The Illinois coal industry is facing the potential loss of 25% of its coal market as a result of the sulfur dioxide emission restrictions contained in the Clean Air Act Amendment of 1990. Phase I of the Clean Air Act will begin in 1995, with more severe Phase II limits beginning in year 2000. Thus, it has never been more important than the present to develop pre-combustion coal cleaning strategies that will maximize the amount of sulfur and ash that can be rejected from a given coal while maintaining high energy recovery values. In this research project, a fine coal circuitry study will be conducted using advanced fine coal cleaning technologies in an effort to identify a circuit that will provide the best separation efficiency at a high mass flow rate.

The circuit arrangement that is commonly used to treat the fine coal (28 M x 0) in today's coal preparation plants utilizes coal spiral concentrators and conventional froth flotation. In this circuit, the coal spirals are used to treat the 28 x 100 mesh size fraction while the 100 x 0 mesh size fraction is treated using conventional flotation. However, despite its wide acceptance, this circuit has some inherent problems. Due to the low throughput of each spiral unit (4-5 tph) and its separation inefficiencies, a large number of spiral units are needed, thus, requiring a relatively large amount of floor space to treat a given mass throughput. In addition, the method of controlling the separation performance from each spiral makes it difficult to optimize product quality and energy recovery. The disadvantages of conventional flotation includes its inability to effectively recover ultrafine coal particles and reject finely dispersed clay particles.

Recently, column flotation and enhanced gravity concentration has received a great deal of attention for the treatment of fine coal. Column flotation provides excellent recovery of ultrafine coal while producing low ash content concentrates. However, like other flotation processes, column flotation is not efficient for treating fine coal containing significant amounts of mixed-phase particles. Current studies have shown that mixed-phased particles can be more effectively treated using enhanced gravity separators. A disadvantage of gravity separators is that ultrafine clay particles are not easily rejected. Thus, a combination of these two technologies may provide a circuit that maximizes both the ash and sulfur rejection that can be achieved by physical coal cleaning while maintaining a high energy recovery.

The work in the research project will be conducted in two phases. In the first phase, a proven flotation column and an enhanced gravity separator will be used individually or in combination to treat an Illinois No. 5 flotation feed (100 M x 0). The second phase involves a circuitry study for the treatment of a fine coal circuit feed (28 M x 0). In this circuit, a Floatex hydrosizer will be tested as a pre-cleaner to the advanced fine coal cleaning technologies. Past studies have found that the Floatex provides an economical and efficient rejection of the coarser gangue particles in the fine coal, thereby, unloading the downstream processes by as much as 54%. In addition, screening the Floatex overflow which contains coarse coal particles, fine coal particles, and fine gangue particles produces

a final clean coal product. In the Phase II circuit, the screen underflow is subsequently treated by either a flotation column or enhanced gravity separator.

The flotation column that provides the best separation efficiency at the highest possible throughput will be used for the tests based on the conclusions from last year's ICCI project. Considering the operation convenience and separation performance, the Falcon concentrator will be used for the circuitry experiments.

In the first phase of this project, the flotation feed sample will be first treated using column flotation, which will generate a recovery-ash or sulfur content relationship that equals or exceeds the release analysis results. The optimum parameter values used in the column comparison project will be used in the column tests. To generate the recovery-grade relationships, the critical parameter that slides the column result up-and-down the ultimate curve will be varied while the others are maintained at their optimum values.

Centrifugal washer tests using the Falcon C10 Concentrator (about 4 tph) will also be conducted on the flotation feed sample. As with the column test, the goal will be to obtain the best possible recovery versus grade relationship. The results will be compared to release and washability results obtained for the flotation feed sample. Desliming of the concentrate (overflow) will be tested since clays tend to be dispersed in both streams.

Past research conducted by Yoon and Luttrell (1993) has found that enhanced gravity separators (i.e., Multi-Gravity Separator, Carpco) are effective at rejecting the coal pyrite reporting to froth concentrates (i.e., Microcel flotation column) as middling particles. Thus, to demonstrate this on other separators, a column flotation test will be conducted utilizing the optimum parameter values corresponding to its maximum separation efficiency. The froth concentrate will be collected and retreated in the Falcon C10 gravity separator under conditions which provide for maximum pyritic sulfur rejection. In addition, research conducted at SIUC has shown that the Falcon Concentrator is effective at rejecting coal pyrite and fine mineral matter. However, clay slimes tend to be dispersed in both the underflow and overflow streams. Column flotation is an excellent process for treating materials containing clay slimes. Therefore, the Falcon C10 unit will be tested as a precleaner to column flotation.

In the second phase, Floatex hydrosizer tests will be conducted on the fine coal circuit feed (16 x 0 mesh) at Kerr-McGee's Galatia preparation plant. The goal of the initial experiments will be to determine the optimum elutriation water rate and the screen size to produce coarser clean coal product. The optimum elutriation water rate will be used to collect the samples for the flotation column and enhanced gravity separator experiments.

The screen underflow from the Floatex circuit will be treated in a number of different circuitry arrangements utilizing enhanced gravity separation or column flotation in combination and separately. Complete proximate analyses to obtain the total sulfur, ash, and BTU content will be conducted on all products generated from each circuit.

In summary, the goal of this research project is to improve the efficiency of fine coal cleaning and maximize sulfur and ash rejection using column flotation and enhanced gravity separation, either in combination or separately.

During this reporting period, a in-plant Box-Behnken test program of the Floatex hydrosizer has been conducted at Kerr-McGee's Galatia preparation plant. The results have shown that the Floatex hydrosizer can be successfully used to reject most of coarser (+100 mesh) pyrite and mineral matter in the coal stream to the plant. With a single operation, ash rejection of 63% and total sulfur rejection of 43% have been achieved while maintaining a combustible recovery as high as 90.5%. A long term duration test under the optimum operating conditions determined from Box-Behnken test results has also been conducted. The feed samples for the following enhanced gravity - column flotation studies, which will be carried out in the next reporting period, have been collected.

