

DOE/PC/91160--T7

**DEVELOPMENT AND TESTING OF
A HIGH EFFICIENCY ADVANCED COAL COMBUSTOR
PHASE III INDUSTRIAL BOILER RETROFIT**

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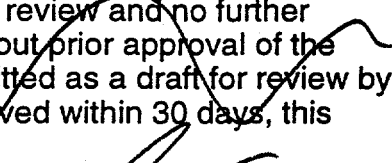


Table of Contents

Executive Summary	1
1.0 Introduction	2
2.0 Task 1 Design, Fabricate and Integrate Components	2
3.0 Task 2 Preliminary System Tests at ABB Combustion Engineering	2
4.0 Task 3 Proof of Concept Tests at Penn State	2
4.1 Summary of Quarterly Activities	2
5.0 Task 4 Economic Evaluation and Commercialization Plan	3
6.0 Task 5 Site Demonstration	3
6.1 Summary of Quarterly Activities	3
6.2 Next Quarter's Plan	3
7.0 Task 6 Decommission Facility	3
8.0 Task 7 Project Management	3
 Attachment I Executive Summary of the "Task 3 Topical Report"	

Executive Summary

The objective of this project is to retrofit the previously developed High Efficiency Advanced Coal Combustor (HEACC) to a standard gas/oil designed industrial boiler to assess the technical and economic viability of displacing premium fuels with microfine coal. This report documents the technical aspects of this project during the fourteenth quarter (January '95 through March '95) of the program.

During this reporting period, the "Task 3 Topical Report" was completed. This report was transmitted to DOE-PETC as a draft for their review. The executive summary of the "Task 3 Topical Report" is attached with this quarterly report (Attachment I). Based on all the results obtained to date the ABB/Penn State team and DOE/PETC have decided to conduct a 1000 hr demonstration test (Task 5).

A technical paper "Experimental Testing of a Retrofit Industrial Sized Burner Using Microfine Coal" was prepared and presented at the 20th International Technical Conference on Coal Utilization & Fuel Systems, in Clearwater, during March 20-23, 1995.

The ABB project team met with cognizant DOE-PETC and Penn State personnel on February 15, 1995 at Penn State to discuss our ideas for a new burner (RSFC-based) to replace the HEACC burner prior to the long term (~1000 hrs) demonstration phase of this project. The main reasons for the proposed new burner were to improve combustion efficiencies and NOx reduction. Recent, experience at MIT with 5 million Btu/hr coal firing experiments on RSFC burner have shown remarkable performance. Results indicate that RSFC-based burner has the potential to produce lower NOx and higher carbon conversion efficiencies than the HEACC burner. M.I.T. developed the RSFC burner and obtained a patent for the concept. A decision was made to go with the new, RSFC-based burner during 1000 hr demonstration. ABB-CE will fund the costs (~\$50K) for design /fabrication of the proposed new burner. Penn State plans to improve coal handling by installation of a gravimetric feeder and redesign /installation of a mass flow bottom on the surge bin.

Work has began on outlining how the demonstration (Task 5) can be carried out to maximize the information that is needed to satisfy project objectives.

During the next quarter we plan to complete the design/drawings for the new microfine coal burner, and complete fabrication. It is also planned to complete preparation of a detailed plan for data procurement during the 1,000 hr demonstration phase of the program and initiate testing in July 1995.

1.0 Introduction

The objective of this project is to retrofit the previously developed High Efficiency Advanced Coal Combustor (HEACC) to a standard gas/oil designed industrial boiler to assess the technical and economic viability of displacing premium fuels with microfine coal. A complete microfine pulverized coal milling and firing system will be retrofitted to an existing 15,000 lb/hr package boiler located in the East Campus Steam Plant of the Pennsylvania State University.

Following a brief burner confirmation test at ABB/CE's Power Plant Laboratories, the complete retrofit milling and firing system at Penn State will be run for a total of 400 hours on microfine coal to obtain performance and economic data for comparison against a base fuel (natural gas) case. Pending acceptable technical and economic results, a 1000 hour test will then be run under normal user demands to evaluate the system's capability to perform acceptably under field conditions. It is expected that a successful outcome of this program will help facilitate the acceptance of clean coal technology by American industry. The technical approach chosen for this program, namely direct firing of dry microfine pulverized, low ash coal is the fastest track technology available to displace significant quantities of oil and natural gas in industrial equipment.

