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QUARTERLY TECHNICAL PROGRESS REPORT 2
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ENGINEERING DEVELOPMENT OF ADVANCED PHYSICAL FINE COAL CLEANING FOR PREMIUM FUEL APPLICATIONS

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LEGAL NOTICE

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EXECUTIVE SUMMARY

This project is a step in the Department of Energy's program to show that ultra-clean fuel can be produced from selected coals and that the fuel will be a cost-effective replacement for oil and natural gas now fueling some of the boilers in this country.

The replacement of premium fossil fuels with coal can only be realized if retrofit costs are kept to a minimum and retrofit boiler emissions meet national goals for clean air. These concerns establish the specifications for maximum ash and sulfur levels and combustion properties of the ultra-clean coal.

The cost-sharing contract effort is for 48 months beginning September 30, 1992. This report discusses the technical progress made during the quarter from January 1 to March 31, 1993.

SPECIFIC OBJECTIVES OF PROJECT

The project has three major objectives:

- The primary objective is to develop the design base for prototype commercial advanced fine coal cleaning facilities capable of producing ultra-clean coals suitable for conversion to coal-water slurry fuel. The fine coal cleaning technologies are advanced column flotation and selective agglomeration.

- A secondary objective is to develop the design base for near-term commercial integration of advanced fine coal cleaning technologies in new or existing coal preparation plants for economically and efficiently processing minus 28-mesh coal fines.

- A third objective is to determine the distribution of toxic trace elements between clean coal and refuse when applying the advance column flotation and selective agglomeration technologies.

APPROACH

The project team consists of Amax Research & Development Center (Amax R&D), Amax Coal Industries, Bechtel Corporation, Center for Applied Energy Research (CAER) of the University of Kentucky, and Arcanum Corporation. Dr. Douglas Keller is a consultant to the project.

The engineering development effort has been divided into four phases which are further divided into eleven tasks, including coal selection, laboratory and bench-scale process optimization, design, construction, and operation of a 1.8 tonne/hour process development unit (PDU). Tonnage quantities of the ultra-clean coals will be produced in the PDU for combustion testing by the DOE. Near-term applications of advanced cleaning technologies to existing coal preparation plants will also be studied.

ACCOMPLISHMENTS DURING QUARTER

Task 2. Coal Selection and Procurement

Truckload quantities of five coals were acquired for use during the first phase of the project. The five, all bituminous washed coals representative of the normal production from the respective mines, were as follows:

Coal Seam	Mine	State	Ash, %	Sulfur, %
Taggart	Wentz	Virginia	2.07	0.62
Indiana VII	Minnehaha	Indiana	9.25	0.49
Sunnyside	Sunnyside	Utah	5.11	0.63
Winifrede	Sandlick	West Virginia	8.42	0.94
Elkhorn No. 3	Chapperal	Kentucky	6.04	0.86

These coal were selected from the twenty or more considered because of their availability, geographic diversity, low organic sulfur content, and good liberation of ash minerals. The five coals have been crushed, sampled, and stored at Amax R&D. Detailed characterization studies are in progress on samples of each of the five coals.

One more test coal, to be a low-rank coal, remains to be chosen. Subbituminous coals from the Powder River Basin are being considered for this selection.

Task 3. Development of Near-Term Applications

Two near-term applications for advanced fine coal cleaning technologies have been identified in Amax Coal Industries' preparation plants. The two applications are:

- Production of additional amounts of quality clean coal at the Ayrshire plant (Indiana) by processing fine refuse slurry now being discarded. The additional production would off-set some of the low-sulfur blend coal now being purchased.
- Installation of one of the advanced technologies in place of mechanical cell flotation during the scheduled 1994 expansion of the Lady Dunn plant (West

Virginia). Cost and operating improvements would be gained by the substitution.

Laboratory testing has been conducted on samples of the feed slurries for both applications. Positive test results have been obtained in the laboratory, and Bechtel is conducting an engineering analysis to determine the feasibility of each application.

Task 4. Engineering Development of Advanced Froth Flotation for Premium Fuels

A draft test plan was submitted for conduct of the Subtask 4.1 grinding study. Laboratory testing is proposed to determine the amount of grinding required to liberate sufficient impurities from the test coals in order to meet premium fuel specifications. Continuous testing of open-, closed-, and selective-grinding circuit configurations are scheduled so that an optimized system may be installed for the advanced froth flotation PDU operation. The liberation testing has started and arrangements are being made for the continuous grinding tests at Amax R&D using available and rented equipment.

Task 6. Selective Agglomeration Laboratory Research and Engineering Development for Premium Fuels

Agglomeration Agent Selection

A comparison study was made for selection of candidate bridging liquids using published information. Two distinct agglomeration processes were considered during this study. The two were recovery systems and non-recovery systems. Normal pentane and normal heptane appear to be the best candidates when the bridging liquid is recovered for reuse, and high flash-point naphtha and asphalt-diesel mixture appear the best when the bridging liquid remains in the product and not reused. These agglomerating agent evaluations were based upon safety and environmental issues, expected performance for recovering coal and rejecting ash and pyrite, the ease of preparation of slurry fuel from the recovered coal, and the expected costs associated with their use. A draft topical report is under preparation which will recommend the selection of agglomerating agents for the program.

Grinding

A draft work plan was submitted for conduct of the Subtask 6.2 grinding study. Laboratory batch and continuous testing is proposed to determine the amount of grinding required to liberate sufficient impurities from the test coals in order to meet the premium fuels specifications. The grinding activities scheduled for the selective agglomeration tasks will be coordinated with the advanced froth flotation grinding work to avoid duplication of effort.

INTRODUCTION/BACKGROUND

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

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

The cost-shared contract effort is for 48 months beginning September 30, 1992, and ending September 30, 1996. This report discusses the technical progress made during the second 3 months of the project, January 1 to March 31, 1993.

SPECIFIC OBJECTIVES OF PROJECT

The three major objectives of this project are discussed below.

The primary objective is to develop, by FY 1997, the design base for prototype commercial advanced fine coal cleaning facilities capable of producing ultra-clean coals suitable for conversion to stable, highly loaded coal-water slurry fuels which contain less than 860 grams ash per gigajoule HHV and preferably less than 430 grams ash per gigajoule HHV and less than 258 grams of sulfur per gigajoule HHV. These amounts are equivalent to the 2 pounds of ash and preferably less than 1 pound of ash per million Btu HHV and less than 0.6 pound of sulfur per million Btu HHV stated in the solicitation. The advanced fine coal cleaning technologies to be employed are advanced column froth flotation and selective agglomeration. Operating conditions during the advanced cleaning processes will allow recovery of at least 80 percent of the Btus in run-of-mine source coals at an annualized cost of less than \$2.37 per gigajoule (\$2.50 per million Btu), including the mine mouth cost of the raw coal.

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

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

APPROACH

A team headed by Amax Research & Development Center (Amax R&D) was formed to accomplish the project objectives. Amax R&D is managing the project and also providing laboratory and pilot plant facilities and expertise in the areas of coal characterization and coal slurry fuel preparation. Amax Coal Industries will provide operating and coal marketing experience and some of the coals to be used during the program. Bechtel Corporation will provide engineering and design capabilities and the operating experience it gained while managing similar proof-of-concept projects for the DOE. The Center for Applied Energy Research (CAER) at the University of Kentucky will provide research and operating experience in the column flotation area, and Arcanum Corporation will provide similar experience in the selective agglomeration area. Dr. Douglas Keller will serve as a consultant in the area of coal source selection and selective agglomeration. Figure 1 shows the project organization chart.

The overall engineering development effort has been divided into four phases with specific activities as follows:

Phase I encompasses preparation of a detailed Project Work Plan, selection and acquisition of the test coals, and laboratory and bench-scale testing. The laboratory and bench-scale work will be to determine the cleaning potential of the selected coals and to establish design parameters and operating guidelines for a process development unit (PDU) containing advanced column flotation and selective agglomeration modules. A conceptual engineering design will be prepared for a fully integrated and instrumented 1.8-tonne/hour PDU incorporating the features determined from the laboratory and bench-scale studies. A generic approach will be followed during the laboratory studies for selection of the flotation and agglomeration systems for the PDU which will best meet project objectives.

The properties of slurry fuels prepared from the ultra-clean coals also will be determined during Phase I, and test lots of ultra-clean coals will be prepared by

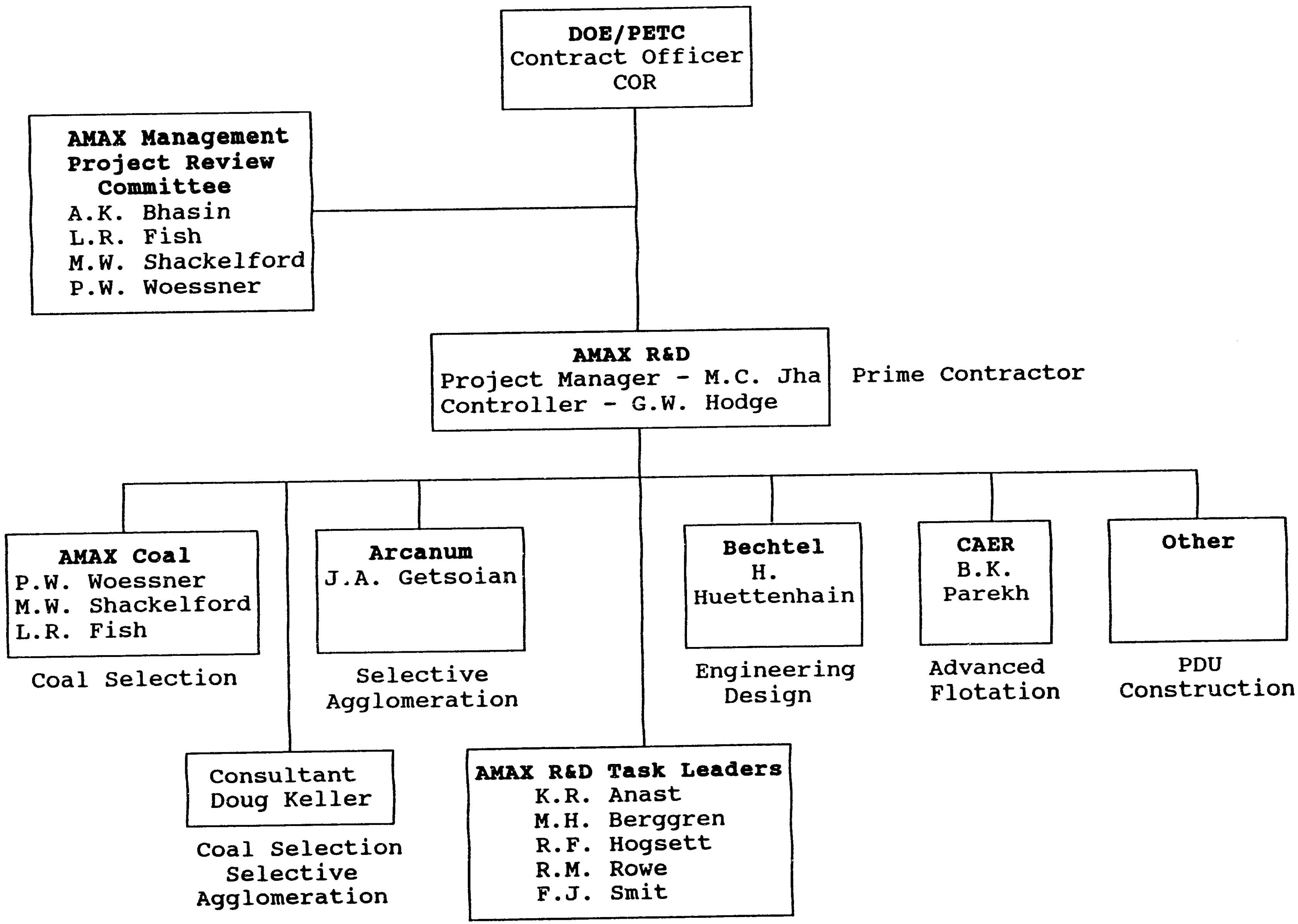


Figure 1. Project management organization chart.

bench-scale column flotation and bench-scale selective agglomeration for end-use testing by the DOE. The distribution of toxic trace elements will be determined during production of these test lots.