During the next reporting period, the samples collected from the Floatex overflow at Kerr McGee's Galatia preparation plant will be classified using a suitable screen size so that the screen overflow will be final clean coal product. The screen underflow will be treated in the Falcon C10 concentrator and by column flotation.

OBJECTIVES

The goal of this project is to improve the efficiency of fine coal cleaning and maximize sulfur and ash rejection using column flotation and enhanced gravity separation, either in combination or separately. In light of this goal, the project objectives are:

1. To determine the circuitry arrangement, which uses column flotation and/or enhanced gravity separation, that will provide maximum pyritic sulfur and ash rejection while achieving high BTU recovery values for the treatment of flotation feed (-100 mesh);

2. To evaluate the feasibility of using a Floatex hydrosizer for achieving significant ash and pyritic sulfur rejection and a clean coal product prior to column flotation and enhanced gravity separation;

3. To identify the fine coal circuit, which may involve a combination of a Floatex hydrosizer, column flotation, and enhanced gravity separation, that will provide efficient cleaning with maximum pyritic sulfur and ash rejection for the treatment fine coal circuit feed (-16 mesh).

These objectives are to be achieved through the following tasks:

Task 1: Treat An Illinois No. 5 flotation feed coal sample (-100 mesh) with column flotation and enhanced Gravity Separation separately or in different combination.

Task 2: Conduct Floatex tests with the fine coal circuit feed (16 x 0 mesh) at Kerr-McGee's Galatia preparation plant.

Task 3: Treat the screen underflow from the Floatex circuit (Task 2) in the Falcon C10 concentrator.

Task 4: Treat the screen underflow from the Floatex circuit (Task 2) by column flotation.

Task 5: Test two different circuit arrangements. The first circuit will involve the treatment of the screen underflow from the Floatex circuit (Task 2) by column flotation followed by the Falcon C10 concentrator. The second circuit will treat the same material by Falcon C10 concentrator and then by column flotation.

Task 6: Prepare quarterly and final reports.

INTRODUCTION AND BACKGROUND

The treatment of the fine coal fraction (28 M x 0) in a number of today's preparation plants generally involves the use of both coal spiral concentrators and conventional flotation. The spiral concentrators are used to treat the 28 x 100 mesh size fraction while conventional flotation is commonly used to treat the 100 x 0 mesh size fraction (Figure 1). There are a few plants that simply discard the 100 x 0 mesh size fraction due to its insignificant quantity, inability of the flotation process to meet product grade requirements, and/or the high moisture content of the final coal product.

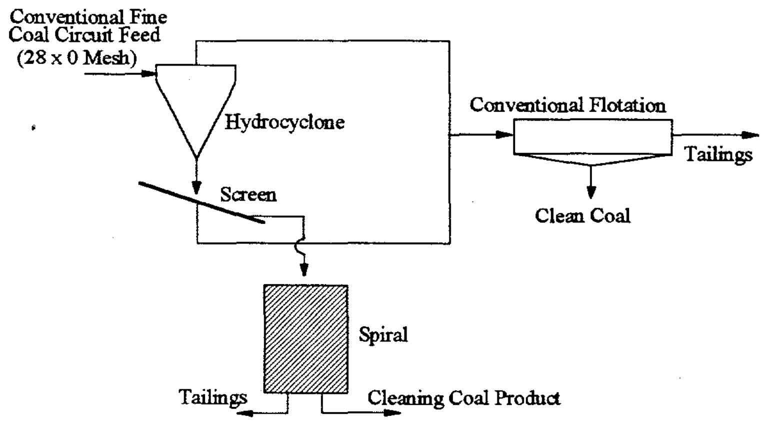

Figure 1. The conventional fine coal processing circuit.

One of the most important developments in fine coal cleaning in the 1980's was the development of spiral concentrators, a gravity-based separation method, made specifically for coal applications. Their popularity among coal preparation plant personnel is very high due to their operational simplicity and cheap cost. However, the throughput of each spiral is relatively low (i.e., 4 - 5 tph) which results in the requirement of a large number of spirals to treat a typical plant mass flow rate. This results in a large floor space requirement. In addition, due to the inefficiencies associated with spirals, secondary treatment of the primary spiral middling is commonly practiced (Bethell, 1988). The splitter position control for separation performance combined with the large number of spirals required makes spirals very difficult for plant operators to effectively control the final product grade and coal recovery. This is especially true when fluctuations in feed rate, feed solids content, and feed grade are quite common.

The treatment of the ultrafine coal fraction (100 M x 0) in today's coal preparation plants is generally limited to froth flotation. Conventional flotation, which is the most commonly used flotation method, has proven to be very successful for treating fine particle fractions from several coal seams. Unfortunately, conventional flotation becomes ineffective when the particle size is very small or when the flotation pulp contains a large amount of finely dispersed clay or silicious gangue. Small hydrophobic particles, such as fine coal, have a low probability of collision with air bubbles, resulting in a low recovery (Yoon and Luttrell, 1989; Reay and Ratcliff, 1973; Sutherland, 1948). In addition, fine mineral matter particles are entrained into the froth product along with the process water, resulting in poor selectivity (Engelbrecht, and Woodburn, 1975; Bishop and White, 1976; Lynch et al., 1981). When processing the fine particles in a typical flotation feed, both of these problems must be resolved to obtain the desired separation performance.

A solution to the entrainment problem is the use of flotation columns. In such devices, the smaller cross-sectional area provides the support needed for deeper froths as compared to those found in conventional flotation. Wash water is added to the froth phase to create a net downward flow of water so that the flow of pulp water to the froth phase is prevented. As a result, entrained gangue particles entering the flotation froth are rejected back into the pulp phase. Therefore, flotation columns can be used to obtain high product quality.

