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UTILIZATION OF COAL ASSOCIATED MINERALS

QUARTERLY REPORT No. 10

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OBJECTIVE AND SCOPE

The purpose of this research program is to examine the effects of coal mineral materials on coal waste by-product utilization and to investigate new and improved methods for the utilization of waste by-products from the cleaning, combustion and conversion processing of coal. The intermediate objectives include: (1) the examination of the effects of cleaning, gasification and combustion on coal mineral materials; and (2) the changes which occur in the coal wastes as a result of both form and distribution of mineral materials in feed coals in conjunction with the coal treatment effects resulting from coal cleaning or either gasification or combustion.

SUMMARY OF PROGRESS TO DATE

In the preceding quarterly report, it was reported that while sampling the Solvent Refined Coal II (SRC II) pilot plant at Fort Lewis, Washington the plant went down and vacuum bottoms waste material representing the minerals flow at the last steady state condition were obtained.

This plant has been sampled again and samples of the incoming feed coal, sized coal and vacuum bottoms waste material were obtained.

As part of our effort to trace the same mineral suite through mining, preparation and conversion new samples of feed coal, cleaned coal and refuse were obtained from the District 4 commercial preparation plant. This preparation plant supplies coal to the SRC II pilot plant at Fort Lewis, Washington.

A study of the thermal insulating properties of fired flyash based structural materials was completed during this quarter and is included in this report.

A financial report and milestone chart are presented in Appendix A.

SAMPLE COLLECTION

District 4 Coal Preparation Plant

During this quarter samples were collected according to the terms of the subject contract from a preparation plant in District 4 (Ohio). Raw coal, clean coal, refuse and fine refuse slurry samples were collected during an eight hour day shift period.

Eight 55 gallon drums of raw coal were removed from the run-of-mine slope belt feeding storage silos at the plant. The belt was sampled by a four (4) man crew. The belt was stopped for 60 seconds every 15 minutes, allowing the four men to shovel off a three foot cross section. The belt was stopped 10 times over a three hour period in order for the crew to fill the drums. A total of 40 sampling increments were taken representing approximately 4,000 lbs. of 4 x 0 run-of-mine coal.

Eight 55 gallon drums of refuse were obtained by filling the bucket of a front end loader from the main refuse hopper. The refuse was shoveled onto two tarps, coned, quartered and shoveled into the drums. Approximately 6,000 pounds of refuse was collected.

One 30 gallon drum of fine refuse slurry was collected through a 1-inch bleeder pipe from the main 6 inch slurry pipe feeding the slurry pond. The slurry was run at a slow rate allowing a layer of solids to fill up the drum approximately half way. The sample was estimated to be 50 percent solids by volume.

Two 55 gallon drums of 1 1/2" x 0" clean coal were collected by making six sampling increments. The samples were taken from the clean-coal-belt feeding-silo for a railroad car loader. The belt was stopped every

fifteen minutes for 1 hour in order to collect a 1,000 pound sample of clean coal.

The samples were all sealed and labeled for delivery and shipped to the coal processing facility in Morgantown. When received in Morgantown the samples of coal and refuse were spread out to air dry and were processed in the normal manner. The slurry sample was sealed in a Nalgene sample vessel in an inert atmosphere pending chemical analysis. A written description of the preparation plant is included in this text.

Coal cleaning in the Pittsburgh No. 8 plant was accomplished by 3-product jigs for coarse coal and classifying cyclones for fine coal.

Scalped 4" x 0" run-of-mine coal was fed to the twin jig circuit where a 3-product separation was made. The clean coal product from the jig was dewatered and sized on double-deck screens. The screens separated the clean coal into 4" x 1 1/4", 1 1/4" x 1/4", and 1/4" x 0" size-fractions. The middlings from the jig circuit were dewatered and sized at 1/2" on a screen. Refuse from the jigs was also passed over a dewatering screen. The plus 28 M refuse was transferred to a refuse belt and the minus 28 M refuse was combined with the minus 1/2" material from the middling screen and sent to a spiral classifier. A 65 M separation was made by the refuse classifier; plus 65 M material was transferred to the refuse belt, and minus 65 M material was sent to a static thickener.

The plus 1/2" coal from the middling screen and the 4" x 1 1/4" coal from the clean coal screen were combined and sent to a ring crusher which reduced the top size of the coal to 1 1/2". The 1 1/2" x 0" product from the crusher was transferred to the clean coal belt.