In addition, methods for applying the advanced cleaning technologies in existing coal preparation plants in the near term will be studied during Phase I.

Phases II and III cover the construction and operation of the 1.8-tonne/hour PDU. Phase II will be for advanced column flotation and Phase III will be for selective agglomeration. Process performance will be optimized at the PDU-scale, and 180-tonne lots of ultra-clean coal will be prepared by column flotation and selective agglomeration from each of three test coals. Toxic trace element distributions will also be determined during the production runs. The ultra-clean coals will be delivered to the DOE for end-use testing.

In addition and as part of Phases II and III, existing preparation plant streams will be tested in the PDU to determine the performance of the advanced column flotation and selective agglomeration technologies for near-term applications.

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

ACCOMPLISHMENTS DURING QUARTER

As shown in the Work Breakdown Structure (Table 1), the four phases of the project have been further divided into tasks and subtasks. Each task and subtask has specific objectives which can be inferred from its title. Work was done on Tasks 2, 3, 4, and 6 during the January 1 to March 31, 1993, quarterly reporting period.

TASK 2. COAL SELECTION AND PROCUREMENT

Successful accomplishment of the project objectives will depend upon selection of suitable source coals since not all United States coals are likely to be acceptable feedstock for preparation of premium fuel. Economic factors also restrict interest in some coals because of their limited availability or remote location. On the other hand, the significance of the project in terms of providing important alternative sources of retrofit boiler fuel will be substantially enhanced if a diverse set of potential source coals were investigated at this stage. Thus, Task 2, for the selection, acquisition and characterization of six test coals for use during Phase I, is a significant part of the project. The test coals are selected specifically for Task 4, Engineering Development of Advanced Froth Flotation for Premium Fuels, and for Task 6, Selective Agglomeration Laboratory Research and Engineering Development for Premium Fuels.

Subtask 2.1. Coal Selection Plan

A draft coal selection plan was prepared and submitted to the DOE on December 18, 1992, for review and comment. A two-step process was proposed for selection of six test coals for use during the program. The first step was a screening process based upon readily available information. Candidate coals from diverse coal mining districts in the United States were identified in this manner based upon sulfur analyses, current production status, and any information available to the project team related to cleanability. The draft plan proposed that the candidates be rated next by a quantitative ranking procedure utilizing a matrix format to aid in selection of the six most promising prospects from among the candidates.

At the suggestion of the DOE, the proposed selection procedure was revised so that only coals with reserves of at least 250 million tonnes (300 million short tons) were considered further. Minor changes in the weighting for coal quality and production cost elements were also made in the selection matrix. Table 2 shows the revised weighting assigned to elements in each category of the coal selection matrix.

Revised January 12, 1993

Table 1. Outline of Work Breakdown Structure

Phase I. Engineering Analysis and Laboratory and Bench-Scale R&D

Task 1.	Project Planning
Subtask 1.1.	Project Work Plan
Subtask 1.2.	Project Work Plan Revisions
Task 2.	Coal Selection and Procurement
Subtask 2.1.	Coal Selection
Subtask 2.2.	Coal Procurement, Precleaning and Storage
Task 3.	Development of Near-Term Applications
Subtask 3.1.	Engineering Analyses
Subtask 3.2.	Engineering Development
Task 4.	Engineering Development of Advanced Froth Flotation for Premium Fuels
Subtask 4.1.	Grinding
Subtask 4.2.	Process Optimization Research
Subtask 4.3.	CWF Formulation Studies
Subtask 4.4.	Bench-Scale Testing and Process Scale-up
Subtask 4.5.	Conceptual Design of the PDU and Advanced Froth Flotation Module
Task 5.	Detailed Engineering Design of the PDU and Advanced Flotation Module
Task 6.	Selective Agglomeration Laboratory Research and Engineering Development for Premium Fuels
Subtask 6.1.	Agglomeration Agent Selection
Subtask 6.2.	Grinding
Subtask 6.3.	Process Optimization Research
Subtask 6.4.	CWF Formulation Studies
Subtask 6.5.	Bench-Scale Testing and Process Scale-up
Subtask 6.6.	Conceptual Design of the Selective Agglomeration Module
Task 7.	Detailed Engineering Design of the Selective Agglomeration Module

Phase II. PDU and Advanced Column Flotation Module Testing and Evaluation

Task 8.	PDU and Advanced Column Froth Flotation Module
Subtask 8.1.	Coal Selection and Procurement
Subtask 8.2.	Construction
Subtask 8.3.	PDU and Advanced Coal Cleaning Module Shakedown and Test Plan
Subtask 8.4.	PDU Operation and Clean Coal Production
Subtask 8.5.	Froth Flotation Topical Report

Phase III. Selective Agglomeration Module Testing and Evaluation

Task 9.	Selective Agglomeration Module
Subtask 9.1.	Construction
Subtask 9.2.	Selective Agglomeration Module Shakedown and Test Plan
Subtask 9.3.	SA Module Operation and Clean Coal Production
Subtask 9.4.	Selective Agglomeration Topical Report

Phase IV. PDU Final Disposition

Task 10.	Disposition of the PDU
Task 11.	Project Final Report

Table 2. Maximum Weighting Assigned to Elements in Each Category in Coal Selection Matrix

Category	Element	Maximum Weighting
Product Quality	Potential Sulfur Content	20
	Potential Ash Content	20
	Ash-Free Inherent Moisture	10
	Subtotal	50
Production Cost	Price of Coal at Mine	15
	Liberation Size	10
	Ash Content of Feed Coal	5
	Hydrophobicity	5
	Grindability	5
	Subtotal	40
Availability	Production of Source Mine	10
	Grand Total - Maximum Points	100

Candidate Source Coals

The initial screening identified candidate source coals in Pennsylvania, West Virginia, Virginia, Kentucky, Alabama, Indiana, Illinois, Wyoming, Colorado, and Utah as listed in the January 1993 quarterly report. Subsequently two more eastern coals (No. 2 Gas from two locations in West Virginia and Elkhorn No. 3 from Kentucky) and three more low-rank coals (Dietz, Rosebud, and Lower Smith) from the Powder River Basin were added to the list of candidates. Three coals (from Alabama, Pennsylvania, and Kentucky) were removed because of an inadequate reserve base.

Five-kilogram test samples of typical production were obtained from the mines listed in Table 3 and tested for the quantitative ranking step. Coal selections for the Phase I testing were based upon these evaluations.

The project work plan calls for testing five bituminous coals during Phase I. The first thirteen candidates listed in Table 3 are bituminous coals, and Tables 4 and 5 present the testing results and quantitative ranking scores based upon the 5-kilogram samples of these coals. With a few exceptions, the prospects appear quite good that the target ash and sulfur specifications for premium fuel can be met by deep cleaning these coals.

Table 3. Candidate Coals for Preparation of Premium Fuels

	Coal Seam	State	County	Mine	Mine Operator
1.	Upper Freeport	PA	Indiana	Helen	Helen Mining
2.	Stockton/Mercer	WV	Kanawha	130 Mine	Amax - Cannelton
3.	Winifrede	WV	Boone	Sandlick	Amax - Cannelton
4.	Taggart	VA	Wise	Wentz	Westmoreland
5.	Hazard 4A/5A	KY	Knott	Ky Prince	Roaring Creek
6.	Elkhorn No. 3	KY	Pike	Chapperal	Costain
7.	No. 2 Gas	WV	Wyoming	*	*
8.	No. 2 Gas	WV	Boone	*	*
9.	Indiana VII	IN	Sullivan	Minnehaha	Amax - Midwest
10.	Illinois No. 5	IL	Wabash	Wabash	Amax - Midwest
11.	Maxwell	CO	Las Animas	Golden Eagle	Basin Resources
12.	O'Connor	UT	Carbon	Skyline	Utah Fuels
13.	Sunnyside	UT	Carbon	Sunnyside	Sunnyside
14.	Wyodak	WY	Campbell	Belle Ayr	Amax - West
15.	Dietz	MT	Big Horn	Spring Creek	Nerco
16.	Rosebud	MT	Rosebud	Rosebud	Western Energy
17.	Lower Smit	WY	Campbell	Eagle Butte	Amax - West

* Identity withheld by request.