There are several flotation column technologies commercially available. The largest difference in these technologies is their method of bubble generation. In general, the generation of small bubble sizes produced by these technologies is controlled by increasing the shear rate at the bubble nucleation point. The importance of small bubbles in flotation having size D_b can be realized by the following equation:

in which P_c is the probability of bubble-particle collision, D_p the particle diameter, and

$$P_c \propto \left(\frac{D_p}{D_b}\right)^n, \qquad [1]$$

n equals 2 for most flotation conditions. Equation [1] suggests that the probability of bubble-particle collision decreases at a given bubble size as particle size is reduced, thereby, decreasing recovery. A solution to this problem is to use smaller bubbles to treat ultrafine particles. Conventional flotation machines provide bubble sizes much larger than those produced by the flotation columns. Therefore, by using column flotation, smaller bubbles can be generated to improve combustible recovery and wash water can be applied directly to the froth phase to improve the grade of the final products.

However, a disadvantage of column flotation and any other froth flotation process is their inability to effectively treat fine coal containing a large portion of mixed-phase particles. The reason for this inefficiency is due to the non-selective nature of the flotation process towards middling particles. For instance, a particle that contains as little as 10% coal on its surface and, thus, represents a high ash content particle, has a good chance to report to the flotation product as a result of bubble attachment to the coal portion of the particle surface. Therefore, achieving a high combustible recovery value for coal fines containing a large amount of middling particles results in high product ash and sulfur content values. Also, producing a low product ash and sulfur content concentrate results in a low combustible recovery.

The inability to treat the middling particles may be part of the explanation for the low pyritic sulfur rejections achieved by froth flotation. Past research has found that the pyrite and ash-forming minerals in some coals are not well liberated even at micronized sizes (Hsieh and Wert, 1983; Kneller and Maxwell, 1985; Adel et al., 1989; Remesh and Somasundaran, 1990). In a study by Zitterbart et al. (1985), only approximately 45% of the pyritic sulfur was found to be completely liberated in several Illinois No. 6 coal samples having a mean size of 600 μm. At a mean size of 100 μm, approximately 73% of the pyrite was liberated. Several other studies have found that the pyrite in Illinois Basin coals is finely dispersed within the coal matrix and, thus, is not completely liberated in the finest coal fraction. This indicates a large middling content in the fine fractions of these coals which results in poor selectivity using any froth flotation process (Adel et al., 1989; Wang et al., 1992).

Another possible explanation for the low pyritic sulfur rejection values achieved by flotation involves the natural hydrophobicity of the coal pyrite due to a sulfur-rich surface. This problem has been the topic of many research investigations and publications over the past two decades. The actual flotation mechanism of the pyrite is still being debated and researched in several laboratories across the country (Kawatra and Eisle, 1991; Yoon, 1992). To alleviate this problem, several new processing schemes have been suggested such as primary flotation of the coal followed by reverse flotation to float the pyrite from the coal using xanthates (Hucko and Miller, 1980). However, the operating costs of using this type of approach would be prohibitively high.

A better technical and economical means of treating fine coals that have a high middlings and/or pyrite content may be to use a gravity-based separation method. Past research compared the washability curves obtained from a laboratory centrifuge with the release curve generated from froth flotation and found that gravity-based processes are much more efficient than flotation at treating middling particles (Perry and Aplan, 1985; Luttrell, 1992; Wang, 1994). However, past full-scale gravity-based processes were ineffective for treating fine sizes due to a lack of particle inertia.

Over the past few years, several continuous enhanced gravity separators have been developed for the treatment of particles less than 28 mesh. These units include the Multi-Gravity Separator, the Knelson Concentrator, the Falcon Concentrator, and the Kelsey Jig. The advantages of the centrifugal washers over flotation columns are a larger mass throughput per cross-sectional area and a better rejection of pyritic sulfur. In comparison to spiral concentrators, a commercially-available centrifugal washer unit having a capacity of 40 tph can be used to replace several coal spirals. This reduces floor space requirements and allows for better process control.

Past research conducted on a Falcon Concentrator at Southern Illinois University has found that the separator was very effective at reducing the total sulfur content of a 28 x 0 Illinois No. 5 seam coal sample. Excellent ash rejections were also achieved down to a particle size of approximately 10 μm. The high ash content in the -10 μm fraction of the products indicated that significant quantities of sub-micron clay particles can not be separated from the clean coal particles using enhanced gravity separation. One possible solution to this problem is to possibly size the enhanced gravity separator overflow product using high-pressurized hydrocyclones to produce a final coarse clean coal product (say 28 x 200 mesh) and a fine stream that would be treated using column flotation. As a result, spiral concentrators would be eliminated and the number of flotation columns required minimized.

The current project will conduct circuitry testing which incorporates both enhanced gravity separation and column flotation in combination and separately. This study will be conducted on both a Illinois No. 5 fine coal circuit feed (16 M x 0) and a flotation feed (100 M x 0) from Kerr-McGee's Galatia Preparation Plant. In addition, a Floatex hydrosizer will be tested on the fine circuit feed to evaluate its ability to provide an initial rejection of ash-forming minerals and pyritic sulfur which will reduce the amount of material to be treated by down-stream processes.

EXPERIMENTAL PROCEDURE

During this reporting period, the Box-Behnken test program for the Floatex hydrosizer has been conducted at Kerr-McGee Coal Preparation plant in order to determine its potential as a precleaning equipment for this project as well as a substitute for the existing spirals in the plant. Three operating parameters were considered significant for achieving best possible separation performance, i.e., the feed flowrate, wash water flowrate, and bed level. Therefore, using a commercial computer software "Design-Expert", a plan with total 15 tests were arranged as shown in Table 1.

The work in the first phase of the test program was to run these 15 tests and analyze collected feed, overflow (product), and underflow (tailings) samples from each test. All these samples were screened into +100 and -100 mesh size fractions. Because the main objective of using Floatex hydrosizer is to reject coarser pyrite and mineral matter and keep the combustible recovery as high as possible, it was expected that the fine gangue particles can not be efficiently separated from coal particles under utilized wash water flowrate. Therefore, only +100 mesh size fractions were filtered, dried and weighed. Then, all these samples were analyzed for their ash and total sulfur contents.

Table 1 The Box-Behnken test program for the Floatex hydrosizer conducted at.

