CALDERON COKEMAKING
PROCESS/DEMONSTRATION PROJECT

Quarterly Report

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QUARTERLY TECHNICAL PROGRESS REPORT
CALDERON COKEMAKING PROCESS/DEMONSTRATION PROJECT
CALDERON ENERGY COMPANY
COOPERATIVE AGREEMENT NO. DE-FC22-95PC92638

Reporting Period: 5-26-98 to 8-25-98

Date of Report: 9-22-98; Award Date: 5-25-95; Anticipated Completion Date: 11-25-99

Total Project: \$ 7,354,195.00 Total DOE Share: \$3,039,389.00

Contracting Officer's Representative (COR): Dr. Michael J. Baird;

Project Director: Albert Calderon

Abstract

This project deals with the demonstration of a coking process using proprietary technology of Calderon, with the following objectives geared to facilitate commercialization:

- (i) making coke of such quality as to be suitable for use in hard-driving, large blast furnaces;
- (ii) providing proof that such process is continuous and environmentally closed to prevent emissions;
- (iii) demonstrating that high-coking-pressure (non-traditional) coal blends which cannot be safely charged into conventional by-product coke ovens can be used in the Calderon process; and
- (iv) demonstrating that coke can be produced economically, at a level competitive with coke imports.

The activities of the past quarter were focused on the following:

- Consolidation of the project team-players;

- Recruiting Koppers Industries as an additional stakeholder;
- Developing a closed system for the production of binder pitch from tar in the Calderon coking process as the incentive for Koppers to join the team;
- Gathering appropriate equipment for conducting a set of experiments at bench scale to simulate tar quality produced from the Calderon coking process for the production of binder pitch; and
- Further progress made in the design of the commercial coking reactor.

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Introduction

The commercialization path of the Calderon cokemaking process consists of the following general phases:

- Phase I-- Proof of capability to produce acceptable product coke, proof of the process being environmentally closed, proof that non-conventional coal blends can be used, and proof that coke can be economically produced domestically using U.S. metallurgical coals at a level competitive with low cost-producer coke produced from foreign countries that are not subjected to U.S. environmental standards.
- Phase II-- Scale-up of coking reactor to full commercial size (PDU-II) in support of first commercial facility.
- Phase III-- Construction and operation of first commercial facility.
- Phase IV-- Worldwide commercialization of the technology to produce coke competitive with that produced by low-cost producer coke-exporting countries.

Accomplishments and Discussion

During the past quarter the work was focused on the consolidation of the team and further progress made in the design of the commercial coking reactor. At the successful conclusion of the tests which were conducted in the fall of 1997 in Alliance, Ohio, both Bethlehem and U.S. Steel decided to conduct an economic assessment of the Calderon cokemaking process. Such assessment was completed and it showed that the Calderon process will make a ton of coke lower than competition by a minimum of \$8.20 and a maximum of \$23.33.

In November 1997 (following the successful results in Alliance) Calderon received a letter from Koppers dated November 4, 1997, regarding the possibility of using tar from our process to produce binder pitch (letter is attached). The goal of the Calderon process is to have an entirely closed system and originally the tars were to be cracked. In view of Koppers' interest in the tar, an approach had to be found wherein the generation of tar would still maintain the Calderon process closed. Such approach was developed and is titled "Calderon Process for the Co-Production of Coke, Electrode Grade Pitch & Power"; this paper is enclosed. A secrecy agreement between Koppers and Calderon was negotiated and executed, and this approach was disclosed to Koppers.

In view of the approach to the question of the binder pitch, a visit of the Alliance, Ohio test site, and meetings with the other stakeholders, namely, Bethlehem Steel, Bechtel and Calderon, Koppers requested a list of items as a pre-condition to becoming a member of the team. These items were officially put in written form in a second letter dated September 10, 1998 (letter is attached). The first item in the list included the conducting of a set of experiments in conjunction with Calderon, to simulate tar quality from the Calderon coking process. Calderon gathered the equipment needed to conduct such tests and made arrangements for shipment of a coal blend from Koppers Monessen coke plant; and also arrangements were made with Cast Masters (a Bowling Green, Ohio foundry) for making use of induction furnaces for the pyrolysis of the coal and for the cracking of the volatile matter at 1900°F. A diagram of the equipment, titled "Calderon Process Equipment for Koppers Test at Cast Masters Bowling Green, Ohio" is shown in the last page of this report.

In addition to the above activities, further work relating to the design of the commercial reactor has taken place. Heat transfer calculations have shown that the insulation between the shell and tile

was inadequate, and had to be increased. Such increase demanded the increase in the diameter of the shells, the anchoring mechanism and the gas distribution from one of the burners to the flues of the tile.

Conclusion

The details of the team formation are being worked out and the activities for the next quarter will focus on the following:

- The conducting of the tests for Koppers in September;
- The formation of the team with letters of commitment from the stakeholders in October;
- The request for U.S. Government contribution of its share for the project filed with DOE.
- The detailed engineering for the project begun.

Submitted by:

Albert Calderon
Project Director

Koppers Industries, Inc.
1005 William Pitt Way
Pittsburgh, PA 15238

Telephone: (412) 826-3970
FAX: (412) 826-3999

November 4, 1997

Mr. Albert Calderon
P.O. Box 126
Bowling Green, OH 43402

Dear Mr. Calderon:

Because of current conditions in the U. S. coking industry, the production of coal tar is declining. Consequently, Koppers Industries Inc., a producer of binder pitch, has been actively searching out feedstocks to replace the shortfall from current coking operations. As part of that effort, we would like to meet with you to discuss the possibility of using tar from your coking process as feedstock for binder pitch production.