Table 4. Properties of Candidate Bituminous Test Coals

	1	2	3	4	5	6	7	8
Coal Seam	Upper Freeport	Stockton/Mercer	Winifrede	Taggart	Hazard 4A/5A	Elkhorn No. 3	No. 2 Gas	No. 2 Gas
Mine	Helen	130 Mine	Sandlick	Wentz	Kentucky Prince	Chapperal	Wyoming Co	Boone Co
Proximate, As-Received, Weight %								
Ash	9.24	11.5	6.79	3.18	8.02	6.11	3.47	5.06
Volatile Matter	24.33	32.0	28.33	36.07	32.83	33.60	28.45	32.47
Fixed Carbon	59.93	50.0	47.94	59.24	55.15	53.74	62.16	55.96
Moisture	6.50	6.5	16.94	1.51	5.00	6.55	5.92	6.51
Sulfur, As-Received, Weight %								
Total	1.46	0.84	0.75	0.64	0.86	0.80	0.62	0.80
Pyrite	0.89	0.10	0.14	0.06	0.11	0.16	0.02	0.10
HHV, As-Received, Btu/lb	13,118	12,250	11,506	14,571	12,978	13,138	14,110	13,449
Equilibrium Moisture, %	1.34	2.69	2.94	2.14	2.95	3.04	1.86	2.48
Hardgrove Grindability Index	95	47	46	58	44	44	58	58
Sink-Float Results								
Dry Ash in Float, %								
1.6 Sp Gr Float at 100 m	6.36	6.31	4.58	1.85	5.45			
1.9 Sp Gr Float at 100 m	7.71	8.85	5.58	2.97	6.06			
1.6 Sp Gr Float at 325 m	4.49	6.09	4.17	1.67	4.69			
1.9 Sp Gr Float at 325 m	6.48	7.15	4.59	3.10	4.87			
Product Quality Properties								
Potential Sulfur, g/GJ	245	267	238	176	256	220	184	230
Potential Ash, g/GJ	1,472	2,138	1,066*	493	1,418	550*	641*	755*
Equilibrium Moisture (AF), %	1.51	3.15	3.30	2.26	3.32	3.35	1.97	2.69
Production Cost Factors								
Mine Price, $/GJ	0.87	0.90	0.90	0.90	0.90	0.90	1.15	0.90
Coarse Liberation, g Ash/GJ	2,085	2,215	1,712	546	1,661	~1,000	1,057	~1,000
Ash in Feed Coal, % Ash	9.88	12.3	8.17	3.23	8.44	6.54	3.69	5.41
Hydrophobicity Indicator, MAF kJ/kg	36,196	34,734	35,074	35,544	34,691	34,973	36,207	35,359
Hardgrove Grindability Index	95	47	46	58	44	44	58	58
Availability Factors								
Mine Production, Tonnes/yr	300,000	1,000,000	300,000	300,000	200,000	450,000	160,000	230,000
Reserves, Million Tonnes	540	720	540	275	590	455	7,300	7,300

* Agglomeration or flotation amenability test.

Table 4. Properties of Candidate Bituminous Test Coals
(Continued)

	9	10	11	12	13
Coal Seam	Indiana VII	Illinois No. 5	Maxwell	O'Connor	Sunnyside
Mine	Minnehaha	Wabash	Golden Eagle	Skyline	Sunnyside
Proximate, As-Received, Weight %					
Ash	9.58	11.14	9.48	9.60	5.06
Volatile Matter	28.68	30.81	29.11	39.87	34.98
Fixed Carbon	43.79	47.40	55.76	43.72	52.57
Moisture	17.95	10.65	5.65	6.81	7.39
Sulfur, As-Received, Weight %					
Total	0.81	1.31	0.41	0.56	0.59
Pyrite	0.35	0.61	0.03	0.12	0.08
HHV, As-Received, Btu/lb	10,540	11,391	13,075	11,909	13,227
Equilibrium Moisture, %	14.04	8.81	1.54	6.83	3.29
Hardgrove Grindability Index	55	56	65	56	50
Sink-Float Results					
Dry Ash in Float, %					
1.6 Sp Gr Float at 100 m	6.00	5.09	6.28	2.79	2.54
1.9 Sp Gr Float at 100 m	7.28	5.65	7.33	3.22	3.00
1.6 Sp Gr Float at 325 m	6.58	6.23	5.08	2.81	1.71
1.9 Sp Gr Float at 325 m	7.23	6.36	5.56	3.17	1.84
Product Quality Properties					
Potential Sulfur, g/GJ	217	312	122	167	171
Potential Ash, g/GJ	2,685	2,352	1,493	1,015	495
Equilibrium Moisture (AF), %	15.61	11.04	1.71	8.17	1.75
Production Cost Factors					
Mine Price, $/GJ	1.04	1.00	0.74	0.80	0.85
Coarse Liberation, g Ash/GJ	2,449	1,922	1,870	1,008	742
Ash in Feed Coal, % Ash	11.67	12.47	10.05	10.30	5.46
Hydrophobicity Indicator, MAF kJ/kg	33,810	33,864	35,821	33,123	35,124
Hardgrove Grindability Index	55	56	65	56	50
Availability Factors					
Mine Production, Tonnes/yr	1,000,000	1,000,000	1,400,000	2,000,000	300,000
Reserves, Million Tonnes	450	3,600	900	1,200	1,100

Table 5. Ratings of Candidate Bituminous Test Coals

	1	2	3	4	5	6	7	8
Coal Seam	Upper Freeport	Stockton/Mercer	Winifrede	Taggart	Hazard 4A/5A	Elkhorn No. 3	No. 2 Gas	No. 2 Gas
Mine	Helen	130 Mine	Sandlick	Wentz	Kentucky Prince	Chapperal	Wyoming Co	Boone Co
Product Quality Properties (50 Points)								
Potential Sulfur	15	7	18	20	15	18	20	18
Potential Ash	0	0	10	17	0	17	17	15
Equilibrium Moisture (AF)	10	10	10	10	10	10	10	10
Subtotal	25	17	38	47	25	45	47	43
Production Cost Factors (40 Points)								
Mine Price	12	12	12	12	12	12	9	12
Coarse Liberation	0	0	0	10	0	0	0	0
Ash in Feed Coal	1	0	1	5	1	3	5	3
Hydrophobicity Indicator	3	5	5	5	5	5	3	5
Hardgrove Grindability Index	5	0	0	3	3	0	3	3
Subtotal	21	17	18	35	21	20	20	23
Availability Factors (10 Points)								
Mine Production	8	10	8	8	8	8	6	8
Total Points for Candidate Coal	54	44	64	90	54	73	73	74

Table 5. Ratings of Candidate Bituminous Test Coals
(Continued)

	9	10	11	12	13
Coal Seam	Indiana VII	Illinois No. 5	Maxwell	O'Connor	Sunnyside
Mine	Minnehaha	Wabash	Golden Eagle	Skyline	Sunnyside
Product Quality Properties (50 Points)					
Potential Sulfur	18	0	20	20	20
Potential Ash	0	0	0	10	17
Equilibrium Moisture (AF)	3	5	10	5	10
Subtotal	21	5	30	35	47
Production Cost Factors (40 Points)					
Mine Price	9	9	15	12	12
Coarse Liberation	0	0	0	0	10
Ash in Feed Coal	1	0	1	1	3
Hydrophobicity Indicator	3	3	3	3	5
Hardgrove Grindability Index	3	3	3	3	3
Subtotal	16	15	22	19	33
Availability Factors (10 Points)					
Mine Production	10	10	10	10	8
Total Points for Candidate Coal	47	30	62	64	88

Taggart (Virginia) and Sunnyside (Utah) coals scored significantly higher in Table 5 than the other coals and were among the first bituminous coals selected for Phase I testing. The scores for the Elkhorn No. 3 and the two No. 2 Gas samples were very close together, but the Elkhorn No. 3 (from eastern Kentucky) was selected because of the willingness of the mine operator to provide coals for the project and because the project team was more familiar with its beneficiation properties. Winifrede coal was selected to represent a more difficult coal to process and because it is an important part of Amax Coal Industries' production in West Virginia. Indiana VII from the Minnehaha Mine was selected as representative of midwestern coal production since it usually contains less sulfur than most coals from that region.

The Project Work Plan calls for testing one low-rank coal. The last four coals listed in Table 3 are subbituminous. Test data and selection matrix scores for these four coals are shown in Tables 6 and 7. There was little basis for distinguishing between these coals. Selective agglomeration amenability testing suggests that more of the ash can be rejected from the Dietz Spring Creek coal than from the other coals, though. The results of additional follow-up tests, now in progress, will be used to make a final selection of which low-rank coal to include in the test program.

Subtask 2.2. Coal Procurement, Precleaning, and Storage

Twenty-tonne truckload quantities of the five selected bituminous test coals (Taggart, Elkhorn No. 3, Winifrede, Indiana VII, and Sunnyside) have been acquired for the Phase I testing. Washed coals were obtained in each case, and the mine supplied typical washing plant yield data for use when calculating the run-of-mine (ROM) Btu recovery from the advanced cleaning technologies. The mines have since been requested to provide ROM coal samples for analyses of toxic trace elements and for DOE combustion tests.

The five coals were delivered to Golden in covered dump trucks and crushed at Ralston Development Company to passing 12.7 mm screen (1/2 inch) openings. The crushed coal was placed in 600-kg bulk bags. Half of the bags of each coal are being stored indoors and the other half are being stored outside. Sample cuts were taken while filling each bag so that three drums of coal were collected from each lot. Each of the three drums was intended to be representative of the entire lot of minus 12.7 mm coal. One drum from each set was shipped to CAER and 25 kg was split from another drum and shipped to Arcanum. Additional subsamples were also split from the second drum for analyses and other testing at Amax R&D. The remaining drum is being held in reserve.

The available analytical data for each of the five bituminous coals are summarized in Table 8. The coarse coal washabilities at 12.7 mm x 0 and 6 mesh x 0 have been completed on the Taggart, Indiana VII, and Sunnyside coals and are

Table 6. Properties of Candidate Low-Rank Test Coals

	14	15	16	17
Coal Seam	Wyodak	Dietz	Rosebud	Lower Smith
Mine	Belle Ayr	Spring Creek	Western	Eagle Butte
Proximate, As-Received, Weight %				
Ash	4.44	4.79	7.97	3.92
Volatile Matter	30.78	33.14	28.17	29.88
Fixed Carbon	34.30	39.00	38.11	34.99
Moisture	30.48	23.07	25.75	31.21
Sulfur, As-Received, Weight %				
Total	0.33	0.28	0.81	0.28
Pyrite	0.04	C.02	0.35	0.06
HHV, As-Received, Btu/lb	8,365	9,592	8,887	8,283
Equilibrium Moisture, %	24.36	19.77	22.43	23.23
Hardgrove Grindability Index	55	48	50	55
Sink-Float Results				
Dry Ash in Float, %				
1.6 Sp Gr Float at 100 m	4.71			
1.9 Sp Gr Float at 100 m	5.05			
1.6 Sp Gr Float at 325 m	4.70			
1.9 Sp Gr Float at 325 m	5.07			
Product Quality Properties				
Potential Sulfur, g/GJ	151	121	257	117
Potential Ash, g/GJ	2,417[a]	1,450[a]	2,492[a]	1,718[a]
Equilibrium Moisture (AF), %	25.64	20.80	24.46	24.30
Production Cost Factors				
Mine Price, $/GJ	0.23	0.23	0.23	0.23
Coarse Liberation, g Ash/GJ	2,422	2,145	~2,500	~2,500
Ash in Feed Coal, % Ash	6.38	6.22	10.73	5.70
Hydrophobicity Indicator, MAF kJ/kg	29,881	30,913	31,174	29,688
Hardgrove Grindability Index	55	48	50	55
Availability Factors				
Mine Production, Tonnes/yr	13,000,000	2,700,000	8,700,000	13,000,000
Reserves, Million Tonnes	17,000	17,000	17,000	17,000

[a] Agglomeration amenability test.

