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**TEST AND EVALUATE THE TRI-GAS LOW-BTU
COAL GASIFICATION PROCESS**

**Quarterly Report for the Period
January-March 1980
(BCR Report L-1090)**

**Bituminous Coal Research, Inc.
Monroeville Pennsylvania**

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**PREPARED FOR
THE UNITED STATES DEPARTMENT OF ENERGY**

Under Contract No. DE-AC21-80ET10254

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BITUMINOUS COAL RESEARCH, INC.
DOE-SPONSORED RESEARCH PROGRAM

TEST AND EVALUATE THE TRI-GAS LOW-BTU
COAL GASIFICATION PROCESS

Report No. FE-10254-78
(BCR Report L-1090)

I. INTRODUCTION AND PROJECT OBJECTIVE

This report summarizes progress during the quarter January to March 1980 on fluidized-bed gasification research being conducted by Bituminous Coal Research, Inc., under the general program, "Test and Evaluate the TRI-GAS Low-Btu Coal Gasification Process." This research was initiated under Contract No. 14-32-0001-1207, was subsequently transferred to Contract No. E(49-18)-1527, then to Contract No. EF-77-C-01-1527, then to Contract No. ET-78-C-01-2798, then to Contract No. DE-AC21-78MC02798, and is now being conducted under Contract No. DE-AC21-80ET10254, as sponsored by the U.S. Department of Energy.

The overall objective of the program continues to be to develop processes for gasifying coal, with emphasis on the production of a fuel gas. Laboratory-scale coal gasification experimentation is to be continued, together with process and equipment development.

Success of laboratory studies has led to the design and construction of a 100 lb/hr process and equipment development unit. This unit is being operated to demonstrate the process and economic feasibility of fluidized-bed gasification for the commercial production of low-Btu fuel gas. No liquids, tar, or char are produced as waste or by-product.

II. SCOPE OF WORK

Laboratory-scale gasification experimentation is to be continued, together with process and equipment development. The laboratory work will be conducted to improve the fluidized-bed coal gasification process and to provide data for design of continuous flow systems.

The primary purpose of the process and equipment development work is to generate data and provide information needed to design a pilot-scale system.

III. ABSTRACT

New silicon carbide liners were cast for all three reactor vessels. The new liners will facilitate installation of the new reactor heaters and make possible a better seal between the heaters and vessel internals.

Globar heating elements were received, cut to length, and installed on the new silicon carbide vessel liners in Stages 2 and 3. The heater for Stage 1 was reassembled on the new silicon carbide liner and installed in the vessel.

Preliminary tests were made following the installation of the silicon carbide liners and heaters. The Stage 2 heater failed "open," due to poor contact, after a few hours of testing. This problem was solved by nickel plating the ends of the Globars and using graphite packing to cushion the connector set screws.

IV. DETAILED DESCRIPTION OF TECHNICAL PROGRESS

A. Fluidized-bed Gasification Studies

1. Fluidized-bed Gasification PEDU Testing

a. Experimental Program: As reported last quarter, the Stage 2 and Stage 3 reactor heaters were damaged beyond repair in PEDU Test No. 3S-54. Because there was insufficient heater ribbon to rebuild the heaters, the design of the heaters was re-evaluated. The feasibility of using Globar*-type silicon carbide heating elements in place of Chromel A ribbon was discussed with the Carborundum Company. Using six 1-1/4-inch diameter x 40 inch long (heated length) Type LL Globars, 30 kW would be supplied to the vessels. The original heaters for the Stages 2 and 3 produced 35 kW and 25 kW, respectively; therefore, this design should be acceptable. The new design has the advantage of being simpler to install because of the reduced number of elements. Since new silicon carbide liners had to be cast, the casting was modified so that the Globars are secured by the liner, eliminating the insulators of the previous design. The bottom lip on which the Globars rest also supports the liner prior to the installation of the bottom flange. The bottom of the liner is now sealed to the grid plate rather than to the support plate. In fact, the liner is lifted off the support plate by the grid when the bottom is installed. This makes the seal between the heaters and the vessel internals independent of the support plate, as shown in Figure 1. It is hoped that the new seal arrangement will eliminate contamination of the heater chamber with process gas and char.

Following receipt of the Globar heating elements, they were cut to length (they have a 40-inch heated length). Since the electrical connections to the Globars had to be made inside the vessels, special connectors had to be fabricated. Rods of alloy 330 stainless steel were threaded into 2-inch lengths of 1-1/2 inch nickel tube. The Globars were inserted into the nickel tubes and secured by set screws. Since the silicon carbide liner allows for expansion of the alloy 330 rods, there should not be any stresses on the Globars due to thermal expansion. The Globars were then assembled on the

*Globar is a registered trademark of the Carborundum Company.

