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TECHNICAL REPORT
March 1, 1994 through May 31, 1994

Project Title: **DEVELOPMENT OF A USE FOR ILLINOIS COAL
CONCENTRATES FOR SLURRY FED GASIFIERS**

Doe Grant No: DE-FC22-92PC92521 (Year 2)
ICCI Project No: 93-1/1.1A-3M
Principal Investigator: Latif A Khan, ISGS
Other Investigators: John M. Lytle, Saleem Khan, and
Mahmood At-Taras, ISGS and Henry P.
Ehrlinger III, Consultant
Project Manager: Daniel D. Banerjee, Illinois Clean
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ABSTRACT

The primary purpose of this project is to identify and test concentrates made from preparation plant fines as to their amenability as feed for slurry fed, slagging, entrained-flow gasifiers. The high sulfur content and high BTU value of Illinois coals are particularly advantageous in such a gasifier. Elemental sulfur is recovered as a revenue producing product in gasifier technologies, and the higher BTU Illinois coal concentrate requires less water to produce a pumpable slurry than western coal (30-35% vs 45%) thereby reducing the amount of heat lost in the vaporization of entrained water. This means that 66 tons of Illinois coal concentrate, containing 13,000 BTU per pound, at 70% solids would provide as much net heat as 100 tons of 9500 BTU coal pumped at 54% solids.

During the current reporting period a number of continuous flow tests were conducted in which the grades and recoveries were compared with respect to reagent dosage. All were conducted on the minus 65 mesh material from a single coal except for Test A which was minus 100 mesh. With frother dosage, feed rate, wash water rate, and air rate all held at a near constant figure, the collector rate was varied. The concentrates all contained nearly the same grade, but the recoveries of coal in those concentrates varied from quite low (36.3%) through medium recovery ranges to quite high (94.3%) in a very predictable line.

One ultimate analysis on a concentrate from earlier work has been completed, and the results forwarded to Destec for their performance prediction tests. In this test they convert the chemical analysis of a given product into a heat rate determination using a proprietary formula. Part of the same product has been forwarded to William's Technology's Viscosity Laboratory where the pumpability of this product will be determined. All of these data will be available for the Contractors Conference in August.

U.S. DOE Patent Clearance is NOT required prior to the publication of this document.

EXECUTIVE SUMMARY

The coal industry of Illinois discards a significant amount of coal as fines from washing plants. A small amount is recovered in three flotation plants and several fine-size gravity separation plants which treat washing plant waste. An estimate is that about 4,000,000 tons of recoverable coal is being impounded as waste per year from the thirty existing washing plants. This coal when concentrated by gravity and/or flotation approaches the size and chemical requirements for gasification.

The gasification of coal slurry is a technology which has been proven to be scientifically and environmentally effective. Integrated gasification -combined cycle (IGCC) plants have the capability to achieve heat rates as low as 8200 BTU/KWH (42% efficient). Additionally, IGCC plants are largely waste free. The products are medium BTU clean gas, steam, inert granulated slag, and elemental sulfur. The slag and sulfur are marketable, the slag has been examined by a number of State Highway Departments and found acceptable for highway base use, while the sulfur is sold for about \$67.00 per ton in the midwest, and up to \$115 per ton in the Florida market area. Illinois coal meets all of the desirable characteristics needed for gasification: first, it can be concentrated to a grade higher than 13,000 BTU/lb as compared to about 9500 BTU/lb for western coal; second, it can be densified to over 70% solids and remain pumpable as compared to about 55% for western coals; third, the sulfur is a marketable product in a gasifier rather than a penalty as when Illinois coal is utilized in conventional coal fired power generation, and fourth, it is partially ground to plant specifications when it is delivered to the IGCC plant.

With these opportunities and advantages Illinois coal has over western coal it was suggested that these opportunities be developed toward commercial usage. During the first, and this second reporting period samples have been obtained from the washing plant wastes from coal from underground mines, both No 5 and No. 6 seams, from a surface mine, and from an old tailings pond which had been in place for more than five years. Tests have been made on some of these, and without exception, concentrate grades in excess of 12,000 BTU/lb are the standard. On several occasions grades in excess of 13,000 BTU/lb have been made. The recovery of BTU's has varied from the mid 50% range to over 96%, and the rejection of ash has been in the mid to high 80% range.