Obs	Run Ord	Blk	X1 Feed Rate gallon/min	X2 Wash Water gallon/min	X3 Level	Dsn ID
6	1	1	60	12	50	6
2	2	1	60	8	60	2
14	3	1	45	12	60	14
9	4	1	45	8	50	9
10	5	1	45	16	50	10
8	6	1	60	12	70	8
15	7	1	45	12	60	15
7	8	1	30	12	70	7
12	9	1	45	16	70	12
5	10	1	30	12	50	5
4	11	1	60	16	60	4
1	12	1	30	8	60	1
3	13	1	30	16	60	3
13	14	1	45	12	60	13
11	15	1	45	8	70	11

Based on the analysis results obtained, the ash rejection, total sulfur rejection, and combustible recovery were calculated for each test. These separation performance data were then served as responses in the software "Design-Expert" and three models were generated. The model-based optimization was further conducted with respect to each response.

After obtaining the optimized operating parameters, a long duration test was conducted using these parameters as the second phase of the test program. During this period, total 25 fifty-five gallon barrels overflow was collected continuously as the feed samples for the following circuitry tests. Also nine samples were also collected to test the stability and the yield of the Floatex hydrosizer.

RESULTS AND DISCUSSION

The results of the Floatex Box-Behnken test program are given in Table 2 and 3. As can be seen from Table 2, for the +100 mesh size fraction, a single Floatex operation can produce a coal product of 8 - 13% ash content from a feed stream of 17 - 28% ash content, which yield 44 - 87% ash rejection with 74 - 96% combustible recovery. One can also find the tailings containing as high as 73% ash content. For these tests, it was found that the average feed solids concentration is about 30.2% by weight and weight percent of the +100 mesh size fraction 76.3%.

Table 2 The Ash analysis results of Floatex Box-Behnken test for Kerr-McGee coal samples.

	Ash %			Ash Rej.	Comb. Rec.	S. E.
Test #	Feed	Product	Tailings	%	%	%
1	17.1	9.6	58.1	52.54	92.18	44.73
2	18.4	10.3	65.6	52.22	93.83	46.05
3	19.6	9.4	60.5	61.61	90.19	51.81
4	19.3	13.1	69.1	39.64	95.76	35.40
5	19.5	10.8	36.9	63.08	73.87	36.95
6	19.4	8.7	72.7	62.65	94.34	56.99
7	17.9	9.9	43.8	57.74	83.85	41.59
8	27.8	8.5	41.4	87.36	52.39	39.75
9	20.4	10.2	72.5	58.19	94.34	52.53
10	15.9	7.9	38.4	63.35	80.79	44.13
11	20.7	9.7	63.2	62.77	90.46	53.23
12	17.8	11	72.1	45.08	96.22	41.30
13	21.8	9.9	63.7	64.63	89.73	54.36
14	20.4	13.1	69.6	44.08	95.07	39.15
15	21.8	11.7	60.2	57.51	89.40	46.91

As the total sulfur content concerned, the total sulfur rejection data also appear to be satisfactory as shown in Table 3. This one stage separation reduced the total sulfur content from 2.0 - 2.6% to 1.6 - 2.0%, and in most of tests, tailings contain more than 4.5% total sulfur. By comparing the total sulfur rejection data with ash rejection data, it seems that most sulfur containing particles are too fine to be rejected as Floatex underflow. These kinds of particles will be further treated in the circuits consisting of enhanced gravity separation and approved flotation technique.

Figure 2 and 3 show the trends of the separation performance in terms of combustible recovery versus ash rejection and total sulfur rejection, respectively. From Figure 2 it can be seen that higher than 90% combustible recoveries can be achieved with about 60% ash content rejected. Figure 2 also tells us that the Floatex hydrosizer can be

Table 3 The total sulfur analysis results of Floatex Box-Behnken test for Kerr-McGee coal samples.

	Total Sulfur %			T.Sul.Rej.	Comb. Rec.
Test #	Feed	Product	Tailings	%	%
1	1.99	1.7	4.45	23.58	92.18
2	2.09	1.83	4.78	20.16	93.83
3	2.21	1.7	4.72	36.07	90.19
4	2.21	1.65	5.22	37.05	95.76
5	2.26	1.75	3.62	43.68	73.87
6	2.07	1.63	5.92	29.33	94.34
7	2.21	1.55	3.64	52.01	83.85
8	3.15	1.59	3.44	92.09	52.39
9	2.24	1.76	5.41	31.76	94.34
10	2.21	1.64	3.78	45.56	80.79
11	2.57	1.82	5.67	42.98	90.46
12	2.3	1.88	5.84	26.93	96.22
13	2.47	1.89	5.3	36.50	89.73
14	2.35	2	5.87	22.59	95.07
15	2.43	1.82	4.86	40.13	89.40

operated under a wide parameter ranges while achieving relatively stable separation performance. With respect to Figure 3, the typical total sulfur rejection is about 40% when about 90% combustible recovery required. As explained earlier, the Floatex hydrosizer itself can not be blamed for this not high total sulfur rejection.

The relationship between combustible recovery and product ash is described in Figure 4. A average feed ash Of 19.85% is used for the sake of comparison. As shown, the product ash can be reduced to about 9% with a combustible recovery above 95%.

Figure 5 shows that with a average feed containing 2.32% total sulfur, the Floatex hydrosizer can produce a product with about 1.70% total sulfur while maintaining combustible recovery higher than 95%. It is expected that after further treatments, almost all the pyritic sulfur in the final product of this project can be efficiently eliminated.