Table 7. Ratings of Candidate Low-Rank Test Coals

	14	15	16	17
Coal Seam	Wyodak	Dietz	Rosebud	Lower Smith
Mine	Belle Ayr	Spring Creek	Western	Eagle Butte
Product Quality Properties (50 Points)				
Potential Sulfur	20	20	15	20
Potential Ash	0	3	0	0
Equilibrium Moisture (AF)	0	0	0	0
Subtotal	20	23	15	20
Production Cost Factors (40 Points)				
Mine Price	15	15	15	15
Coarse Liberation	0	0	0	0
Ash in Feed Coal	3	3	0	3
Hydrophobicity Indicator	0	0	0	0
Hardgrove Grindability Index	3	0	0	3
Subtotal	21	18	15	21
Availability Factors (10 Points)				
Mine Production	10	10	10	10
Total Points for Candidate Coal	51	51	40	51

Table 8. Properties of Truck Lots of Bituminous Test Coals

	Taggart Wentz		Indiana VII Minnehaha		Sunnyside Sunnyside		Winifrede Sandlick		Elkhorn No. 3 Chapperal	
	As-Received	Bone Dry	As-Received	Bone Dry	As-Received	Bone Dry	As-Received	Bone Dry	As-Received	Bone Dry
Proximate, %										
Ash	2.01	2.07	7.50	9.25	4.78	5.11	7.89	8.42	5.62	6.04
Volatile Matter	35.35	36.46	28.14	34.70	34.85	37.29	31.79	33.95	33.45	35.98
Fixed Carbon	59.60	61.47	45.45	56.05	53.84	57.60	53.97	57.63	53.90	57.98
Moisture	3.05		18.91		6.53		6.35		7.03	
Sulfur, %										
Total	0.60	0.62	0.40	0.49	0.59	0.63	0.88	0.94	0.80	0.86
Pyrite	0.05	0.05	0.12	0.15	0.07	0.07	0.14	0.15	0.16	0.17
Sulfate	0.001	0.001	0.002	0.002	0.002	0.002	0.001	0.001	0.007	0.007
HHV, Btu/lb	14,829	15,296	10,924	13,472	13,378	14,313	12,957	13,836	13,138	14,059
HHV, GJ/T	34.48	35.56	25.40	31.32	31.10	33.28	30.13	32.17	30.55	32.69
Air-Dried Moisture, %	1.27		10.29		2.03		1.73		2.42	
Equilibrium Moisture, %	1.01		9.30		2.52		2.93		3.04	
Hardgrove Grindability Index	58*		55*		50*		46*		44*	
Density, Dry Coal, kg/m^3		1,267		1,387		1,303		1,362		
Sulfur, lb/mmBtu	0.41		0.36		0.44		0.68		0.61	
Sulfur, g/GJ	174		156		189		292		263	

* Preliminary

in progress on the Winifrede and Elkhorn No. 3. The fine coal washability will begin next.

TASK 3. DEVELOPMENT OF NEAR-TERM APPLICATIONS

Bechtel, together with Amax R&D and Amax Coal Company, is conducting engineering analyses of near-term applications of advanced froth flotation and selective agglomeration technologies for processing coal fines in existing and new preparation plants. The goal is to produce coal which can be sold in the existing marketplace. It is expected that the goal for the near-term applications can be achieved in one or both of the following manners:

- Increase the percentage recovery of marketable coal from the ROM coal.

- Improve the quality and value of the marketable coal (heating value, sulfur or ash content, and handling characteristics) in a cost effective manner.

Last quarter, the preparation plant at the Ayrshire Mine in Indiana was identified as a potential near-term application of advanced cleaning technologies. An additional potential near-term application was subsequently identified at the Lady Dunn preparation plant of Cannelton in West Virginia. The Ayrshire application is for processing the fine refuse that is now being discarded, while the Lady Dunn is for the treatment of additional fines that will be available from a scheduled plant expansion. Bechtel has begun a Subtask 3.1 engineering analysis of both applications, and samples were obtained from both plants for laboratory studies at Golden, CAER, and Arcanum.

Evaluation of Ayrshire Plant Samples

Samples of two streams from the Ayrshire washing plant were obtained for laboratory testing. Similar samples were sent to Arcanum and CAER. The first of the two streams was the fine refuse stream now directed to the slurry pond. It consists mostly of minus 100-mesh classifying cyclone overflow from the jigging plant dewatering system. The second stream was the cake from the centrifuge used to dewater the nominally 28 x 100-mesh fine circuit classifying cyclone underflow. Although relatively high in ash, the latter product is normally included in the daily clean coal production. Table 9 shows Amax R&D's analyses for each of these product samples. The fine refuse stream amounts to around 90 tonnes (100 short tons) per hour of solids and the centrifuge cake amounts to 18 tonnes (20 short tons) per hour.

The main focus of the Bechtel engineering analysis is the 90 tonnes per hour of fine refuse going to the pond. It is viewed as a potential source of low sulfur coal which could replace some of the coal now being purchased as blending stock.

Table 9. Amax R&D Analyses of Ayrshire Preparation Plant Samples

	Fine Refuse Slurry		Centrifuge Cake	
	As-Received*	Bone Dry	As-Received	Bone Dry
Proximate, %				
Ash	9.73	64.47	20.44	26.79
Volatile Matter	2.20	14.58	23.42	30.70
Fixed Carbon	3.16	20.95	32.43	42.51
Moisture	84.90		23.71	
Solids	15.10			
Sulfur, %				
Total	0.19	1.26	2.24	2.93
Pyrite	0.15	1.02	1.59	2.09
Sulfate	0.003	0.022	0.034	0.045
HHV, Btu/lb	681	4,508	7,878	10,327
HHV, GJ/T	1.58	10.48	18.32	24.01
SO_2, lb/mmBtu		5.59		5.67
Sulfur, g/GJ		1,202		1,220
Particle Size, %				
Passing 28 Mesh		98.8		65.5
Passing 100 Mesh		90.6		7.8
Passing 325 Mesh		78.4		1.7

* Partially thickened before shipment.

Washability and release analysis tests have also been made on each of these samples. The washability results summarized in Table 10 show that a significant component of low-ash 1.6 specific gravity float coal is found in each stream and significant amounts of pyrite concentrate in the 1.9 specific gravity sink products.

Release analyses flotation tests on the fine refuse were conducted both at Amax R&D and CAER to provide a baseline comparison of procedures and test results. Diesel fuel and MIBC frother were used at both locations, but the reagent amounts and froth collection times differed. Figure 2 is the release analysis curve established by Amax R&D and Figure 3 is the curve established by CAER. The Amax R&D curve shows a well defined "knee" around 11 percent ash and 96 percent HHV (higher heating value) recovery. The "knee" in the CAER curve is less well defined and at a higher cumulative ash content in the froth. The differences probably are due to the larger number of flotation increments obtained at Amax R&D (14 versus 7) and the larger reagent additions.

Table 10. Washability of Ayrshire Plant Samples

Specific Gravity Sink	Float	Weight %	Product Analyses Ash, %	S(t), %	S(py), %	Btu/lb	SO_2 lb/mmBtu
			Fine Refuse Slurry				
	1.60	22.78	6.97	1.43	0.64	13,266	2.16
1.60	1.90	10.38	18.63	0.96	0.46	11,579	1.66
1.90		66.83	88.32	1.30	1.26	705	36.88
Composite Feed		100.0	62.55	1.30	1.04	4,696	5.54
			Centrifuge Cake				
	1.60	69.12	8.79	2.15	1.13	12,781	3.36
1.60	1.90	8.95	34.50	2.87	2.23	8,735	6.57
1.90		21.93	77.21	5.08	4.93	2,255	45.06
		100.0	26.1	2.86	2.06	10,110	5.66

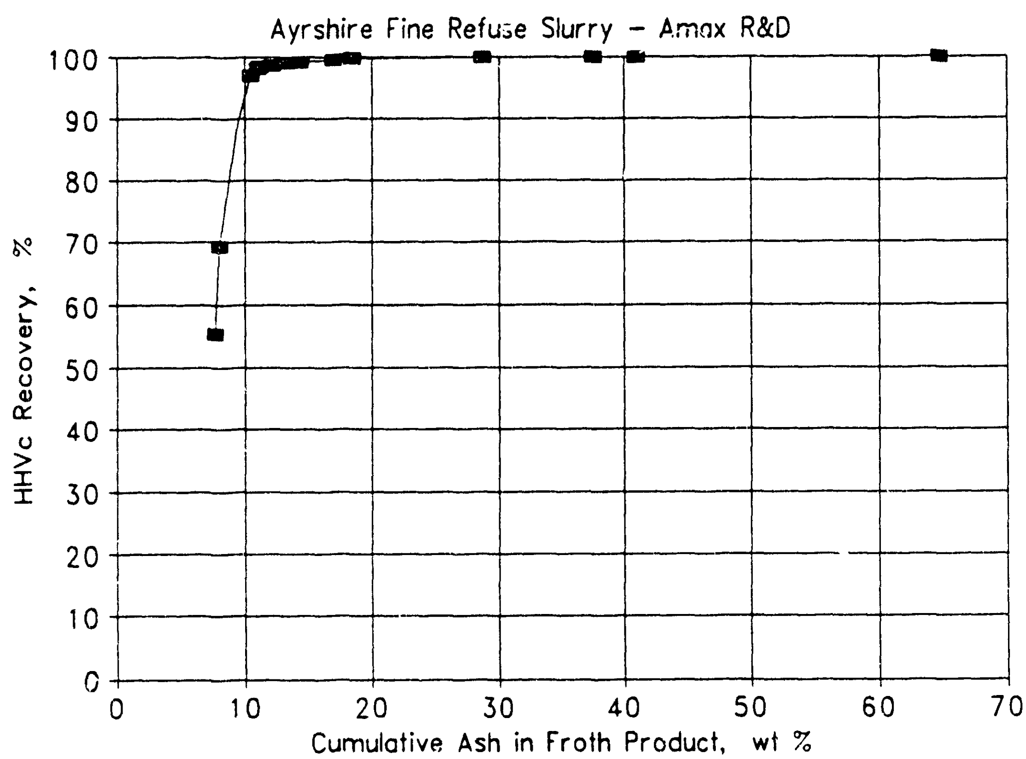


Figure 2. Higher heating value release analysis curve for Ayrshire fine refuse slurry established by Amax R&D.