This quarterly report describes a series of tests on waste streams from a single plant. Many of the parameters were maintained at essentially the same level, these being the feed rate, the percent solids, the frother and frother addition rate, and the air and water additions to the bubble generators in the column, and the wash water. The collector (kerosene)

feed rate was varied from 2.5 pounds per ton to 1.0 pounds per ton. The concentrate grades remained almost uniform at about 12,600 BTU, but the recovery of these BTU's in the concentrate varied from 36.3% to 94.3% The differences in the ash content in the concentrate were brought about by our trying to bring as much coal bearing froth off the top of the cell as possible, in some cases when it was not very well activated. Table 1 demonstrates this:

Table 1. Grade vs Recovery Comparison

Test No.	Conct	Concentrate Analyses			Distribution		Collect	
	Wt %	Ash	T/S	BTU	Ash	T/S	BTU	#/Ton
A	67.37	10.77	3.15	12886	21.0	75.7	94.3	2.5
B	44.24	13.93	3.50	12497	12.9	54.3	75.0	2.0
C	35.43	15.63	3.37	12217	11.6	42.3	59.3	1.5
D	21.34	12.39	3.21	12695	5.5	21.9	36.3	1.0

OBJECTIVES

The goals and objectives of this project are to have coal from Illinois washing plant waste streams used for gasifier feed for power generation. To do so, this project will utilize waste products from real plant waste streams from a variety of sources to develop a series of examples of concentrates which have low ash content, high BTU content, and sulfur which will be saleable when the coal is used for power generation using IGCC technology.

The coal industry of Illinois discards a significant amount of coal as fines from washing plants. A small amount is recovered in three flotation plants and several fine sized gravity separation plants which treat washing plant waste. An estimate is that about 4,000,000 tons of recoverable coal is being impounded as waste per year in Illinois. This coal when concentrated by gravity and/or flotation approaches the size and chemical requirements for slurry-fed, slagging, entrained-flow gasification. There are presently enough coal fines mined and discarded in Illinois annually to provide fuel for a 2400MW power plant. This is much larger than any existing coal fired power plant in the state.

Samples of coal concentrates generated from several different plant sources will be made and given a gasification amenability review to determine their acceptability as gasifier feed. In addition to current plant wastes, at least one sample of impounded waste will be examined under the same criteria.

Additionally, several of these concentrate samples will be tested for their potential as pumpable coal slurry. Earlier work indicated that existing pipeline technology had every reason to be a transportation method of choice.

This work at this time has a very important impact on the Illinois Coal Industry. Because of the recently legislated Clean Air Act, many of the markets for Illinois high-BTU, high-sulfur coal are in jeopardy. Three alternatives are available to users of coal to meet the mandated sulfur to energy ratios. First, substitute low BTU western coal for Illinois coal; this can be done either by total substitution, or by blending to a desired endpoint. Second, install scrubbers in any of their many forms, or lastly, adapt power plants to take advantage of the high BTU, high-sulfur feedstock available with Illinois coal. Illinois coal has ideal properties for integrated gasification combined cycle plants which produce power at about 25% higher efficiency than conventionally fired power plants, and produce no appreciable solid, liquid or gaseous pollutants.

INTRODUCTION AND BACKGROUND

The gasification of coal slurry is a technology which has been proven to be scientifically and environmentally effective. Integrated gasification combined cycle (IGCC) power plants have the capability to achieve heat rates as low as 8200 BTU/KWH (42% efficiency); this is compared to 10,300 BTU/KWH for conventional coal fired generation (33% efficiency).

Additionally, the IGCC plants are virtually waste free: the products are medium BTU clean gas, steam, inert granulated slag, and elemental sulfur. The slag and the sulfur are marketable, the sulfur at about \$115 per ton, and the granulated slag has been appraised by several different state Departments of Transportation and found to be acceptable road construction material. A pulverized coal plant generates steam, slag in some form and either SO₂ or NO_x gasses or scrubber sludge, neither of which is desirable. Destec Energy, Inc of Plaquemine, LA and Texaco's Cool Water plants have used several coals to prove their technologies, and both have used Illinois coals on controlled runs.

During the 1991-1992 contract year (with ICCI) the Illinois State Geological Survey contracted to study **Gasifier Feed, Tailor-made from Illinois Coal**. During the first two quarters products were made from Illinois coals in which the heat rate was reduced to 8490 BTU/KWH on real samples generated at Kerr-McGee's Galatia plant, a marked improvement when compared to either washed Illinois coal or western coal. The products from plant testing were submitted to Williams Technologies Slurry Pumping Test Facility in Flagstaff, AZ and found to be amenable to long distance pumping at high densities without additives.

