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

**Quarterly Report
for the Period January 1, 1993 - March 31, 1993**

By

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EXECUTIVE SUMMARY

Formed coke development continued with char derived from Penelec filter cake and a coking coal blend from Koppers Industries. Good to excellent coke was obtained from both coals.

A total of eight CMGU test runs were completed. Obtaining the maximum thermal efficiency of the pyrolyzer and producing char in the 8% to 12% volatile matter range were the main objectives for these test runs. The design capacity of 1000 lbs/hr coal feed was demonstrated for longer durations.

CMGU improvements included alterations to the screw feeder and condenser system.

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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

During the first quarter of 1993, eight different coke tests were made. These tests were done using materials from two different potential partners in a scaled up commercial coke venture, Penelec and Koppers.

The work with Penelec filter cake resulted in coke with a CRI of 34.0 and a CSR of 51.2. One hundred and forty pounds of green briquettes and 60 pounds of coke were sent to Penelec for their evaluation. An independent consultant for Penelec has advised them that coke of this quality can be sold all over the world.

A 70 pound sample of continuous coke sized to +2" -3" for the coke tumble test ASTM D3402-81 was made and sent to Koppers Industries for their evaluation. This coke sample was made by making large briquettes 6" x 5" x 3 1/2" , crushing them, and screening them to the desired size. The results of the stability test which these briquettes were made for was a 70.2. Stability greater than 60 is considered good so this coke was very good. Proven data and technology used in making the 2 3/4" x 1 3/4" x 3/4" briquettes will have to be slightly modified to produce the optimum larger coke briquette.

Another sample of standard size continuous coke was made using a blend of Koppers conventional coking coals with CTC's continuous coke process and tested by Koppers. The test results were:

V.M.	.54
F.C.	92.48
Ash	6.98
Sulfur	.59
Stability	65.9
Hardness	69.1
Reactivity	7.0

These test results are very good, in fact, better than conventional coke made from the same feed coal. A reactivity of 12 on the Bethlehem method is considered acceptable, 7.0 is excellent.

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

Test runs 1-93 through 8-93 were completed during the first quarter of 1993. Penelec coal fines, Pocahontas #3, and a Koppers' coking coal blend were used as feed coals.

Emphasis was given to determine the minimum heat input to pyrolyze coal to a volatile matter (VM) content in the range of 8% to 12%. Reductions in the range of 25% to 33% were achieved by using an on-off controller connected to the zone 2 bottom heater. Decreasing the natural gas supply pressure to the screws' jet burners from 3 psig to 1 psig also increased the thermal efficiency of the pyrolyzer.

The pyrolyzer design capacity of 1000 lbs/hr coal feed was reached several times during this quarter. Priority was given to produce char with a given VM content which prevented prolonged operation at 1000 lbs/hr or greater coal feed rates.

Improvements to the CMGU included alteration of the feed screw to form a vapor blocking plug and removal of a rate limiting star valve. Work also continued to improve the condensers and to determine the minimum condenser capacity needed.

Accumulated coal liquids were distilled to separate water up to 250°F vapor temperature, organic compounds up to 500°F vapor temperature, and the residue. The residue is being evaluated as a binder in formed coke preparation.

Glenn W. O'Neal
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