Figure 1. New Heater Chamber Seal

new silicon carbide liners for Stages 2 and 3. The heater-liner assembly for Stage 2 is shown in Figure 2.

The vessel heater for Stage 1 was removed from the original liner and reinstalled on the new liner. As with the other vessels, this new liner should improve the heater chamber seal. Due to the smaller size of this vessel, Globars could not be used. This vessel operates at a lower temperature than Stages 2 and 3; therefore, this arrangement should be acceptable. The heater-liner assembly was reinstalled in the Stage 1 vessel.

Connections from the heaters to the vessel electrical feed-throughs were made with stranded copper wire in all vessels. In the past, these connections, of nickel rods or stranded nickel wire, have broken and caused many heater failures.

After the silicon carbide liners were installed in the Stage 2 and 3 vessels, electrical power was supplied to the heaters. After several hours, the Stage 2 heater failed "open." Originally, the Globars were secured by set screws in the upper connectors, but the bottom connection relied on the weight of the Globar to make the connection. After the failure of the Stage 2 heater, it was decided to add set screws to the bottom connectors as well. After making this change, the heaters were tested and reinstalled in the vessels. However, the Stage 2 heater failed "open" again after several hours of operation.

Apparently, high contact resistance on some of the connectors eventually resulted in arcing in the connector. The arcing caused the bar to loosen in the connector and thus open the connection. To correct this problem, the ends of the bars were plated with nickel to improve the contact between the Globar and the connector. Additionally, graphite was packed between one side of the Globar and the connector (a nickel tube) before the set screws were tightened. The graphite prevents the set screw from gouging the Globar and its elasticity should help maintain contact. Since these changes were made, the heaters have not failed.

After the heater problem was solved, the vessels were sealed and pressure tested. The char transfer system from Stage 2 to Stage 3 was tested by loading a bed into Stage 2 and transferring it to Stage 3. It was hoped that the new gas distribution system would improve char transfer. The transfer system was described in BCR Report L-886 (May 1978). The pressure of the isolation chamber had been controlled by a globe valve; however, when the system was tested, this valve quickly plugged. Apparently, the pressure differential between the chamber and Stage 2 was large enough that with the new gas distribution system, too much char was being transferred. Therefore, the globe valve was replaced with a ball valve (to preclude plugging the valve) and this valve was connected between the isolation chamber and the outlet of Stage 2. With this lower pressure differential, the system operated smoothly during testing.

b. Cold Model Testing: Extensive cold model testing of new probes was conducted. Based on these tests, the fritted metal grid plates were

8012P57

Figure 2. Stage 2 Reactor Heater Assembly

replaced with solid grid plates. In Stage 3, the gas will enter the reactor through a set of nozzles screwed into the grid plate. The nozzles are about 3 inches high and jet horizontally into the bed. In Stages 1 and 2, nozzles are used for the preheater gases and circular probes for the RL-40 and PG-33 gases. Additionally, the withdrawal lines have been extended about 5 inches above the grid plates to keep the feed gases from disturbing char withdrawal.

c. Data Processing

(1) Automated Data Acquisition: During the quarter, several changes were made to the TRI-GAS data acquisition system. Specifically, the Honeywell gas chromatograph routine was modified to enable the sampling of oxygen in Stage 3 product gas instead of ethane, which is currently being sampled. Oxygen for Stage 3 product gas will be read via the A2D from an oxygen analyzer (Beckman Model 755) independent of the Honeywell gas chromatograph. Equations used to calculate both J- and K-type thermocouples were changed to provide greater accuracy for the temperature ranges being utilized. Constants used to calculate gas flows were changed to match corresponding orifice changes. Also, the Honeywell gas chromatograph was calibrated and the total analysis time lengthened; the Honeywell sampler routine was modified to reflect these changes. A utility listing program for the Honeywell gas chromatograph, "HW8012", now includes a printout of the heating value, in Btu's, for the product gases.

(2) Scientific Computing: Previously developed computerized mathematical models of the TRI-GAS process continue to be available for generating simulated runs of the PEDU. No changes were made to TRIKM.