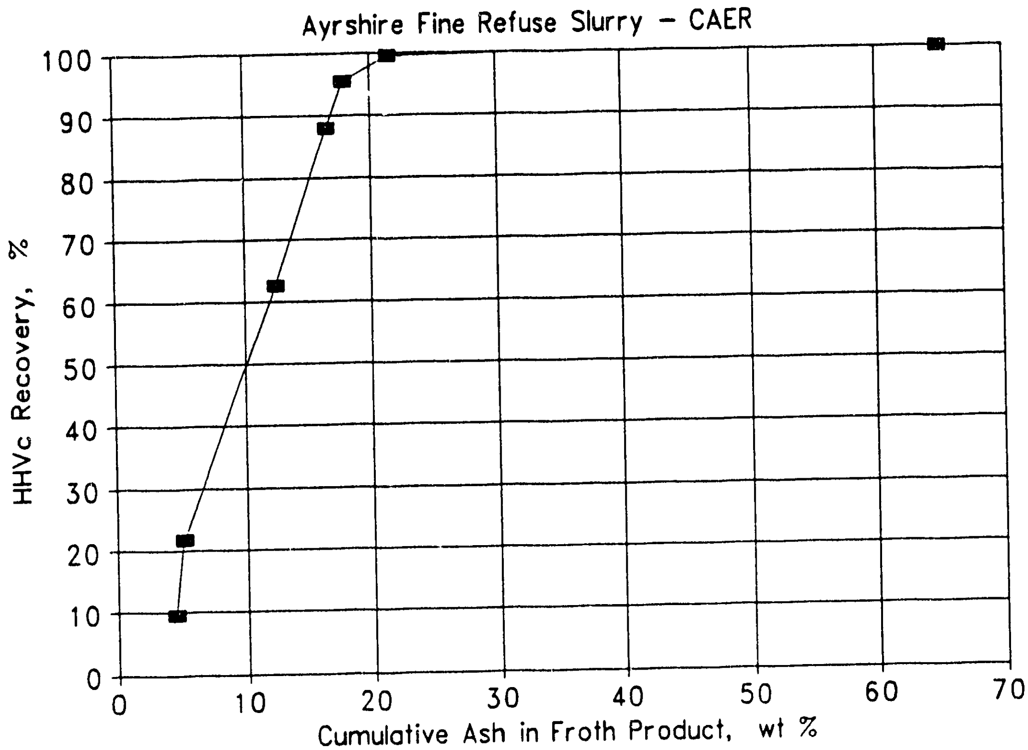


Figure 3. Higher heating value release analysis curve for Ayrshire fine refuse slurry established by CAER.

Figure 4 is the release analysis curve generated at Amax R&D for the nominally 28 x 100-mesh centrifuge cake. The knee of the curve for this material is at about the same location as the knee for the fine refuse shown in Figure 2, that is, at 12 percent ash and 90 percent HHV recovery. The close match between the two suggests that impurities in the coarser centrifuge cake particle size range are as well liberated as the impurities in the finer classifier cyclone overflow size range. A release analysis test is planned, though, to determine whether grinding would improve the quality of the coal which can be floated from the 28 x 100-mesh stream.

Denver cell time-recovery and cleaner flotation tests were performed on the fine refuse slurry at Amax R&D. As shown in Figure 5, the time-recovery test indicated that between 4 and 8 minutes were required to float 90 percent or more of the HHV from the refuse slurry. The cleaner flotation test indicated that 10.35 percent dry ash clean coal could be produced at 78 percent HHV recovery. Details of the cleaner flotation test are provided in Table 11.

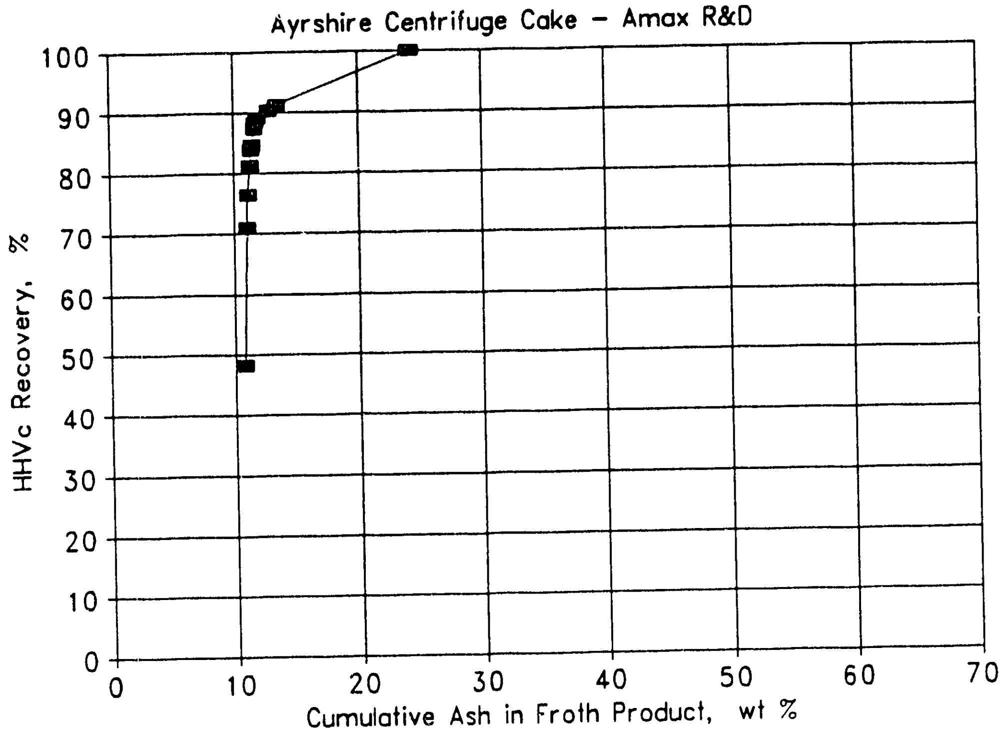


Figure 4. Higher heating value release analysis curve for Ayrshire centrifuge cake.

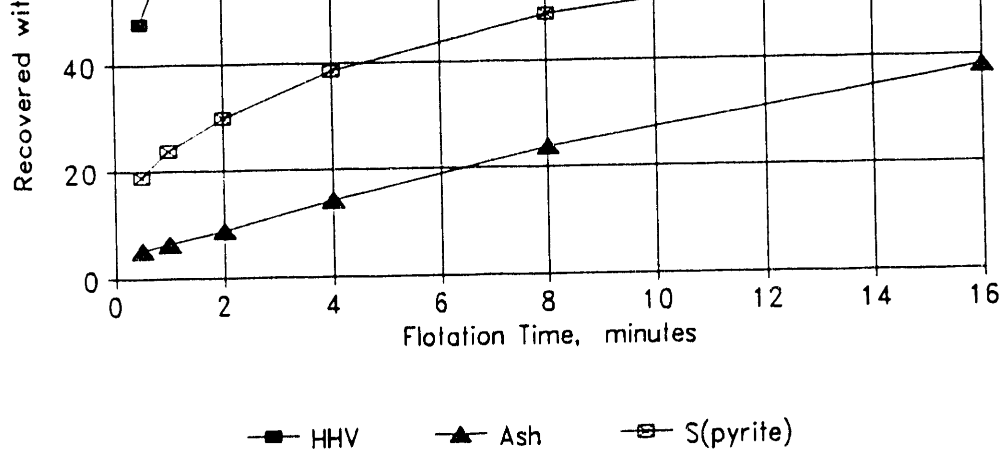


Figure 5. Time-recovery curves for Denver cell flotation of Ayrshire fine refuse slurry.

Table 11. Rougher/Cleaner Flotation of Ayrshire Fine Refuse Slurry

Equipment: Automated D-12 Denver Cell with 4.4 Liter Tank

Feed: Nominally Minus 100-Mesh Refuse Slurry Diluted to 7.5 Percent Solids

Reagents: 0.57 kg/t MIBC
3.21 kg/t Diesel Fuel

Times: Rougher - 4 Minutes
Cleaner - 4 Minutes

Product	Weight %	Product Analyses: Ash, %	S(t), %	S(py), %	HHV, Btu/lb	HHV, GJ/t	Distribution, %: Ash	S(t)	S(py)	HHV	SO_2 lb/mmBtu
Cleaner Coal	28.00	10.35	1.92	1.22	12,792	29.75	4.57	42.35	32.04	78.51	3.00
Cleaner Tail	6.29	89.62	0.73	0.72	329	0.77	8.89	3.62	4.26	0.45	44.38
Rougher Tail	65.71	83.46	1.05	1.04	1,461	3.40	86.53	54.04	63.30	21.04	14.37
Calculated Feed	100.00	63.37	1.27	1.07	4,563	10.61	100.00	100.00	100.00	100.00	5.57

HEI_{ash} = 73.94
HEI_s = 36.16

Laboratory column flotation tests were performed at CAER on the Ayrshire fine refuse slurry. The effects of varying feed rate, airflow, and wash water on the recovery and grade of the clean coals were investigated. A 2-inch column was used and 1 kg/t of fuel oil and 1 kg/t MIBC reagents were added. The feed slurry contained 11 percent solids. Figure 6 shows the effect of the airflow rate on MAF (moisture- and ash-free) coal recovery and the ash content of the clean coal. As expected, the MAF coal recovery increased with increasing airflows; however, the ash content of clean coal for airflows above 1.5 liters/minute remained essentially constant. The highest MAF coal recovery, about 85 percent, was obtained at 3 liters/minute airflow. The ash content of the clean coal was 9.9 percent, which agrees with the Amax R&D release analysis curve.

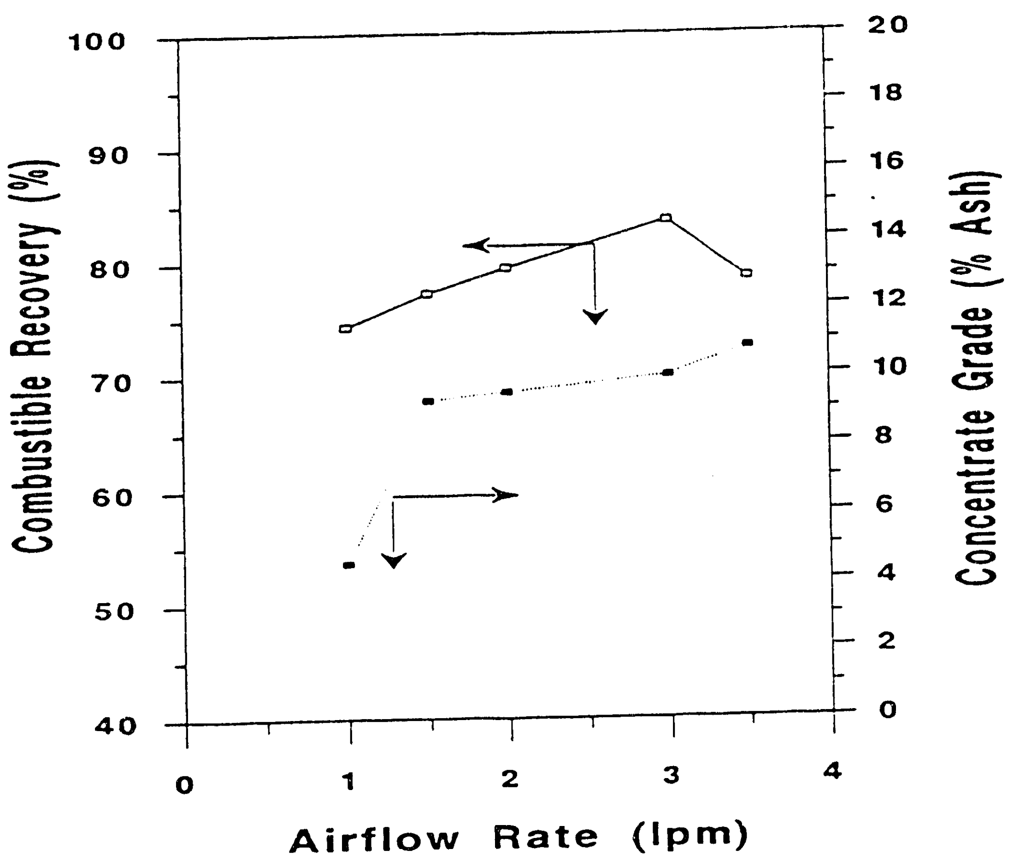


Figure 6. Effect of airflow rate on combustible (MAF coal) recovery and ash content of the clean coal obtained from the Ayrshire slurry (feed rate = 1 lpm, wash water = 0.4 lpm).

