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

Quarterly Report
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By

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EXECUTIVE SUMMARY

The coke reactivity test furnace was installed and checked. Design of a long lasting reaction vessel is underway with emphasis on material of construction for elevated temperatures. Development of a formed coke formula is continuing in preparation of a 70 pound sample for evaluation by a major conventional coke producer.

Ten CMGU test runs were made. Most of the quarter was used to replace the pyrolyzer screws, check-out the screws' pulse burners, and replace the screws' stub shafts. The objective of the determination of the pyrolyzer maximum capacity with the internal screws' heaters should be achieved in October 1992.

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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-condensible 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

The reactivity test furnace and controls were received and installed. Equipment shakedown has been completed. Operation parameters are being refined to achieve the greatest accuracy and repeatability. The present reaction vessel is quickly deteriorating and will have a short life. Material has been ordered to make a replacement vessel. The material ordered is Hayes HR-160 with an operating temperature up to 2300°F. This vessel should last indefinitely. This test equipment is state of the art totally automated, and requires no operator decisions.

A modest amount of work was done to duplicate our better coke. A 70 pound sample is being prepared to send to a major producer of conventional coke for comparative evaluation.

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

During the third quarter of 1992, the number of test runs was limited to ten due to mechanical problems. Failure of one screw five times was the major problem. Two new screws were fabricated using 310 stainless steel schedule 80 stem pipes instead of 304 schedule 40 stem pipes. Welding procedures were followed that retained the high temperature strength of the 310 alloy.

New discharge end stub shafts were also fabricated using six inch 310 stainless steel pipe. The design was changed to minimize machining to provide maximum shaft wall thickness. The strength of the stub shafts now should match that of the screws.

Insulation in the stub shafts is required to prevent over heating of the bearings by the pulse burners installed on the discharge end of the pyrolyzer. The original insulation was a caulk type ceramic material. Water is used in the insulation to make the material flowable or pumpable. This water must be evaporated in the curing period at elevated temperatures. The stub shaft design did not provide adequate escape of the water and the liner pipe collapsed due to high steam pressure generated by high temperatures of the pulse burners' flames entering the shafts through the stub shafts. The new stub shafts were insulated with a 1 inch thick alumina blanket material which eliminated water and the need for curing. The blanket has a 25% greater insulation capability and a 400°F higher maximum temperature rating than the previously used pumpable insulation.

Efforts are continuing to improve the pyrolyzer condenser systems to increase the efficiency of the condensers and to prevent condensation of water with the coal liquids.

The coal dryer fabricated using a 20 feet long 6 inch diameter screw and a surplus hopper is working well. The drying capacity of 700 lbs/hr of coal at 8% moisture to 2.8% was achieved by using stainless steel machine turnings attached to the top of the screw housing for increased heat transfer area and insulation to lower heat loss to the atmosphere.

The previously stated objective of determining the maximum capacity of the pyrolyzer with the pulse burners heating the inside of the screws is still current. This should be accomplished during October.

Sincerely,

Glenn W. O'Neal

Glenn W. O'Neal
Project Manager