EXPERIMENTAL PROCEDURES

Material for the testing program was obtained from several mines in Illinois. The first was a slurry of plant effluent from an operating plant which does not use any flotation process. The fines were collected in the field, returned to Champaign, screened on 65 mesh to remove the oversized material, then stored for use. The second sample was collected from an old tailings pond. The material had never been through a flotation circuit, thus had no flotation reagent associated with it. It is as near representative as the operators could suggest, and had been placed in the pond for longer than five years. This material was removed to Champaign, slurried and screened on the 65 mesh screen for oversize removal. Another slurry was obtained from a plant in which flotation was conducted on the fines from the washing plant; however, the sample for testing was removed prior to the addition of reagents. An additional sample was collected from the waste stream from a plant in which the mining was conducted as surface mining, thus would be expected to contain less fines in the feed.

The procedure was to acquire representative samples of the slurries described above, transfer them to a mix tank, adjust the solids to a range of 6% to 8%, then set the flotation feed rate in appropriate gallons per minute to deliver 10 pounds of dry solids per hour, the nominal feed rate for the Deister Laboratory Continuous Flow Flotation Column. The reagent feed rates to match the feed rate were calculated and started, then the feed was turned into the column. Every effort has been made on all tests to assure that steady state conditions were reached before any sampling was started. For the purpose of this work steady state has been reached when at least six volume changes of slurry have been fed into the column without a feed, tailing, air rate, or reagent rate change. This is normally a little over an hour.

MATERIAL BALANCES ON TYPICAL TESTS

Below we show material balances on several typical tests which were completed during this reporting period. These are four of quite a number of tests, but they represent a flavor for the grades and recoveries that were encountered while we were testing the waste stream from the washing plant fed by the coal from a single underground mine. The major variation lies in the quantity of collector added. Insofar as possible the other parameters remained constant.

Test A

Source: Washing Plant Waste With Plus 100 Mesh Particles Screened Out

Prod	% Wt	A N A L Y S E S			DISTRIBUTION		
		Ash	T/S	BTU	Ash	T/S	BTU
Feed	100.00	34.63	2.80	9321	100.0	100.0	100.0
Conct	67.37	10.77	3.15	12886	21.0	75.7	94.3
Tails	32.63	83.88	2.09	1598	79.0	24.3	5.7

Conditions: See Below

Test B

Source: Washing Plant Waste With Plus 65 Mesh Particles Screened Out

Prod	% Wt	A N A L Y S E S					DISTRIBUTION				
		Ash	T/S	Py/S	O/S	BTU	Ash	T/S	Py/S	O/S	BTU
Feed	100.00	47.62	2.85	1.52	1.32	7374	100.0	100.0	100.0	100.0	100.0
Conct	44.24	13.93	3.50	1.38	2.12	12497	12.9	54.3	40.1	70.9	75.0
Tails	55.76	74.51	2.34	1.64	0.69	3310	87.1	45.7	59.9	29.1	25.0

Conditions: See Below

Test C

Source: Washing Plant Waste With Plus 65 Mesh Particles Screened Out

Prod	% Wt	A N A L Y S E S					DISTRIBUTION				
		Ash	T/S	Py/S	O/S	BTU	Ash	T/S	Py/S	O/S	BTU
Feed	100.00	47.61	2.82	1.59	1.23	7297	100.0	100.0	100.0	100.0	100.0
Conct	35.43	15.62	3.37	1.38	1.99	12217	11.6	42.3	30.8	57.4	59.3
Tails	64.57	65.17	2.52	1.70	0.81	4597	88.4	57.7	69.2	42.6	40.7

Conditions: See Below

Test D

Source: Washing Plant Waste With Plus 65 Mesh Particles Screened Out

Prod	% Wt	A N A L Y S E S					DISTRIBUTION				
		Ash	T/S	Py/S	O/S	BTU	Ash	T/S	Py/S	O/S	BTU
Feed	100.00	47.80	3.13	1.55	1.58	7455	100.0	100.0	100.0	100.0	100.0
Conct	21.34	12.39	3.21	1.05	2.16	12695	5.5	21.9	14.4	29.2	36.3
Tails	78.66	57.40	3.11	1.69	1.42	6033	94.5	78.1	85.6	70.8	63.7

Conditions: See Below

TEST CONDITIONS

For this series of tests the Frother was MIBC and the Collector was Kerosene.