The 1 1/4" x 1/4" material from the clean coal screens was dewatered in centrifuges and discharged onto the clean coal belt. Underflow from the clean coal screens (-1/4") was combined with water from the jig and was pumped to classifying cyclones which made a separation at 28 M. The 1/4" x 28 M underflow from the cyclones was dewatered with screens and centrifuges and discharged on the clean-coal belt. The overflow from the cyclone (-28 M), the underflow from the screens, and the effluent from the centrifuges were pumped to secondary cyclones where a separation at 200 M was made. The 28 M x 200 M underflow from the cyclones was dewatered by vacuum disc filters and discharged onto the clean coal belt. The minus 200 M overflow from the secondary cyclones was sent to the static thickener.

SAMPLE COLLECTION

Solvent Refined Coal II Facility

A second sampling trip was made to the solvent refined coal facility in Fort Lewis, Washington during the quarter. Arrangements were made with plant operation personnel to sample the feed coal weigh-feeder belt every fifteen minutes during an eight hour period. A full-stream belt cut was taken by diverting the entire flow of 1/2" x 0" coal off the end of the belt into the sample container for a 30 second time period. A total of 160 pounds of coal was collected in this manner.

Through consultation with the plant engineer a plant throughput time of eight hours was determined for the current operating conditions. This meant that the first portion of minerals from the sampled feed coal would appear in the waste material eight hours after the first coal sample was taken. Accordingly, eight hours after the first feed coal sample was taken, three-eighths of a 55-gallon steel drum of vacuum bottoms, a medium melting-point tar material, was removed from the waste belt. Again, to

achieve the most representative sample possible, sample was removed from the entire belt width and diverted by a chute into the barrels. At the point of sampling the material was flexible but beginning to quickly solidify into brittle strips at an approximate temperature of 135°F. The material was sampled each half-hour over an eight hour period resulting in a total sample volume of six 55-gallon drums.

Immediately following sampling, each drum (including the feed coal) was sealed with butyl rubber, evacuated with a vacuum pump, and refilled to atmospheric pressure with nitrogen for subsequent shipping to the bulk sample processing facility in Westover, West Virginia. Samples were received approximately three weeks later and processed for analytical characterization procedures with the remainder of sample stored in inert atmosphere for further utilization testing.

COAL BY-PRODUCT UTILIZATION STUDIES

The thermal insulating properties of fired flyash based structural products are discussed in this report. Thermal conductivities were determined using a comparative thermal conductivity instrument.

Four types of flyash structural products were chosen for this study.

A typical composition for a flyash brick will consist of approximately 72 percent flyash, 25 percent bottom slag, and 3 percent sodium silicate by weight.

Two standard flyash brick were used in this study. The flyashes used in the brick were selected as being representative of different major coal seams. The flyashes are designated as Northern West Virginia and Southern West Virginia.

Two lightweight flyash brick were used in this study. In the lightweight flyash brick a lightweight flyash aggregate is used in place of bottom slag. This results in a flyash brick which is lighter in weight than a standard flyash brick. Lightweight flyash brick are discussed in Coal Research Bureau Technical Report No. 153, "Lightweight Flyash Brick". A northern West Virginia flyash and a southern West Virginia flyash were used in the lightweight flyash brick.

For comparative purposes commercial clay brick were obtained from two different sources and were included in this study.

The thermal insulating properties of the fired flyash based structural products were determined by using a comparative thermal conductivity instrument.

The comparative thermal conductivity instrument is used for determining the thermal conductivity of solid materials by comparing this property between the sample material and a known reference material.¹

Thermal conductivity is usually determined by measuring the temperature difference between two points in a material when heat flows from one point in the direction of the other. The temperature difference (ΔT) is related to the amount of heat flow (q) by Fourier's heat conduction equation:

$$\Delta T = \frac{\Delta x}{k} \left[\frac{q}{A} \right]$$

where Δx is the distance between the two temperature measuring points, A is the area of the cross-section perpendicular to the direction of heat flow, and k is the coefficient of thermal conductivity.

It is quite obvious from the above equation that when the quantity q/A is kept the same for two materials, one of known thermal conductivity (k reference) and one of unknown thermal conductivity (k sample), the respective

temperature drops are related as follows:

$$\left(\Delta T \frac{k}{\Delta x} \right)_{\text{sample}} = \left(\Delta T \frac{k}{\Delta x} \right)_{\text{reference}}$$

Thus, by measuring the temperature difference between two thermocouples a distance Δx apart in both reference material and test sample, the unknown thermal conductivity is:

$$k_{\text{sample}} = \left(k \frac{\Delta T}{\Delta x} \right)_{\text{reference}} \left(\frac{\Delta x}{\Delta T} \right)_{\text{sample}}$$

The condition of equal heat flux (or heat flow density, q/A) is obtained by placing a test sample and reference material of equal cross-section in intimate contact with each other and by then holding the two between a heater and a heat sink.