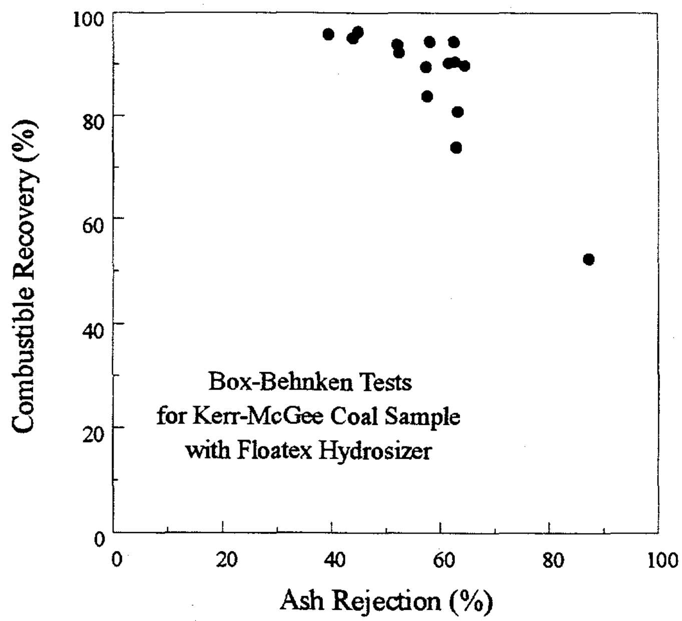

Figure 2 The Floatex hydrosizer separation performance in terms of combustible recovery versus ash rejection for Kerr-McGee coal sample.

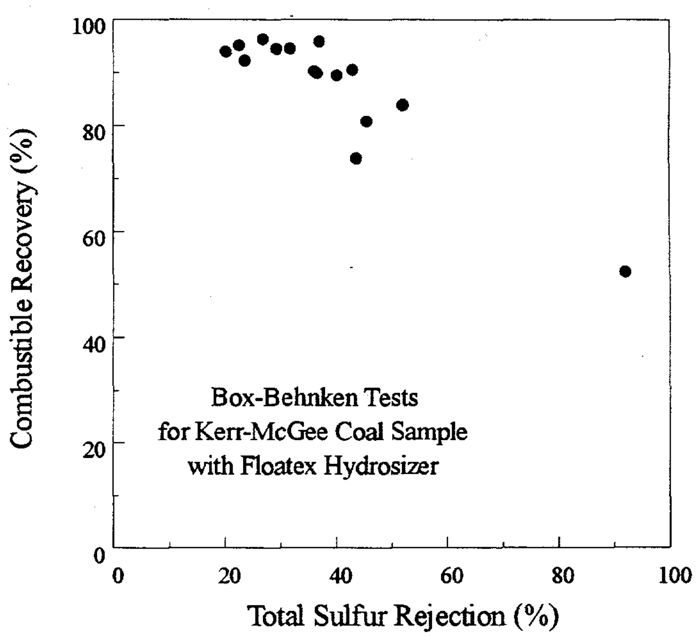

Figure 3 The Floatex hydrosizer separation performance in terms of combustible recovery versus total sulfur rejection for Kerr-McGee coal sample.

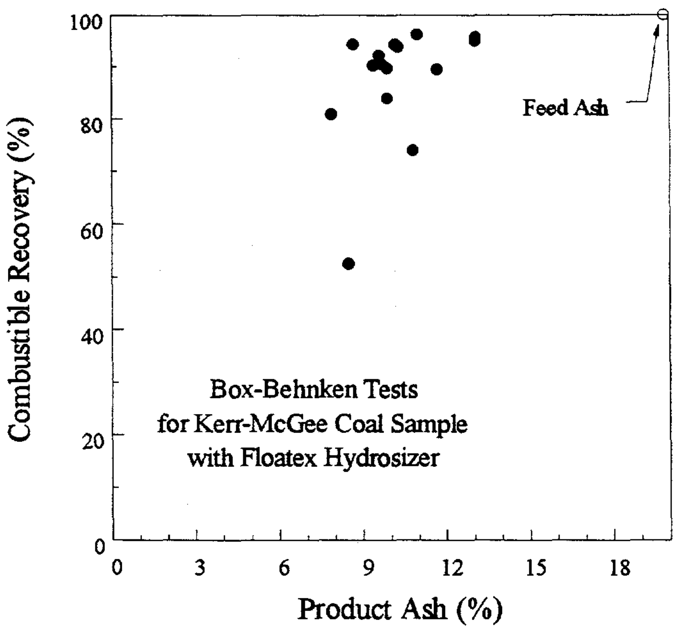

Figure 4 The Floatex hydrosizer separation performance in terms of combustible recovery versus product ash for Kerr-McGee coal sample.

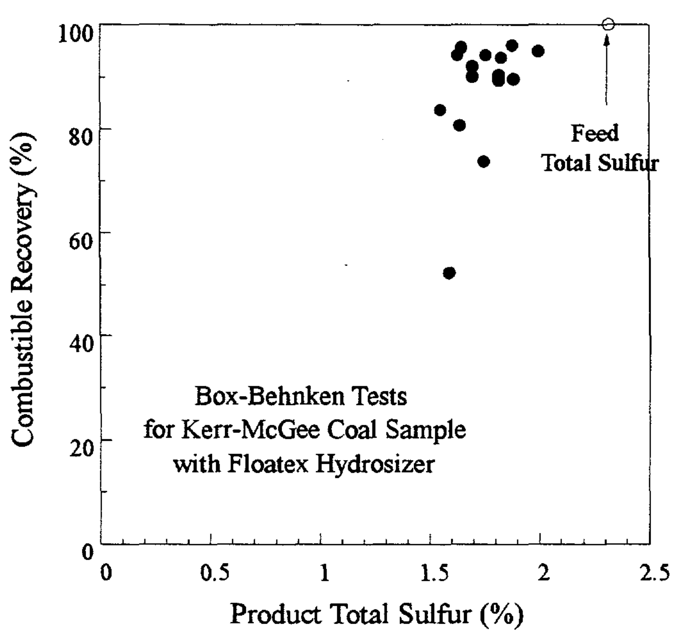

Figure 5 The Floatex hydrosizer separation performance in terms of combustible recovery versus product total sulfur for Kerr-McGee coal sample.

Based on the data shown in Table 2 and 3, four statistical models have been developed using the commercial computer software " Design Expert". The separation efficiency model was then used to determine the optimized operating parameters. The optimization results are given in Table 4.

Table 4 The optimum operating conditions determined by the Box-Behnken test program.

