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Development of an Advanced, Continuous Mild Gasification Process for the Production of Co-Products

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EXECUTIVE SUMMARY

Formed coke was made using char made from Cedar Grove coal which had a CRI of 33.2 and a CSR of 59.4. This coke met commercial specifications. Improvements on form coke development work will result in a planned petrographic study of binder coals. The resulting database will be of value in selecting binder coal for a given char.

Seventeen pyrolyzer test runs using two readily available coals, Lady H and Cedar Grove were completed in the Third Quarter of 1993. Pyrolyzer design capacity of 1000 pounds per hour of coal feed was demonstrated in several test runs. Improvements to the condenser systems were made. Obtaining environmental impact data continued.

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, condensables 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

Coke was made using coal from the Cedar Grove seam. The Cedar Grove seam is one of the largest in West Virginia and could be the coal that gives the best economics in making coke. The results of this test were a CRI of 33.2 and a CSR of 59.4. These results are acceptable for commercial coke.

In discussions with Hoogovens, a large worldwide manufacture of coke ovens and coke, an interesting theory emerged. They agree that higher CSR values indicate better coke but it is their opinion that CSR values of over 58 are not of enough added value to justify any additional cost. Using this approach, cokes with CSR values greater than 58 can

be manipulated to create better economics as long as a minimum CSR value of 58 is maintained.

Plans have been made to do a petrographic study of binder coals next month. After a thorough study of prior form coke work and extensive work at CTC including 172 coke briquette tests CTC engineers have excellent knowledge on the characteristics required in a binder coal, probably the best in the world. However, maximizing the binder coal contribution to the coke product will allow a minimum of pitch or asphalt in the coke which is crucial to the economics of a commercial venture.

Coal Petrographics and their staff have agreed to work with CTC personnel of this petrographic study of binder coals. In addition to petrographic expertise, Coal Petrographics will provide access to one of the biggest and most complete data bases on coal specifications in the world. After this study is complete, choosing binder coals that meet the specifications required will be much improved and expanded with the help of this data base.

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

Seventeen CMGU test runs were completed in the third quarter of 1993. Lady H coal at 27–28% VM and Cedar Grove coal at 32–33% VM were the sources of all feed coal except for one run. This run used only about 700 pounds of Peerless coal.

Coal feed rates of 1000 plus pounds per hour are now achievable when desired. Test runs of 8 hour durations can be scheduled with a good degree of confidence. Longer test runs are feasible if necessary to achieve worthwhile objectives. Slower feed rates are sometimes used to study characteristics of different coals. Chars with VM contents in the range of 8.8% to 15% have been produced for form coke development work.

Efforts are ongoing to design a surface type condenser to separate pyrolyzer off gases into tar or pitch for form coke production, a heavy oil fraction for fuel end use, a light oil fraction for possible chemical recovery, and non–condensable gases for process fuel requirements. Modifications to the experimental condenser installed on the pyrolyzer were made to improve performance.

Samples of the non–condensable gases were analyzed and no problems are anticipated in meeting environmental requirements.

Extension of the contract to develop a process to produce coke from the pyrolyzer char and tar has been requested. The extension will allow use of the pyrolyzer products in a needed end product.

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