The effect of wash water on recovery and grade of the clean coal is shown in Figure 7. It appears from the figure that 0.4 liter/minute of wash water is optimum for this refuse slurry to provide a clean coal containing 9 percent ash at 80 percent MAF coal recovery. Figure 8 shows the effect of varying feed rate on MAF coal recovery and grade of the clean coal. As the feed rate increased, both the clean coal recovery and grade decreased. Thus, it appears that 1 liter/minute of feed, which translates into 6 minutes of retention time in the column, is optimum for the Ayrshire fine refuse slurry.

The consensus of the laboratory flotation tests was that a 9 percent ash product can be prepared from Ayrshire fine refuse slurry at 94 percent HHV recovery (80 percent MAF coal recovery) and that optimum operating conditions were 1 liter/minute slurry feed, 0.4 liter/minute wash water, and 2 liters/minute airflow.

The above test data were provided to Bechtel for their use when preparing an engineering analysis of the potential near-term application of column flotation at the Ayrshire preparation plant.

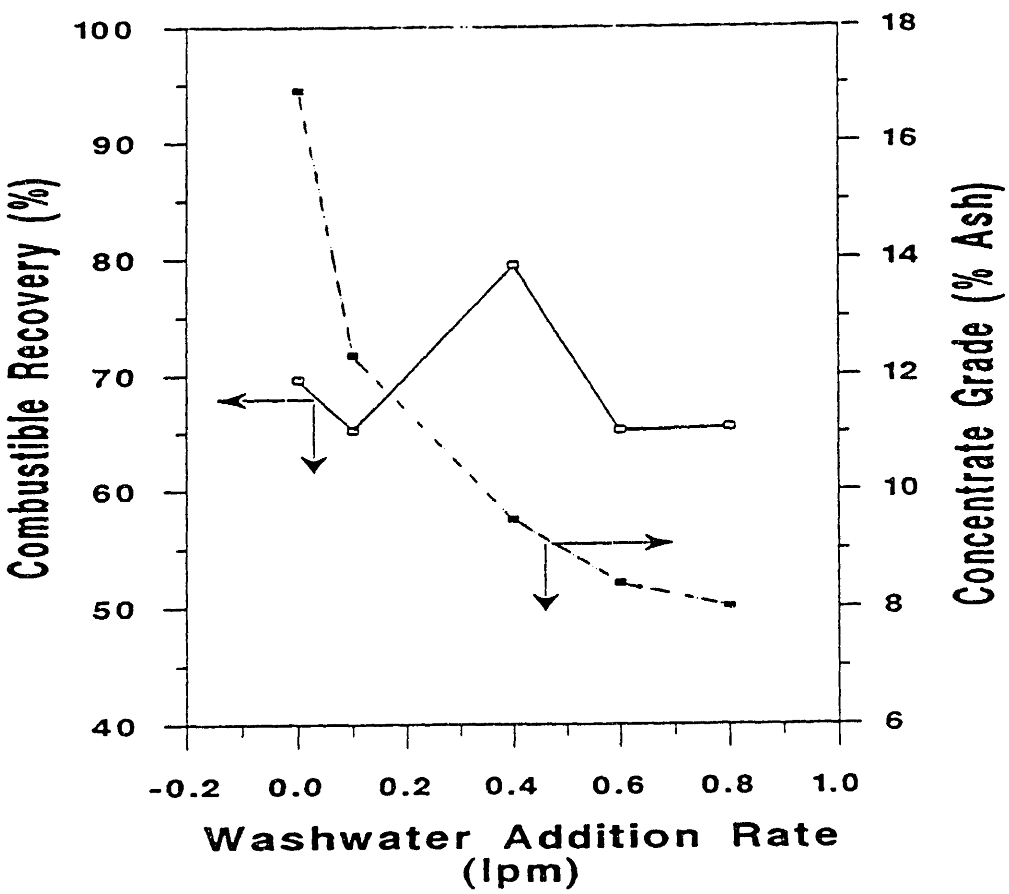


Figure 7. Effect of wash water addition on combustible (MAF coal) recovery and ash content of the clean coal obtained from the Ayrshire slurry (feed rate = 1 lpm, airflow = 2 lpm).

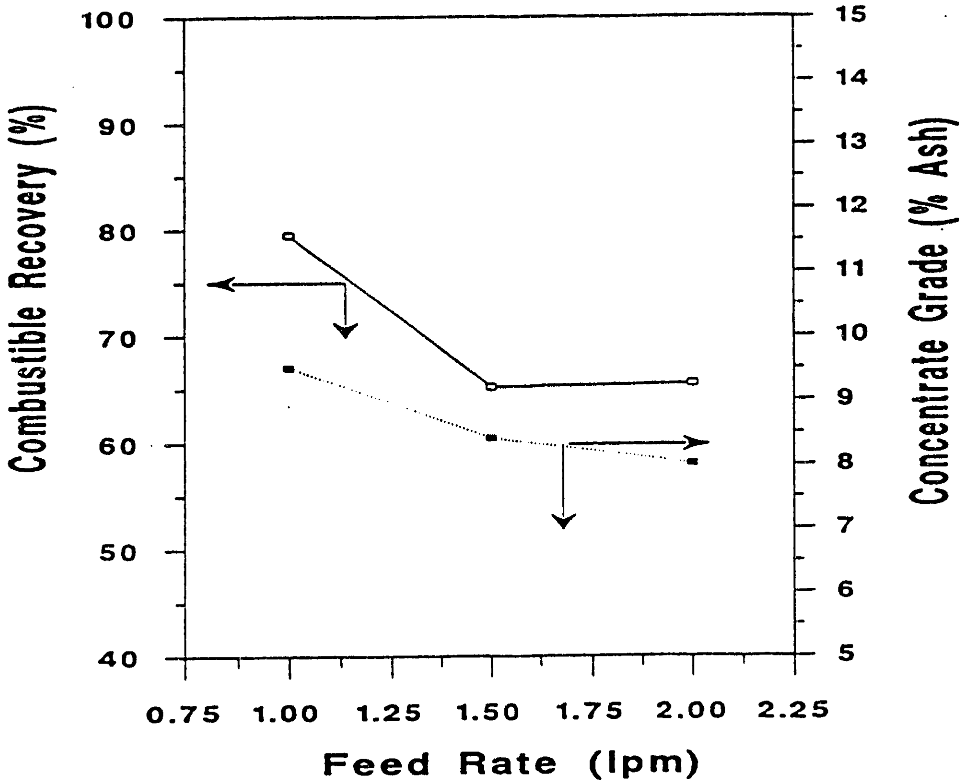


Figure 8. Effect of feed rate on combustible (MAF coal) recovery and ash content of the clean coal obtained from the Ayrshire slurry (airflow = 2 lpm, wash water = 0.4 lpm).

Evaluation of Lady Dunn Preparation Plant Samples

Samples of two products from the Lady Dunn washing plant were obtained for the laboratory testing. The first sample was a cut of the 48 mesh x 0 slurry now feeding the mechanical cell flotation system of the Lady Dunn plant. The sample was taken before the addition of any reagents to the slurry. It was not possible to obtain a 28-mesh sample comparable to the centrifuge cake at the Ayrshire plant. Instead, reject minus 28-mesh slack screened from the Stockton feed coal samples will be used. Stockton seam coal is the principal feed for the Lady Dunn plant, and the raw coal feed samples are taken regularly each day. The 28 x 100-mesh fraction which will be used for the planned testing will be screened from these sampler rejects. Table 12 shows Amax R&D's analyses for these two products. Samples of the flotation feed slurry were sent to Arcanum and CAER as well.

The main focus of the Bechtel engineering analysis is the 48 mesh x 0 flotation feed slurry since that resembles the additional slurry which will go to the column flotation system when the plant expansion is accomplished.

Table 12. Amax R&D Analyses of Lady Dunn Preparation Plant Samples

	Flotation Feed		28 x 100 Mesh	
	As-Received*	Bone Dry	As-Received	Bone Dry
Proximate, %				
Ash	6.76	34.39	30.24	30.56
Volatile Matter	4.30	21.88	25.24	25.51
Fixed Carbon	8.60	43.73	43.46	43.93
Moisture	80.34		1.06	
Solids	19.66			
Sulfur, %				
Total	0.13	0.67	0.84	0.85
Pyrite	0.05	0.27	0.14	0.14
Sulfate		0.002	0.002	0.002
HHV, Btu/lb	1,847	9,396	9,939	10,045
HHV, GJ/T	4.30	21.85	23.11	23.36
SO_2, lb/mmBtu		1.50		1.78
Sulfur, g/GJ		322		382
Particle Size, %				
Passing 28 Mesh		100.0		100.0
Passing 100 Mesh		80.0		0.0
Passing 325 Mesh		71.4		

* Partially thickened before shipment.

Washability tests have been made on both of the Lady Dunn samples. The washability results summarized in Table 13 show that a significant component of low-ash 1.6 specific gravity float coal is found in each stream and that there is some concentration of pyrite in the 1.9 specific gravity sink products.

Release analysis tests have been made on the Lady Dunn flotation feed slurry at both Amax R&D and CAER again using diesel fuel and MIBC reagents. The curves are shown in Figures 9 and 10, respectively. The Amax R&D results show a clean coal grade of 11 percent dry ash at 98 percent HHV recovery. The CAER test indicates somewhat less HHV recovery in clean coal at that ash content.

Denver cell flotation and laboratory column flotation tests are in progress on the Lady Dunn samples. The laboratory results are being provided to Bechtel for their use as the testing data become available.