Bob Wombles, Vice President, Technology, and I could meet with you at your location sometime during the next few weeks. Please let me know when you are available so we can arrange a visit. My phone number is 412/826-3972 and the Fax number is 412/826-3999.

Hope to meet you soon.

Very Truly Yours,

A handwritten signature in dark ink, appearing to read "Ken Krupinski", written in a cursive style.

Ken Krupinski
Senior Research Scientist

CALDERON PROCESS FOR **THE CO-PRODUCTION OF COKE,** **ELECTRODE GRADE PITCH & POWER**

The overall scheme is illustrated in the attached Figure and pertinent details are discussed below.

Coking. The coking operation is carried out at pressure so as to provide hot fuel gas to the combined cycle power production without further compression. The scheme illustrated employs indirect heating of the coker walls with a hot flue gas. The flue gas is produced and employed at a pressure close to that of the coker to minimize leakage through the joints of the coker wall tiles. Recycle of the flue gas is employed to provide the flue gas mass flow and also to moderate the gas temperature resulting from near stoichiometric combustion of the gas. A slip stream of the low O₂ content flue gas is used to transport, to dry and to preheat the coal feed to the individual cokers. The pressurized flue gas vent is combined with the hot gas feed to the combined cycle combustion turbine.

Coke Soaking and Quenching. With the short contact time and high heat flux employed in the coker retort the exiting coke will have a wide temperature gradient. It is allowed to reach a temperature equilibrium in a soaking chamber before quenching. Additional heat is supplied to the coke bed during this soaking by a downward flow of hot gas produced by air addition. A portion of the pyrolysis gas is also drawn downward to avoid air dilution of the net rich gas produced. The product coke is quenched with water and then withdrawn from the pressure system through a water flooded lock hopper.

Tar Recovery and Pitch Stripping. The hot rich gas from the coking is cooled and its tar content condensed by contact with a cooled spray of recycle tar. This quench temperature is adjusted to achieve the best recovery of the heavy pitch components. The spray contactor is designed to maintain totally tar wet surfaces to avoid fouling with polymerizing materials. The fluid recycle of tar is cooled in a steam generator and may be filtered or processed through a hydroclone which is needed to reject entrained char fines. The net tar product is then stripped with a counter flow of a portion of the hot gas from the coke soaker to reject the lower boiling volatile components. The stripping device may be a trayed or packed column or a thin film evaporator as needed to obtain proper heat treating of the product pitch. The hot stripping gas may be passed through a cyclone or filter if needed for char fines rejection.

Fuel Gas Treating. The partially cooled rich gas from the tar recovery is combined with the effluent gas from the tar stripper and excess gas from the coke soaker and contacted with hot lime for destruction of the tar constituents and removal of sulfur. Air is added to the cracker feed stream if needed for added gas preheat. The lime from the cracker is contacted with air (and possibly some steam) in the regenerator. This oxidation in contact with carbon deposited on the lime (from the hydrocarbon cracking) produces elemental sulfur which is recovered from the regenerator off gas by cooling. The regenerator tail gas is used to transport the cracker bottoms lime to the regenerator. Lime fines are separated from the gas which is then burned to provide heat for the coking.

Combined Cycle Power Generation. The hot treated gas from the cracker is combined with the net flue gas vent from the coking and raised in temperature by combustion with air in the combustion turbine. The turbine air compressor also provides combustion air for the above process needs. The turbine exhaust provides heat for the steam cycle of the power generation.

Economic Tradeoffs. The use of air combustion in the coke soaking can reduce the required number of cokers but will also reduce the total coke made by the quantity oxidized in the soaking. This may appear as a reduction in coke fines (breeze) if the fines are preferentially burned and may have a beneficial overall economic impact. The pitch recovery requires the removal of heat from the hot rich gas, and such removal of heat is recovered as steam which may be used for power generation.

CALDERON ENERGY COMPANY		
COKE AND PROCESS AIR FLOW		
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Koppers Industries, Inc.
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Pittsburgh, PA 15238

Telephone: (412) 826-3870
FAX: (412) 826-3833

September 10, 1998

Albert Calderon
500 Lehman Avenue
Bowling Green, OH 43402

Dear Albert:

Koppers Industries is currently evaluating participating on the team to develop and commercially demonstrate the Calderon continuous coking process. If the final decision is made by Koppers to participate, the following is the list of items Koppers would like to receive in return for its financial and intellectual contributions:

- Conduct in conjunction with Calderon Energy a set of experiments to simulate tar quality from the continuous coking process
- Exclusive access to coal liquids from commercial plants
- Opportunity to own/operate Calderon coke plants
- Global involvement in the business of owning/operating Calderon coke plants
- A four reactor plant at Monessen with 75% federal funding
- Lead the business opportunities with aluminum companies if a mega-facility is built

It is my goal to have Koppers' evaluation and a decision regarding our participation made in early October.

Sincerely,

A handwritten signature in black ink that reads "Robert H. Womble".

Robert H. Womble
Vice President, Technology

CALDERON PROCESS EQUIPMENT FOR KOPPERS TEST AT CAST MASTERS BOWLING GREEN, OHIO