2.0 Task 1 Design, Fabricate and Integrate Components

Complete

3.0 Task 2 Preliminary System Tests at ABB Combustion Engineering

Complete

4.0 Task 3 Proof-of-Concept-Tests at Penn State

4.1 Summary of Quarterly Activities

During this reporting period, the "Task 3 Topical Report" was completed. This report was transmitted to DOE-PETC as a draft for their review. Based on all the results obtained to date the ABB/Penn State team and DOE/PETC have decided to conduct a 1000 hr demonstration test (Task 5).

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Results indicate that RSFC-based burner has the potential to produce lower NOx and higher carbon conversion efficiencies than the HEACC burner. M.I.T. developed the RSFC burner and obtained a patent for the concept. A decision was made to go with the new, RSFC-based burner during 1000 hr demonstration. ABB-CE will fund the costs (~\$50K) for design /fabrication of the proposed new burner. Penn State plans to improve coal handling by installation of a gravimetric feeder and redesign /installation of a mass flow bottom on the surge bin.

5.0 Task 4 Economic Evaluation and Commercialization Plan

No work was scheduled or performed during this quarter.

6.0 Task 5 Site Demonstration

6.1 Summary of Quarterly Activities

Work has began on outlining how the demonstration Task can be carried out to maximize the information that is needed to satisfy project objectives.

6.2 Next Quarter's Plan -

Complete final design for new microfine coal burner, prepare drawings, and complete the fabrication. Complete preparation of detailed plan for data procurement during the 1,000 hr demonstration phase of the program.

7.0 Task 6 Decommission Site

No work was scheduled or performed during this quarter.

8.0 Task 7 Project Management

During this reporting period, work included the preparation of required technical, scheduler and financial monthly and quarterly reports. Started preparation/planning of the demonstration phase (Task 5) of this program scheduled to begin in July 1995.

Attachment - I

**Executive Summary
of the "Task 3 Topical Report"**

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**PROOF OF CONCEPT TESTING SUMMARY
(TASK 3.0)**

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March 1995

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Executive Summary

Economics may one day dictate that it makes sense to replace oil or natural gas with coal in boilers that were originally designed to burn oil or gas. In recognition of this future possibility the U.S. Department of Energy, Pittsburgh Energy Technical Center (PETC) has supported a program led by ABB Power Plant Laboratories in cooperation with the Energy and Fuels Research Center of Penn State University to develop the High Efficiency Advanced Coal Combustor (HEACC). The objective of the program is to demonstrate the technical and economic feasibility of retrofitting a gas/oil designed boiler to burn micronized coal.

In support of the overall objective the following specific areas were targeted:

- A coal handling/preparation system that can meet the technical requirements for retrofitting microfine coal on a boiler designed for burning oil or natural gas.
- Maintaining boiler thermal performance in accordance with specifications when burning oil or natural gas.
- Maintaining NO_x emissions at or below 0.6 lb NO₂ per million Btu.
- Achieving combustion efficiencies of 98% or higher.
- Calculating economic payback periods as a function of key variables.

The work carried out under this program is broken into five major Tasks:

- 1.0) Review of current state-of-the-art coal firing system components.
- 2.0) Design and experimental testing of a prototype HEACC burner.
- 3.0) Installation and testing of a HEACC system in a retrofit application.
- 4.0) Economic evaluation of the HEACC concept for retrofit applications.

5.0) Long term demonstration under user demand conditions.

This report summarizes the work done under Task 3, the installation and testing of the HEACC burner in a 15,000 lb/hr package boiler located at Penn State. The period of testing was approximately 400 hours. Key findings were as follows:

Coal Handling/Preparation

A coal handling/preparation system can be designed to meet the technical requirements for retrofitting microfine coal in an oil or gas designed boiler.