<u>ITEM</u>	<u>TEST A</u>	<u>TEST B</u>	<u>TEST C</u>	<u>TEST D</u>
Frother, Low Gen*	1.39#/t	1.39#/t	1.39#/t	1.39#/t
Frother, Upp Gen*	0.60#/t	0.60#/t	0.60#/t	0.60#/t
Collector	2.5#/t	2.0#/t	1.5#/t	1.0/t
Froth Column	20-24"	20-24"	20-24"	20-24"
Water, Low Gen*	5gph	5gph	5gph	5gph
Water, Upp Gen*	5gph	5gph	5gph	5gph
Air, Low Gen*	12SCFH	12SCFH	12SCFH	12SCFH
Air, Upp Gen*	12SCFH	12SCFH	12SCFH	12SCFH
Screen Size	-100m	-65m	-65m	-65m
Feed Rate	10#/hr	10#/hr	10#/hr	10#/hr

*Low Gen is the lower bubble generator and Upp Gen is the upper bubble generator

DISCUSSION

There were several unique features which are pointed out from the results above. The first sample was screened at 100 mesh, following the plant results developed at Kerr-McGee's plant during previous testing (1990-1992). The results were exceptionally good, so it was elected to complete the series screening at 65 mesh to increase the total recovery. The second and rather significant result is that the recovery of energy matter (BTU) drops rapidly as the quantity of collector is reduced. It should be noted also, that even though substantially less recovery is reported, the grade of the final product remains almost the same, there being less than 5% variation in concentrate grade in spite of the significantly different recoveries.

Chemical analyses have been submitted to DESTEC for their Performance prediction tests, and some of the same product

has been shipped to William's Technology's Viscosity Laboratory where the pumpability of the product will be determined. The results of these tests will be included in the Contractor's Conference report, and in the Final Report.

PROJECT MANAGEMENT REPORT
March 1, 1994 through May 31, 1994

Project Title: **DEVELOPMENT OF A USE FOR ILLINOIS COAL
CONCENTRATES FOR SLURRY FED GASIFIERS**

DOE Grant No:	DE-FC22-92PC92521 (Year 2)
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Project Manager:	Daniel D. Banerjee, Illinois Clean Coal Institute

COMMENTS

Third Quarter costs are significantly below the original budget as a number of items are shown as obligation, but not as expended.

SCHEDULE OF PROJECT MILESTONES

Milestones:

- A. Testing using coal from waste streams (Task 1)
- B. Testing using coal from impounded waste (Task 2)
- C. Durability analyses of selected samples (Task 3)
- D. Combustion testing of selected products (Task 4)
- E. Select plant conditions (Task 5)
- F. Report at Annual Contractors Meeting
- G. Technical project management reports prepared and submitted

Financial Plan

A summary of total estimated project costs by major tasks is shown in the following table. Costs of safety, quality control, and report preparation are distributed into the research tables.

Tasks	ICDB Funding
1	
2	31,235
3	31,235
4	9,187
5	5,000
	19,265
Total	96,323

EXPENDITURES - EXHIBIT B
Projected and Estimated Actual Expenditures by Quarter

Quarter*	Types of Cost	Direct Labor	Materials and Supplies	Travel	Major Equipment	Other Direct Costs	Indirect Costs	Total
Sept. 1, 1993 to Nov. 30, 1993	Est. Actual	3,675	99	0	0	826	460	5,060
	Projected	6,746	750	1,326	0	12,598	2,142	23,562
Sept. 1, 1993 to Feb. 28, 1994	Est. Actual	7,995	1,417	1,581	0	10,362	2,134	23,489
	Projected	13,492	1,500	2,652	1,950	25,196	4,479	49,269
Sept. 1, 1993 to May 31, 1994	Est. Actual	12,786	2,389	1,611	0	17,279	3,407	37,472
	Projected	20,238	2,250	3,798	1,950	37,794	6,603	72,633
Sept. 1, 1993 to Aug. 31, 1994	Est. Actual							
	Projected	26,984	3,000	5,304	1,950	50,392	8,763	96,393

* Cumulative by quarter

COSTS BY QUARTER - EXHIBIT C
DEVELOPMENT OF A USE FOR ILLINOIS COAL
CONCENTRATES FOR SLURRY FED GASIFIERS

○ Projected Expenditures
△ Actual Expenditures _____ 23,489

Total ICCI Award \$95,393

**DATE
FILMED**

10/13/94

END