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**DEVELOPMENT OF AN ADVANCED, CONTINUOUS MILD
GASIFICATION PROCESS FOR THE PRODUCTION OF CO-PRODUCTS**

**Quarterly Report
for the Period October 1, 1992 - December 31, 1992**

By

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EXECUTIVE SUMMARY

A 70-pound continuous coke sample was prepared for testing by a major conventional coke producer. Test results were encouraging, but a suggestion was made to produce larger briquettes. Work is underway to produce 6" x 5" x 3.75" briquettes with plans to crush these briquettes to plus 2-inch x minus 3-inch irregular shaped coke.

Work continued to provide a coke reactivity test instrument at CTC. A new vessel was fabricated of Haynes HR-160 which will withstand temperatures up to 2300°F.

A total of 11 CMGU test runs were completed. Coal feed rates of over 1000 pounds per hour for short periods were obtained. Average feed rates of over 800 pounds per hour were reached for two test runs. The jet burners heating the insides of the screws' shafts made these higher rates possible.

Three test runs were made using 28 x 100 mesh Penelec filter cake with the objective of upgrading this coal processing by-product to coke.

Improvements to the PDU continued with two condensers' modifications and improved packing gland seals.

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INTRODUCTION

Petroleum currently accounts for over 42% of the total energy consumption in the United States; over 40% of the petroleum consumed in the United States is imported from foreign countries. The remaining oil reserve available in the United States is less than 6% of proven recoverable fossil energy reserves while over 90% of the proven recoverable reserves are coal (1)*. Total coal resources in the United States are estimated to be more than 3.9 trillion tons (2). Just the demonstrated reserves, that is, the deposits that are proven and can be economically mined using today's technologies and mining techniques amount to 488 billion tons. At an annual production rate of 900 million tons per year, the demonstrated reserves alone will last more than 500 years. In view of the very abundant coal reserves and limited petroleum reserves, it would seem prudent to make good use of coal in our evermore difficult pursuit of energy independence.

Devising a continuous reactor system that can deliver a good quality co-products which require only minimal upgrading before being marketed is a major challenge. At present, mild gasification reactor configurations tend to fall into two broad categories: circulating or fluidized bed types characterized by high heating rates (up to 10,000 °C per second, or fixed or moving bed types characterized by slow (on the order of 0.2 to 0.5 °C per second) heating rates. Circulating or fluidized-bed types produce high liquid yields at the expense of quality. Fixed or moving-bed types produce better quality liquids but in lesser quantities. An optimum reactor is envisioned as one which avoids the secondary reactions associated with slow heating rates and the quality problems associated with high heating rates. Importantly, an optimum reactor would be capable of processing highly caking coals. The reactor concept under investigation in this effort is an advanced derivative of a reactor once used in prior commercial practice which approaches the characteristics of an optimum reactor.

It is important that a mild gasification reactor interface easily with the subsequent product upgrading steps in which the market value of the products is enhanced. Upgrading and marketing of the char are critical to the overall economics of a mild gasification plant because char is the major product (65 to 75% of the coal feedstock). In the past, the char product was sold as a "smokeless" fuel, but in today's competitive markets the best price for char as a fuel for steam generation would be that of the parent coal. Substantially higher prices could be obtained for char upgraded into products such as metallurgical coke, graphite, carbon electrode feedstock or a slurry fuel

*Numbers in parentheses indicate the reference listed at the end of this report.

replacement for No. 6 fuel oil. In this effort, upgrading techniques are being developed to address these premium markets. Liquid products can similarly be upgraded to high market value products such as high-density fuel, chemicals, binders for form coke, and also gasoline and diesel blending stocks. About half of the non-condensable fuel gases produced by the gasification process will be required to operate the process; the unused portion could be upgraded into value-added products or used as fuel either internally or in "across the fence" sales.

The primary objective of this project is to develop an advanced continuous mild gasification process and product upgrading processes which will be capable of eventual commercialization. The program consists of four tasks. Task 1 is a literature survey of mild gasification processes and product upgrading methods and also a market assessment of markets for mild gasification products. Based on the literature survey, a mild gasification process and char upgrading method will be identified for further development. Task 2 is a bench-scale investigation of mild gasification to generate design data for a larger scale reactor. Task 3 is a bench-scale study of char upgrading to value added products. Task 4 is being implemented by building and operating a 1000-pound per hour demonstration facility. Task 4 also includes a technical and economic evaluation based on the performance of the mild gasification demonstration facility.

TASK 1. LITERATURE SURVEYS AND MARKET ASSESSMENT

Objective

The objectives of this Task are: (1) to identify the most suitable continuous mild gasification reactor system for conducting bench-scale mild gasification studies; (2) to identify the most feasible chemical or physical methods to upgrade the char, condensibles and gas produced from mild gasification into high profit end products; and (3) to assess the potential markets for the upgraded products from this process.