B. Visitors During January, February, and March 1980

January 29, 1980

Chang Bi-Jiang
Deputy Chief of Laboratory of
Chemical Engineering

Bao Han-Chen
Vice Director

Huang Ke-Quan
Chief of Laboratory of Separation

Yang Gui-Lin
Associate Professor
Institute of Coal Chemistry
Chinese Academy of Sciences
P. O. B. 165
Taiyuan, Shanxi, CHINA

C. Trips and Meetings During January, February, and March 1980

None

D. Papers Presented During January, February, and March 1980

None

V. WORK PLAN AND SCHEDULE

A. Work Schedule

Work on the fluidized-bed gasification PEDU will continue according to the Milestone Plan attached.

B. Work Planned for April, May, and June 1980

A three-stage PEDU test is scheduled for the week beginning March 31, 1980. Five more tests will be conducted providing there are no further delays.

Laboratory tests will continue.

U. S. ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION
MILESTONE PLAN AND MANAGEMENT REPORT

PAGE OF

1. Contract Identification TEST & EVALUATE TRI-GAS PROCESS		2. Reporting Period Jan. 1, 1980 through Mar. 31, 1980		3. Contract Number DE-AC21-80ET10254	
4. Contractor (name, address) Bituminous Coal Research, Inc. 350 Hochberg Road Monroeville, PA 15146				5. Contract Start Date October 21, 1977	
				6. Contract Completion Date June 30, 1980	
7. Identification Number	8. Reporting Category (e.g., contract line item or work breakdown structure element)	9. Fiscal Years and Months			10. Percent Complete
		<div style="display: flex; justify-content: space-around;"> <div>FY 1978</div> <div>FY 1979</div> <div>FY 1980</div> </div> <div style="display: flex; justify-content: space-around; font-size: small;"> <div> O N D J F M A M J J A S O N D J F M A M J J A S O </div> <div> O N D J F M A M J J A S O N D J F M A M J J A </div> <div> O N D J F M A M J J A </div> </div>			
1	Reactor Modification				100
2	Additions to Coal Preparation Area				100
3	Stage 3 Testing				100
4	Integrated 3-Stage Operations				45
5	Devolatilization in Stage 1				
	Oxidizing Atmosphere				95
	Reducing Atmosphere				20
6	Laboratory Studies				80
7	Final Report				0
11. Remarks					
12. Signature of Contractor's Project Manager and Date		13. Signature of Government Technical Representative and Date			
 3/31/80					

8.

INTERMEDIATE EVENT LOG

Contract No.
DE-AC21-80ET10254

Event No.	Description	Comments
1 A	Modification of Stage 3 Reactor Completed	
1 B	Modification of Stage 1 Reactor Completed	
1 C	Modification of Stage 2 Reactor Completed	
2 A	Pavement of Driveway and Storage Pad Completed	
2 B	Installation on Conveyors and Coal Dryer Completed	
3 A	Testing in Stage 3 at Moderate Temperatures (1500-1600 F)	
3 B	Testing in Stage 3 at High Temperatures (1700-1900 F)	
4 A	Complete Testing with Noncaking Coals (Montana Rosebud)	
4 B	Complete Testing with "Mild Caking" Coals (Illinois No. 6)	
4 C	Complete Testing with "Highly Caking" Coals (Pittsburgh Seam)	
5 A	Devolatilization of Noncaking Coal in an Oxidizing Atmosphere; No Treatment of Products. Task 5.1	
5 B	Devolatilization of Noncaking Coal in an Oxidizing Atmosphere; Products Treated in Gasification Stage 2. Task 5.2	
5 C	Devclatilization of Caking Coal in an Oxidizing Atmosphere; No Treatment of Products. Task 5.5	
5 D	Devolatilization of Caking Coal in an Oxidizing Atmosphere; Products Treated in Stage 2. Task 5.6	

INTERMEDIATE EVENT LOG (continued)

Contract No.
DE-AC21-80ET10254

<u>Event No.</u>	<u>Description</u>	<u>Comments</u>
5 E	Devolatilization in Reducing Atmosphere, Noncaking Coals, No Treatment of Products. Task 5.3	
5 F	Devolatilization in Reducing Atmosphere, Noncaking Coals, Treatment of Products in Stage 2. Task 5.4	
5 G	Devolatilization in Reducing Atmosphere, Caking Coals, No Treatment of Products. Task 5.7	
5 H	Devolatilization in Reducing Atmosphere, Caking Coals, Treatment of Products in Stage 2. Task 5.8	
6	Laboratory Studies in Support of PEDU Operation	
7	Final Report Preparation	

DISTRIBUTION LIST - Report FE-10254-78

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Contracting Officer	(1 copy)
Dr. P. Raymond Hsia	(1 copy)
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