Table 13. Washability of Lady Dunn Samples

Specific Gravity Sink	Specific Gravity Float	Weight %	Product Analyses Ash, %	S(t), %	S(py), %	Btu/lb	SO_2 lb/mmBtu
			Flotation Feed Slurry				
	1.60	30.69	6.59	0.85	0.09	13,951	1.22
1.60	1.90	3.54	32.21	0.77	0.33	9,585	1.61
1.90		5.35	76.10	1.42	1.31	2,561	11.09
-325 Mesh		60.43	46.60	0.57	0.29	7,407	1.54
Composite Feed		100.00	35.39	0.71	0.29	9,234	1.54
			28 x 100 Mesh				
	1.60	62.92	10.72	0.85	0.14	13,353	1.27
1.60	1.90	13.66	39.33	0.84	0.42	8,526	1.97
1.90		23.42	78.73	1.22	1.16	2,040	11.96
Composite Feed		100.00	30.56	1.19	0.042	10,045	2.37

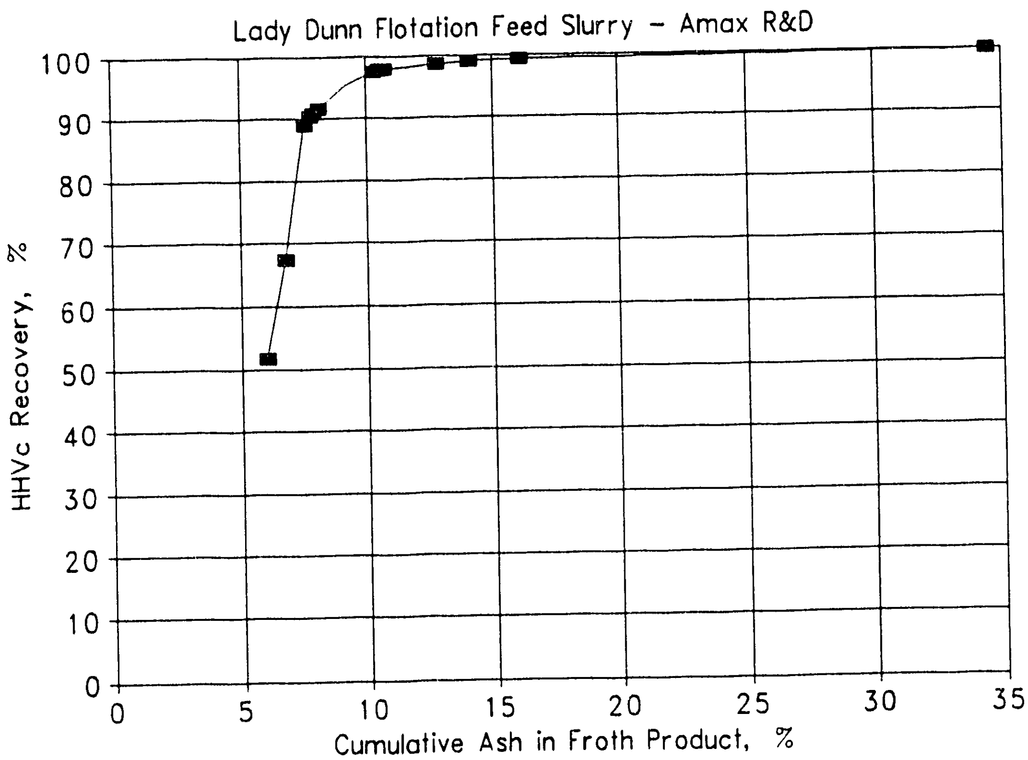


Figure 9. Higher heating value release analysis curve for Lady Dunn flotation feed slurry established by Amax R&D.

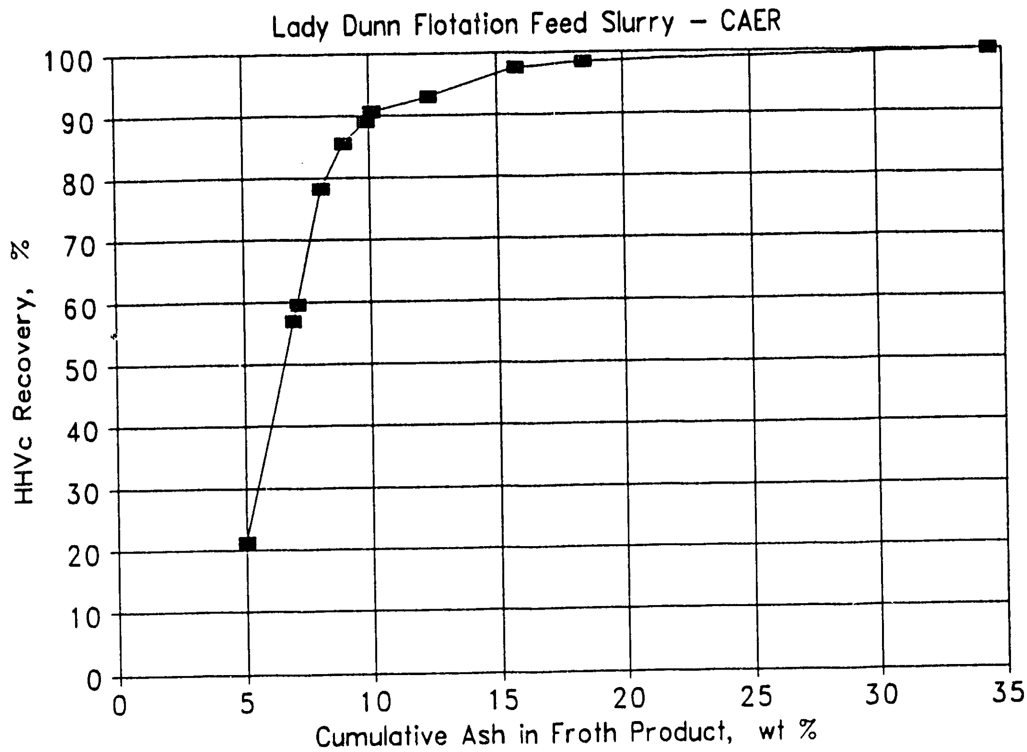


Figure 10. Higher heating value release analysis curve for Lady Dunn flotation feed slurry established by CAER.

Higher Heating Value (HHV) Correlations

Correlations were developed relating HHV analyses, in Btu/lb, to the ash contents of samples of the Ayrshire and Lady Dunn coals. In each case a selected set of 18 and 26 samples, respectively, were picked from the washability fractions and flotation products to represent a range of ash and pyrite contents. A linear least-square regression procedure on the HHV, ash, total sulfur, and pyrite sulfur analyses (all on a bone dry basis) was used to develop the correlation. A very good fit was obtained relating HHV to dry ash. Within the range of the samples investigated, neither total nor pyrite sulfur content had a significant impact upon the heating value of the sample. Figures 11 and 12 illustrate the correlations developed for the Ayrshire and Lady Dunn samples, respectively. The correlation equations are shown along with the figures.

The correlation equations shown with Figures 11 and 12 were used to convert MAF coal recoveries to HHV recoveries in the test results described in the preceding sections.

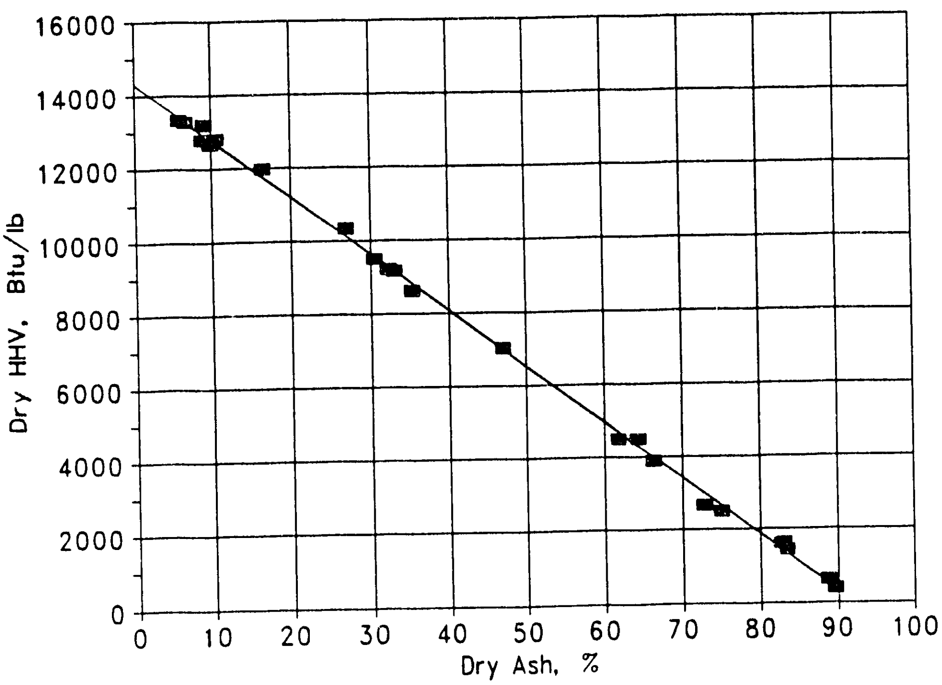


Figure 11. Correlation between higher heating value of Ayrshire samples and ash content. HHV_c = 14,286 - 154.93 (% ash). Standard error = ±167 Btu/lb.

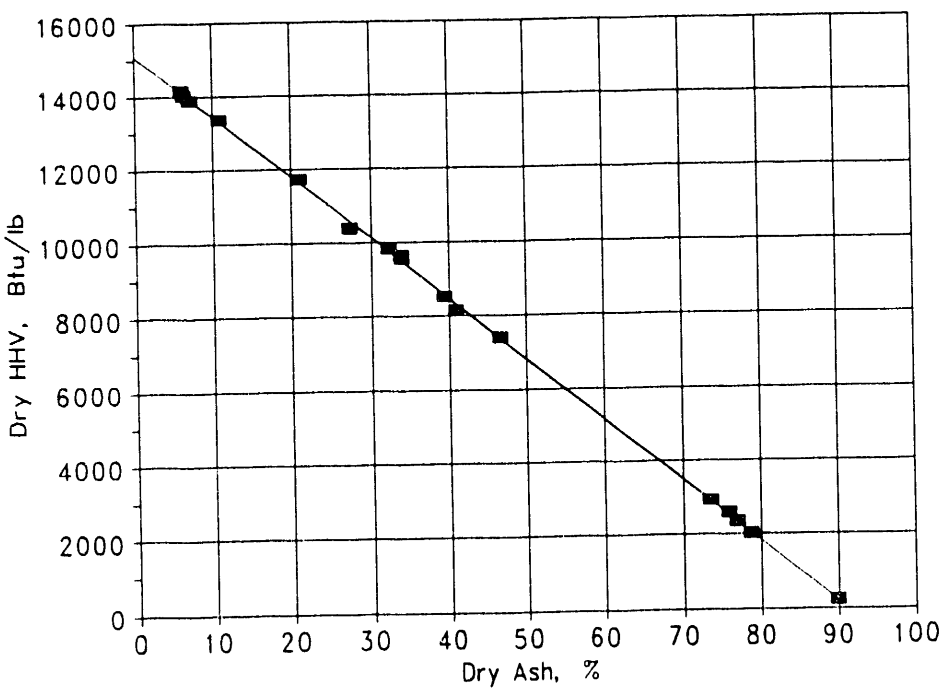


Figure 12. Correlation between higher heating value of Lady Dunn samples and ash content. HHV_c = 15,078 - 165.10 (% ash). Standard error = ±81.6 Btu/lb.