Coal handling problems were experienced during the execution of Task 3. The problems were due to a combination of extreme weather conditions, i.e. the winter of '93/'94, and the design of some of the equipment used at the Penn State site. Raw coal was stored outside. Because of extreme snowfall, considerable quantities of ice and/or snow were contained in the coal shipments that were received in the raw coal hopper at the Penn State site. Those components in the coal handling system that were most sensitive to coal moisture were the surge hopper and the screw feeder. There were times when Penn State personnel had to break up large coal/ice chunks to get them through the grate above the raw coal receiving hopper. The surge hopper was prone to plugging when the crushed coal was wet and operation of the screw feeder was also adversely affected by coal that had a high moisture content. Since the coal preparation/feed system was of a direct fired type, i.e. coal was fed to the microfine coal pulverizer and then directly to the burner, any hang-ups in the feed system to the mill caused interruptions in the coal feed to the burner.

Two changes to the components most affected by the wet coal were recommended: (1) the surge bin bottom should be converted to a mass-flow design, and (2) the volumetric screw feeder should be replaced with a gravimetric feeder. These two changes would prevent problems due to "normally" wet coal. The point here is that some of the conditions experienced were beyond the normal realm of expected weather-related conditions. Under such adverse conditions even those who routinely handle coal would have and did have problems during the winter of '93/'94. It is acknowledged that better (covered) storage of the raw coal before shipping would have gone a long way toward alleviating the problems experienced.

The aforementioned changes to the most affected components will have been completed before the 1000 hour demonstration is initiated.

Boiler Thermal Performance

Boiler thermal performance when firing microfine coal was essentially comparable to that achieved when firing natural gas. In fact because of the greater latent heat loss when burning natural gas (greater formation of water due to higher hydrogen content) firing microfine coal actually gave slightly higher boiler efficiencies despite the need to run at higher excess air levels.

During the relatively short operating periods, usually less than 16 hours, ash deposits did not cause significant changes to the boiler thermal performance. However it is recognized that longer term operation could result in greater build-up of ash deposits which could impact heat transfer. Because of the relatively short duration of the tests any build-up of ash deposits would slough off when the boiler was shut down. A better test of the possible impacts of ash deposits will occur during the long term demonstration phase of the work (Task 5).

NOx Emissions

The NOx emission target was 0.6 lb NO₂ per million Btu fired; this translates to about 450 ppm. Testing with 100% microfine coal showed that this target can be met while meeting nearly all other required conditions. A NOx value of 0.56 lb NO₂ per million Btu was routinely obtained. It is acknowledged that the optimum conditions for low NOx will generally exacerbate carbon conversion efficiencies. Indeed, this was the case with the HEACC burner and the challenge was to find a reasonable balance between meeting the NOx target while not aggravating the carbon conversion efficiency.

Combustion Efficiency

The target for combustion efficiency was 98%. The highest combustion efficiency obtained during testing in Task 3 was slightly over 96%. However, this value was not compatible with meeting the NOx target and was not able to be routinely repeated. A value of 95% combustion efficiency was able to be routinely achieved and was

compatible with meeting the NOx target.

Considerable effort was spent in trying to determine how combustion efficiency might be improved to meet the target. The challenge to meet the combustion efficiency target of 98% is, indeed, a very difficult one. The bulk boiler residence time is about 0.7 seconds. Further complicating the task is the aspect ratio of the boiler, i.e. the length of the boiler is not very much greater than its height or width (approximately 8 ft long x 8 ft high x 6 ft wide). It is likely that the particle residence time is even shorter than the bulk residence time, which further aggravates the situation. Burner modifications are being looked at which might increase the particle residence time.

Coal particle size distribution was also evaluated, the premise being that carbon content must be directly proportional to particle size. While the larger particle size fraction of the collected particulate did contain higher carbon contents than the smaller size fractions the differences were not as great as expected. For example, it would not be possible to dramatically reduce the carbon content of the fly ash by eliminating coal particles larger than 150 microns.

Interestingly, when the economic analysis was done the difference in payback period between 98% combustion efficiency and 95% combustion efficiency was negligible.

From the standpoint of ash disposal and possible impacts that carbon content might have on ash disposal it should be noted that 98% carbon conversion would result in an ash with about 40% carbon whereas 95% carbon conversion would result in an ash with about 60% carbon. It is doubtful that this difference would affect disposal, i.e. if it is alright to dispose of 40% carbon ash it is probably alright to dispose of 60% carbon ash also.