Based on	Feed Flowrate (gallon/min)	Wash Water (gallon/min)	Level
Ash Rejection	43	16	50
Total Sulfur Rejection	43	16	50
Combustible Recovery	30	12	64
Separation Efficiency	41.5	12	58.5

In order to investigate the effect of each operating parameter on the separation performance, the model-based simulations were carried out. The simulation results are illustrated in Figure 6 - 8, respectively. From Figure 6 it appears that ash rejection and total sulfur rejection increase with the increase of the feed flowrate initially, because increasing bed thickness weakens the strength of the upward wash water. However, when feed flowrate is larger than 45 gallons per minute, both ash rejection and total sulfur rejection decrease steadily, for which a short residence time of the feed stream may be responsible. On the other hand, it seems the feed flowrate has a relatively small effect on the combustible recovery.

As wash water flowrate concerned, it has an opposite effect on the separation performance compared to the feed flowrate as shown in Figure 7. At low wash water flowrate, particles containing pyrite and mineral matter have a better chance not to be "wash out" into the overflow stream, therefore, higher ash and total sulfur rejection can expected. With the increase of the wash water flowrate, some of these particles may "squeeze" themselves into the overflow stream. When wash water flowrate increases beyond 12 gallons per minute, the bed is further fluidized to such content that almost all the particles have a free path either going up into the overflow stream or settle down to be discharged as underflow. Therefore, the ash and total sulfur rejection increase again.

The effect of the bed level on the separation performance is shown in Figure 8. It is interesting to note that with the increase of the bed thickness, ash and total sulfur rejection decrease while combustible recovery increases steadily. This may be explained as that for certain feed and wash water flowrates, the thicker the bed is, the shorter the residence time. Therefore, more particles may bypass the separation zone.

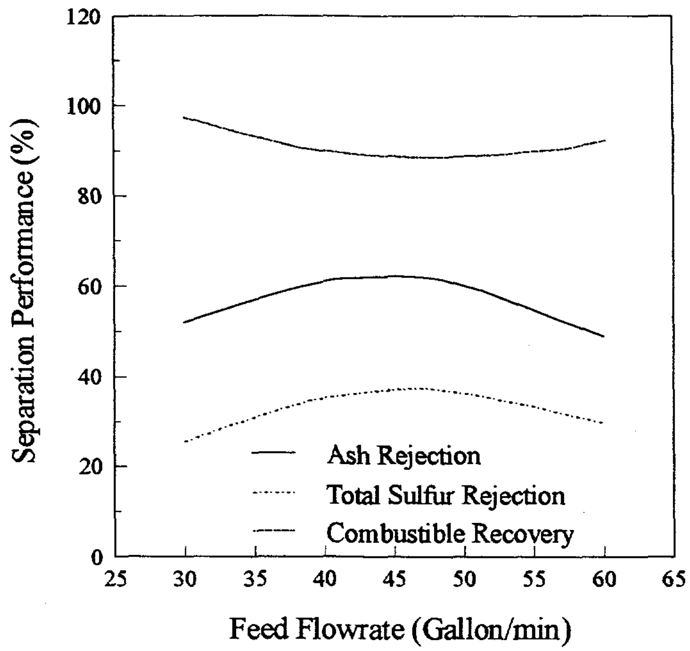

Figure 6 The Floatex hydrosizer simulation results of the effect of the feed flowrate on the separation performance for Kerr-McGee coal sample (wash water flowrate = 12 gallon/min., bed level = 58.5).

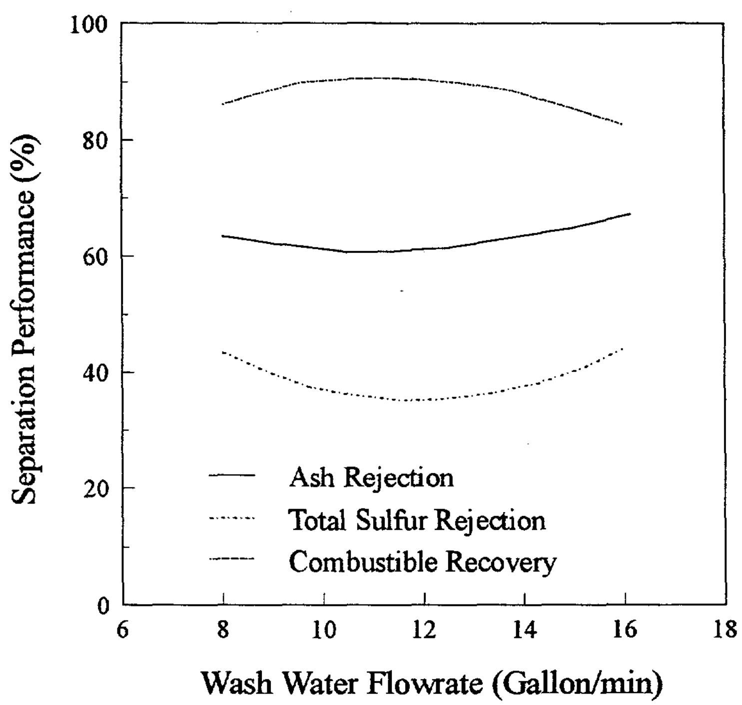

Figure 7 The Floatex hydrosizer simulation results of the effect of the wash water flowrate on the separation performance for Kerr-McGee coal sample (feed flowrate = 41.5 gallon/min., bed level = 58.5).