Engineering Analysis

Bechtel engineers have visited both the Ayrshire and Lady Dunn preparation plants and have obtained the plant operating data they need for making an engineering analysis of potential applications of the advanced fine coal cleaning technologies at both locations. As indicated earlier, Bechtel is focusing on two applications:

- Production of additional amounts of quality clean coal at the Ayrshire plant by processing fine refuse slurry now being discarded.
- Cost and operating improvements to be gained by utilizing one of the advanced technologies for the scheduled 1994 expansion of the Lady Dunn plant.

Bechtel is considering both the column flotation and selective agglomeration advanced technologies for these two near-term applications. The basic process flowsheets have been prepared and major equipment sized for each case. Bechtel is now preparing operating and factored capital cost estimates from this information. The engineering analysis will provide the basis for recommendations of the work to be done during Subtask 3.2. The Bechtel study will be published in a topical report as described in the subtask test plan.

Other Current Activities

Laboratory tests are in progress to determine whether it would be beneficial to process the 28 x 100-mesh streams in the plants by an advanced technology in addition to processing the finer streams identified for immediate attention. The work in progress includes grinding tests to determine whether an improvement in liberation would improve the quality of the clean coal produced from the 28 x 100-mesh materials.

Laboratory testing is in progress at CAER to define operating conditions and expected performance of a column flotation system at the Lady Dunn plant.

Selective agglomeration testing is also in progress at Arcanum to support the Bechtel engineering analysis of that technology for near-term applications. The decision was made to concentrate on non-recovery systems for the agglomeration process.

TASK 4. ENGINEERING DEVELOPMENT OF ADVANCED FROTH FLOTATION FOR PREMIUM FUEL

The draft test plan for Subtask 4.1, Grinding, was circulated to the DOE and team members for comment. Laboratory scale tests are planned to determine the degree of grinding and liberation that will allow flotation of clean coals meeting target ash and sulfur specifications for premium fuel.

The subtask also includes comparison testing of continuous grinding circuits for preparing flotation feed slurries. The configurations include open, closed, and selective grinding circuits, as shown in Figure 13. Grinding equipment on hand at Amax R&D was being set up for the comparison testing at the end of the quarter in preparation for the circuit comparisons. A classifying centrifuge will be rented for the closed-circuit operation.

TASK 6. SELECTIVE AGGLOMERATION LABORATORY RESEARCH AND ENGINEERING DEVELOPMENT FOR PREMIUM FUELS

Task 6 activities during the quarter included work on Subtask 6.1, Agglomeration Agent Selection, and Subtask 6.2, Grinding.

Agglomeration Agent Selection

The project work plan calls for the selection of four candidate bridging liquids for testing during Task 6. At least two of the candidate bridging liquids are to be hydrocarbons with molecular weights and boiling points below n-decane.

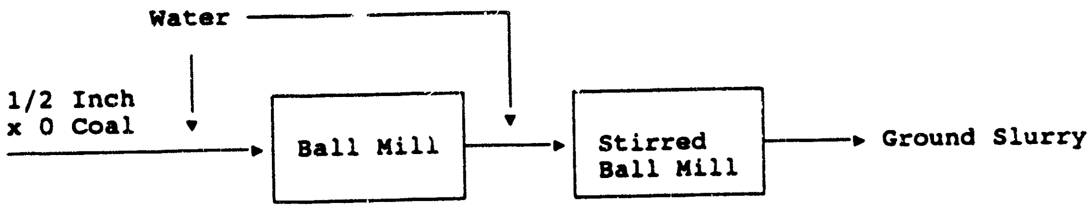
Two processing schemes, requiring differing bridging liquid properties, were recognized while comparing candidate liquids. The two schemes are:

1. Non-recovery processes in which the bridging liquid used to agglomerate the coal is left in the product.

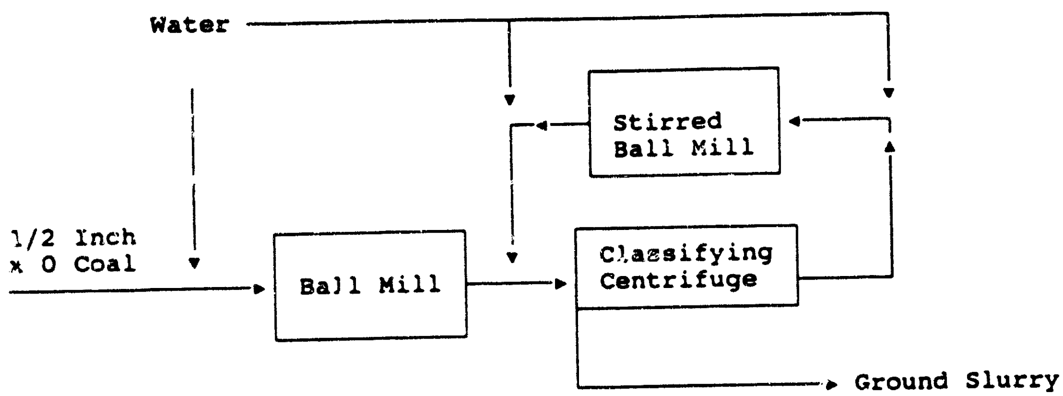
2. Recovery processes in which the agglomerates are grown to screenable sizes and the bridging liquid is then recovered thermally.

Ease and efficiency of stripping and reuse are important issues when considering liquids for recovery processes. On the other hand, purchase price and effectiveness are important issues when the liquid will not be recovered for reuse.

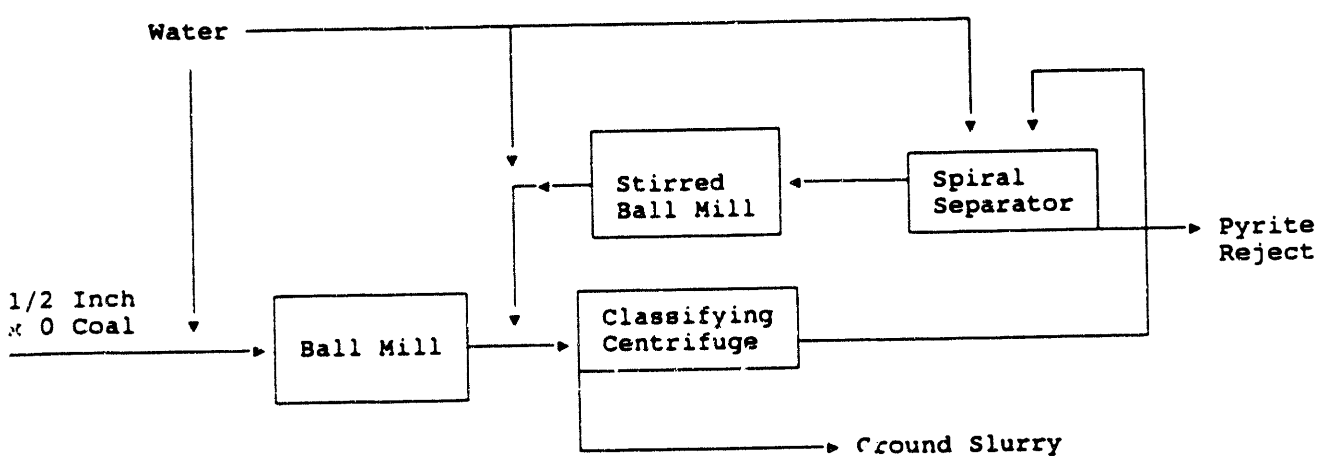
The following prospective bridging liquids were compared when making the agglomeration agent recommendations:



Open-circuit series fine grinding.



Closed-circuit fine grinding.



Selective fine grinding.

Figure 13. Continuous fine grinding circuits.

For Recovery Systems	For Non-Recovery Systems
n-Pentane	Lower Flash Point Naphtha
Cyclohexane	High Flash Point Naphtha
n-Hexane	Kerosene
n-Heptane	No. 2 Fuel Oil/Diesel Fuel
n-Octane	Heavy Fuel Oil (No. 4)
n-Nonane	Crude Oil
Toluene	Naphtha/Asphalt Mixture
p-Xylene	

A matrix procedure was established for ranking the prospective bridging liquids. The elements considered in the selection matrix and the weighing assigned to each are given in Table 14. Based upon their weighted scores, n-pentane, n-heptane, high-flash point naphtha, and diesel/asphalt mixture appear to be the leading candidates for further study. A topical report describing the rationale behind the selection of the bridging agents has been drafted and circulated among the project team members for comment. It will be submitted to DOE by April end.

Grinding

The draft test plan for Subtask 6.2, Grinding, was circulated to the DOE and team members for comment. Laboratory scale tests are planned to determine the degree of grinding and liberation that will allow selective agglomeration of clean coals meeting target ash and sulfur specifications for premium fuel.

The subtask also includes comparison testing of continuous grinding circuits for preparing selective agglomeration feed slurries. The configurations include open, closed, and selective grinding circuits, as shown earlier in Figure 13. To minimize any duplication of effort, the grinding tests for Subtask 6.2 will be coordinated with the parallel grinding tests for Task 4 related to advanced froth flotation.

Table 14. Maximum Weighting Assigned to Elements in Agglomeration Agent Selection Matrix

Element	Maximum Points: Non-Recovery Systems	Maximum Points: Recovery Systems
Ash Rejection	15	15
Pyrite Rejection	15	15
Toxicity	15	15
Flash Point	10	10
Purchase Cost	10	10
Preparation of CWM	10	
Vapor Pressure	10	
Cleanup	10	
Availability	5	
Purge Loss Rate		10
Water Solubility		10
Azeotrope Composition		5
Azeotrope Boiling Point		5
Viscosity		5
Total	100	100

ACTIVITIES FOR NEXT QUARTER

Acquisition and characterization of the sixth test coal will be completed during the forthcoming April to June quarter and the subtask report issued.

Near-term application testing of the Ayrshire and Lady Dunn samples will continue as scheduled in the test plan. The Subtask 3.1 engineering analysis topical report will be issued and recommendations made for the Subtask 3.2 engineering development test plan.

Task 4 activities (grinding, process optimization, CWF formulation, bench-scale testing, and conceptual design of the PDU) will receive concentrated attention during the quarter.

The Subtask 6.1 agglomerating agent selection topical report will be issued during the quarter, and Arcanum will continue with their scheduled selective agglomeration activities for Task 6. Subtask 6.2 grinding studies will take place at Amax R&D in parallel with the grinding work for the advanced froth flotation. A test plan will be drafted for the Subtask 6.3 process optimization research as well.

DATE
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8/23/93

END