To obtain most accurate results the sample is sandwiched between two identical reference materials. The thermal conductivity is now determined as follows:

$$k_{\text{sample}} = \frac{1}{2} \left(\frac{\Delta x}{\Delta T} \right)_{\text{sample}} \left[\left(k \frac{\Delta T}{\Delta x} \right)_{\text{reference}}^{\text{top}} + \left(k \frac{\Delta T}{\Delta x} \right)_{\text{reference}}^{\text{bottom}} \right]$$

Thermal conductivity was determined for the two commercial clay brick, two standard flyash brick and two lightweight flyash brick using the comparative thermal conductivity instrument. The mean temperature of the samples was kept as near to ambient temperature as possible and still consistent with accurate determinations.

The properties of the brick used in the comparative thermal conductivity tests are presented in Table 1. It should be noted that from Table 1 the average thermal conductivity is 1.5 W/m . C for the commercial clay brick, 1.0 W/m . C for the standard flyash brick and 0.8 W/m . C for the lightweight flyash brick.

The lower thermal conductivity values of the flyash brick are the result of the lower bulk density of the flyash brick. The microstructure of flyash brick consists of sealed pores surrounded by touching flyash particles. This

type of microstructure results in low thermal conductivity.

Since the thermal conductivity values of the flyash brick are lower than the clay brick, this indicates that 40 percent of the heat which would normally be lost through a clay brick wall would be saved by a flyash brick wall.

It is estimated that 10 quads of energy are consumed each year in the United States for residential heating and cooling.² The use of flyash brick in place of clay brick would result in considerable energy savings.

In addition to energy savings, the use of flyash brick would increase the usage of flyash, a valuable recyclable by-product produced in electric utility boilers.

This study has shown that, based on thermal conductivity determinations, the use of flyash brick in place of clay brick would save 40 percent of the heat which would normally be lost through a wall.

REFERENCES

1. Operating Manual for the Comparative Thermal Conductivity Instrument. Dynatech R/D Company, Cambridge, Massachusetts.
2. Reader's Digest, June, 1980, p. 73.

TABLE I

PROPERTIES OF BRICK USED IN COMPARATIVE THERMAL CONDUCTIVITY
TEST

	Clay Brick <u>1</u>	Clay Brick <u>2</u>	Northern West Virginia Flyash Brick <u>Brick</u>	Southern West Virginia Flyash Brick <u>Brick</u>	Northern West Virginia Lightweight Flyash Brick <u>Brick</u>	Southern West Virginia Lightweight Flyash Brick <u>Brick</u>
Thermal Conductivity W/m . C	1.46	1.60	1.17	0.78	0.91	0.74
% Abs. 24 Hr. Soak	3.41	3.01	8.73	11.53	11.37	11.95
% Abs. 5 Hr. Boil	3.73	3.68	12.39	15.27	16.65	17.00
Saturation Coefficient	0.91	0.82	0.70	0.76	0.68	0.70
Apparent Porosity, %	8.53	8.68	23.56	26.94	28.47	28.49
Bulk Density, lbs./cu. ft.	142.6	147.2	118.6	110.1	106.7	104.6
Fired Compressive Strength, P.S.I.	7500	3572	6856	7164	4800	7467
Suction, gms. H ₂ O/30 sq. in./min.	3	7	98	108	117	112

APPENDIX A

UTILIZATION OF COAL ASSOCIATED MINERALS

FINANCIAL REPORT

10TH QUARTER, JANUARY 1, 1980 - March 31, 1980

Expenditures This Quarter

Equipment, R & A	\$613.29
Personal Services	\$14,639.97
Current Expense	
Benefits	3,695.59
Overhead	8,159.84
Supplies	3,339.85
Travel	2,796.22
 TOTAL EXPENDITURES 10TH QUARTER	 33,244.76
TOTAL EXPENDITURES TO DATE	\$297,381.99
TOTAL CONTRACT AWARD TO 9/24/80	\$378,000.00
CONTRACT BALANCE	\$80,618.01

UTILIZATION OF COAL ASSOCIATED MINERALS

West Virginia University

Facet	Task	<u>FIRST YEAR</u> (quarters)				<u>SECOND YEAR</u> (quarters)				<u>THIRD YEAR</u> (quarters)			
		1st	2nd	3rd	4th	1st	2nd	3rd	4th	1st	2nd	3rd	4th
I	1												
	2												
	3												
II	4												
	5												
	6												
	Final Report Preparation												

Work Schedule