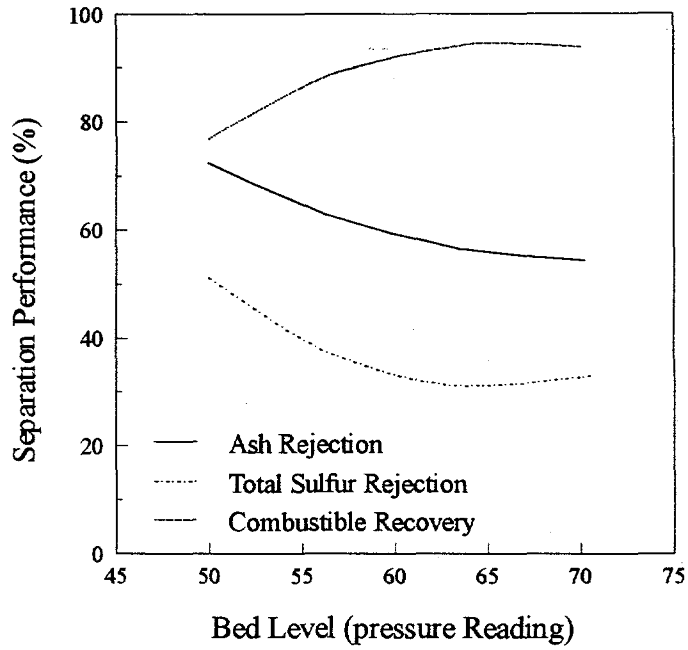

Figure 8 The Floatex hydrosizer simulation results of the effect of the bed level on the separation performance for Kerr-McGee coal sample (feed flowrate = 41.5 gallon/min., wash water = 12 gallon/min.).

The long term duration test is conducted under the optimum operating conditions given in Table 4 (based on separation efficiency) in order to collect the feed samples for the following processes and to test the stability of the Floatex hydrosizer. The results are given in Table 5. The data demonstrate again the excellent separation performance of the Floatex hydrosizer with a rather stable operating condition. During this test, the throughput is calculated as 3.6 ton solids per hour.

Table 5 The long term duration test conducted on the Floatex hydrosizer for Kerr-McGee coal sample.

	Ash (%)			Ash Rej.	Comb. Rec	Yield
Test #	Feed	Product	Tailings	(%)	(%)	(%)
50	19.3	10.7	70.3	52.56	94.69	85.57
51	19	10.01	62.5	56.34	92.071	82.873
52	21.65	9.84	65.23	64.24	90.538	78.678
53	20.98	10.11	63.51	61.62	90.6	79.644
54	19.8	10.2	62.6	57.92	91.456	81.679
55	21.41	10.18	66.28	61.97	91.411	79.982
56	21.05	10.4	62.96	60.6	90.494	79.737
57	21.3	9.9	63.8	63.35	90.271	78.85
58	21.72	10.24	64.57	62.82	90.436	78.87

CONCLUSIONS AND RECOMMENDATIONS

The following conclusions were obtained from the test results achieved during this reporting period:

1. The Floatex hydrosizer can be successfully used as a precleaning facility. Under optimum operating conditions, higher than 62% ash rejection and higher than 90% combustible recovery can be achieved with single stage operation. The throughput for the equipment used in this test is about 3.6 ton solids per hour.

2. The simulation results show that the bed thickness has a important effect on the separation performance. Although the feed flowrate and wash water flowrate have less significant effects compared to the bed level, they do have certain values that change the separation behavior.

3. the excellent separation performance and stability of the operation for the Floatex hydrosizer were further demonstrated through the long term duration test.

During the next reporting period, the samples collected from the Floatex overflow at Kerr McGee's Galatia preparation plant will be classified using a suitable screen size so that the screen overflow will be final clean coal product. The screen underflow will be treated in the Falcon C10 concentrator and by column flotation.

DISCLAIMER STATEMENTS

Energy. The views and opinions of authors expressed herein do not necessarily state or reflect those of the U. S. Department of Energy.

Notice to Journalists and Publishers: If you borrow information from any part of this report, you must include a statement about the DOE and Illinois cost-sharing support of the project.

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PROJECT MANAGEMENT REPORT
December 1, 1994 to February 28, 1995

Project Title: **A FINE COAL CIRCUITRY STUDY USING COLUMN FLOTATION AND GRAVITY SEPARATION**

DOE Cooperative Agreement Number:	DE-FC22-92PC92521 (Year 3)
ICCI Project Number:	94-1/1.1A-1P
Principal Investigator:	Ricky Q. Honaker, Department of Mining Engineering, Southern Illinois University at Carbondale
Other Investigators:	Stephen Reed, Kerr-McGee Coal Corporation
Project Manager:	Ken Ho, Illinois Clean Coal Institute

COMMENTS

The total project costs expended at the end of this reporting period is $40,942 which is less than the projected amount of $47,750. The travel expenses, major equipment cost and other direct costs are the most cost saving items.

The achievement of project milestones has been basically on schedule with the dates in the original milestone chart. The potential of using Floatex hydrosizer as precleaning equipment (Task 2) has been investigated. The samples for the following enhanced gravity, column flotation, and the circuits arranged by different combinations of these two technologies have been collected under the optimum operating conditions. During the next reporting period, the samples collected will be screened. The suitable screen size will be determined. The screen underflow will be treated by enhanced gravity and column flotation.