Summary

This task was completed and the Topical Report was submitted and approved by the DOE in January 1988 (3).

TASK 2. BENCH-SCALE MILD GASIFICATION STUDY

Objective

The objective of Task 2 is to study mild gasification in bench-scale reactor(s) to obtain the necessary data for proper design of the one ton/hour mild gasification screw reactor in Task 4.

Summary

After much consideration, it was concluded that it would not be necessary or desirable to build a bench-scale reactor. Instead, data and experience from Dr. David Camp's single screw reactor at Lawrence Livermore National Laboratory provided much useful information for the design of the reactor for this project. In addition, the information available from the literature on the eight years of operation of the Hayes process at Moundsville, West Virginia and the earlier Lauck's screw reactor supplied valuable process design data.

TASK 3. BENCH-SCALE CHAR UPGRADING STUDY

A 70 pound continuous coke sample was made and sent to a major producer of conventional coke for comparative evaluation. The sample was very well received and an encouraging reply was given. One negative comment was the size of the briquette. Our present 1x2.5x1.75 briquette is smaller than preferred and makes some of the standard testing invalid. Plans have been made to make 6x5x3.75 briquettes which will then be broken. These broken briquettes will then be sized to plus 2 inch minus 3 inch which is

the preferred size for use in the blast furnace. In addition to being the correct size, the irregular shape will make the continuous coke look more like conventional coke.

A new reactivity vessel was designed and built out of a high temperature alloy, Haynes HR-160, which will withstand the temperature of the reactivity test. Ten shake down tests were then run first to fine tune the temperature cycle and then to compare test results of samples with known test values. Another test was then run, the temperature recorded, and the temperature vs. time graphed (see Figure 1).

Char made from Penelec coal fines is presently being studied to determine the suitability for making blast furnace coke with it. Three samples have been made and tested. The best has a CSR of 48.7 and a CRI of 34.1. We plan to continue testing until a CRI of 30 or 31 is achieved which will be more attractive to the steel industry.

TASK 4. 1000 LB/HR CONTINUOUS MILD GASIFICATION UNIT (CMGU)

Test runs 42-92 through 52-92 were completed during the 4th Quarter of 1992. Top priority was given to determination of the coal pyrolyzing capacity of the CMGU with the jet burners installed. The design capacity of 1000 lbs coal/hr was set as a goal. Feed rates surpassing the goal were obtained for short durations and average feed rates of 800 lbs coal/hr were reached during test runs 49-92 and 50-92. Test run 49-92 was made using Red Ash coal and test run 50-92 used 28 x 100 mesh Penelec filter cake.

Test runs not only provided information about different coals, but emphasis was given to obtain data for design of a commercial sized plant. Efforts to determine the minimum required heat input (minimum natural gas flow) to pyrolyze coal at a given rate are underway. During test run 52-92, the total heat input was lowered from 1.6m Btu/hr to 1.1m Btu/hr at constant coal feed rate which is a 31% decrease. Increasing the proportion of the total heat input that is provided by the jet burners should increase the thermal efficiency of the PDU.

A total of 8,000 pounds of 28 x 100 mesh Penelec filter cake was pyrolyzed in three test runs. The filter cake was dried from 40% moisture down to less than 4% in a heated screw dryer before pyrolyzing. The objective of this work is to upgrade coal fines produced in coal processing to blast furnace coke and by-product coal liquids. The finer than normal coal feed created no processing problems in the PDU.

Improvements to the PDU included installation of sloped bottoms on two condensers as was previously done for one of the three

condensers. The sloped bottoms improve drainage of coal liquids and tar. Also, the screws' shafts packing glands were improved to provide better seals at the pyrolyzer end plates.

A handwritten signature in cursive script, reading "Glenn W. O'Neal".

Glenn W. O'Neal
Project Manager

CTC Reactivity Test CSR/CRI

<u>X Data</u>	<u>Vessel Series 1</u>	<u>Furnace Series 2</u>
0:00	17	15
	20	137
	228	492
0:20	471	748
	765	856
	907	943
	1011	1025
0:40	1075	1078
	1095	1096
	1101	1101
	1102	1103
1:00-Start CO ₂	1102	1104
	1102	1104
	1098	1100
	1096	1100
1:20	1095	1100
	1095	1099
	1094	1099
	1094	1100
1:40	1094	1100
	1095	1099
	1095	1100
	1095	1100
2:00	1096	1100
	1096	1101
	1097	1101
	1097	1102
2:20	1097	1102
	1097	1102
	1097	1102
	1098	1103
2:40	1099	1103
	1099	1104
	1100	1104
	1100	1105
3:00 - End CO ₂	1100	1105
	1100	1104

FIGURE 1

END

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