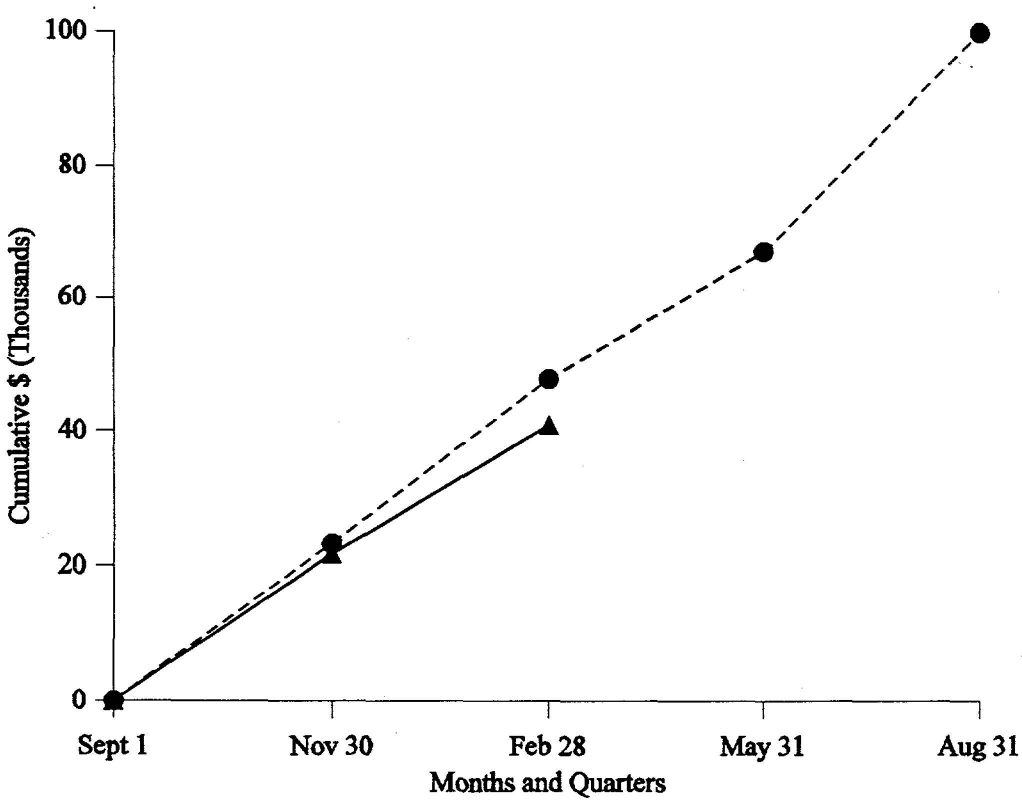
PROJECTED AND ESTIMATED EXPENDITURES BY QUARTER

Quarter*	Types of Cost	Direct Labor	Fringe Benefits	Materials and Supplies	Travel	Major Equipment	Other Direct Costs	Indirect Cost	Total
Sept. 1, 1994 to Nov. 30,1994	Projected	10,876	1,440	1,650	0	3,600	3,578	2,114	23,258
	Estimated	10,145	1,813	603	499	4,923	2,242	1,530	21,755
Sept. 1, 1994 to Feb. 28, 1995	Projected	21,753	2,881	3,300	1,200	7,200	7,075	4,341	47,750
	Estimated	21,541	3,013	2,547	450	5,084	4,938	3,369	40,942
Sept. 1, 1994 to May 31, 1995	Projected	32,629	4,321	4,950	1,200	7,200	10,653	6,065	67,018
	Estimated								
Sept. 1, 1994 to Aug. 31, 1995	Projected	53,335	7,726	6,600	1,700	7,200	14,150	9,071	99,782
	Estimated								

*Cumulative by Quarter

CUMULATIVE COSTS BY QUARTER

A Fine Coal Circuitry Study Using Column Flotation and Gravity Separation

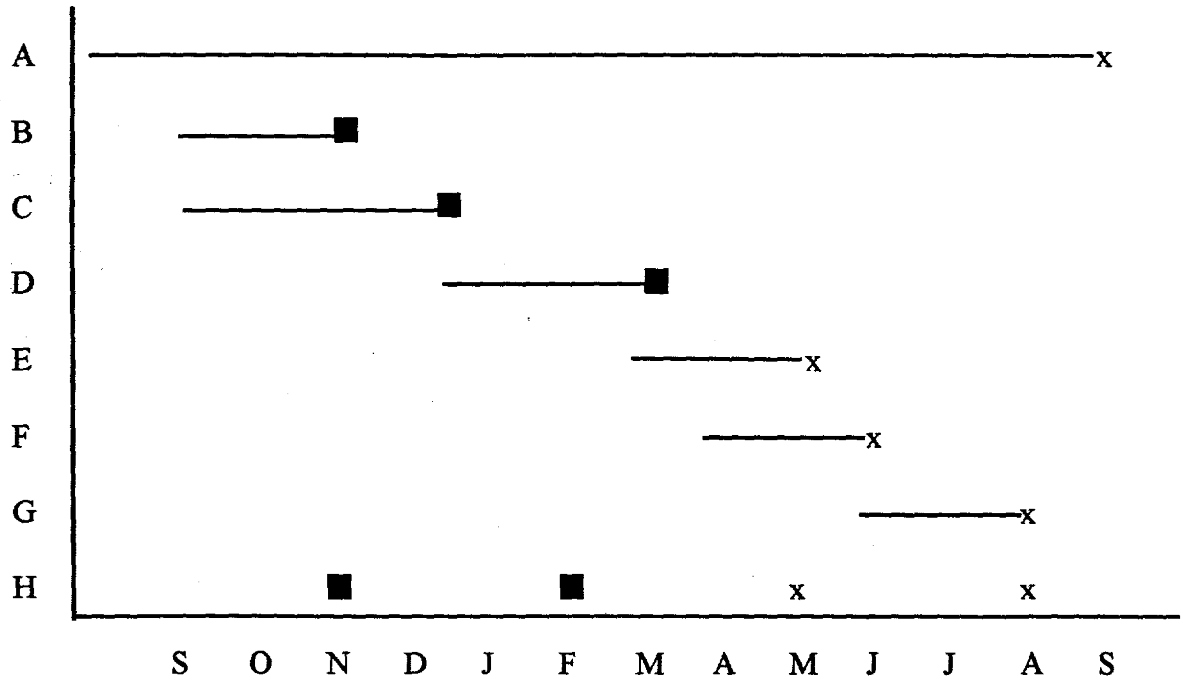


● = Projected Expenditures - - - - - - -
▲ = Actual Expenditures ________

Total Illinois Clean Coal Instutute Award $99,782

DISCLAIMER

SCHEDULE OF PROJECT MILESTONES



Begin
Sept. 1
1994

Hypothetical Milestones:

- A: Research assistants employed
- B: Equipment ordered and received
- C: Column flotation/Enhanced gravity separation (Task 1)
- D: Floatex testing (Task 2)
- E: Floatex/Enhanced gravity separation (Task 3)
- F: Floatex/Column flotation (Task 4)
- G: Floatex/Column flotation/Gravity separation (Task 5)
- H: Reporting (Task 6)