Quarterly Technical Progress Report
for the period ending March 31, 2002

METHANE de-NOX® for Utility PC Boilers

Covering Period: January 1, 2002 to March 31, 2002

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ABSTRACT

The project seeks to develop and validate a new pulverized coal combustion system to reduce utility PC boiler NO_x emissions to 0.15 lb/million Btu or less without post-combustion flue gas cleaning. Work during previous reporting periods completed the design, installation, shakedown and initial PRB coal testing of a 3-million Btu/h pilot system at BBP's Pilot-Scale Combustion Facility (PSCF) in Worcester, MA. Based on these results, modifications to the gas-fired preheat combustor and PC burner were defined, along with a modified testing plan and schedule.

During the current reporting period, BBP's subcontract was modified to reflect changes in the pilot testing program, and the modifications to the gas-fired preheat combustor were completed. The Computational Fluid Dynamics (CFD) modeling approach was defined for the combined PC burner and 3-million Btu/h pilot system. Modeling of the modified gas-fired preheat combustor was also started.

EXECUTIVE SUMMARY

Project Objectives: The overall project objective is the development and validation of an innovative combustion system, based on a novel coal preheating concept prior to combustion, that can reduce NO_x emissions to 0.15 lb/million Btu or less on utility pulverized coal (PC) boilers. This NO_x reduction should be achieved without loss of boiler efficiency or operating stability, and at more than 25% lower levelized cost than state-of-the-art SCR technology. A further objective is to make this technology ready for full-scale commercial deployment in order to meet an anticipated market demand for NO_x reduction technologies resulting from the EPA's NO_x SIP call.

Background: Conventional measures for NO_x reduction in PC combustion processes primarily rely on combustion modifications and post combustion controls. In general, combustion modification technologies try to reduce the formation of NO_x precursors while destroying already-formed NO_x. A variety of NO_x reduction technologies are in use today, including Low-NO_x Burners (LNB's), flue gas recirculation (FGR), and gas or other fuel reburning. Selective Non-Catalytic Reduction (SNCR) and Selective Catalytic Reduction (SCR) are post combustion techniques. NO_x reduction efficiencies from these technologies vary from 30 to 60%, with up to 90% for SCR.

A novel pulverized coal-preheating approach for NO_x reduction has been developed by the All Russian Thermal Engineering Institute (VTI), in Russia, for use on PC utility boilers. The technology consists of a burner modification that preheats pulverized coal to elevated temperatures (up to 1500°F) prior to coal combustion. This releases coal volatiles, including fuel-bound nitrogen compounds, into a reducing environment, which converts the coal-derived nitrogen compounds to molecular N_2. The quantity of natural gas fuel required for PC preheating is in the range of 3 to 5% of the total burner heat input. Basic combustion research and development of the preheat PC burner was conducted by VTI in the early 1980's. Following these promising laboratory results, commercial-scale coal preheat burners of 30 and 60 MW_t capacity were developed and demonstrated in field tests conducted in several Russian power stations.

The advanced pulverized coal (PC) preheat combustion system being developed in this project for direct-fired PC boilers combines the modified VTI preheat burner together with elements of IGT's successful METHANE de-NOX technology for NO_x reduction. METHANE de-NOX has been commercially demonstrated on coal, MSW and biomass-fired stoker boilers in the U.S. and Japan. Overall, the new PC preheat system combines several NO_x reduction strategies into an integrated, low-NO_x, PC combustion system, including a novel PC burner design using natural gas-fired coal preheating, and internal and external combustion staging in the primary and secondary combustion zones. This integrated system can achieve very low NO_x levels – down to 0.15 lb/million Btu – without the complications, limitations and expense of SCR or SNCR technology.

Work during previous reporting periods completed the design, installation, shakedown and initial PRB coal testing of a 3-million Btu/h pilot system at BBP's Pilot-Scale Combustion Facility (PSCF) in Worcester, MA. Analysis of test data demonstrated that the PC Preheat process has a significant effect on final NO_x formation in the coal burner and that the mechanism by which this is effected is not directly controlled by the final preheat temperature but rather by the residence time of the coal in the high temperature region within the gas-fired preheat combustor. A second significant determination from testing was that the PC burner design utilized was not optimally constructed for low-NO_x combustion of the preheated char and pyrolysis products generated in the preheat combustor. Modifications to the PC Preheat pilot system gas-fired combustor and PC burner were determined to be necessary in order to test the full potential of the PC Preheat process for NO_x reduction. A revised testing plan and schedule was also developed to complete the pilot-scale testing and development activities.

During the current reporting period, BBP's subcontract was modified to reflect changes in the pilot testing program, and the modifications to the gas-fired preheat combustor were completed. The Computational Fluid Dynamics (CFD) modeling approach was defined for the combined PC burner and 3-million Btu/h pilot system. Modeling of the modified gas-fired preheat combustor was also started.

Project Status:

EXPERIMENTAL

Task 1.1 *Pilot-Scale Design*

All work in this task is complete.

Task 1.2 *CFD Modeling*

Several modeling tasks were started during the period:

The modeling approach for the original VTI-designed PC-burner coupled with the BBP pilot-scale furnace was defined during the reporting period. This model will be validated using the operating data collected during PRB coal testing to date, and will then be adjusted to evaluate a modified PC burner design optimized for use with preheated pulverized coal.

Development of the computational mesh for the modified gas-fired combustor was completed during the quarter. Combustor modifications are required to increase the residence time of the pulverized coal in the high temperature region of the combustor. In addition to increasing the length of the combustion chamber, a set of secondary gas inlets was added partway down the chamber from the coal inlet to reheat the pyrolysis products after initial devolatilization (See Figures 1 and 2).

Modeling of the 100-million Btu/h PC Preheat prototype will be started once pilot-scale operating data analysis is completed.

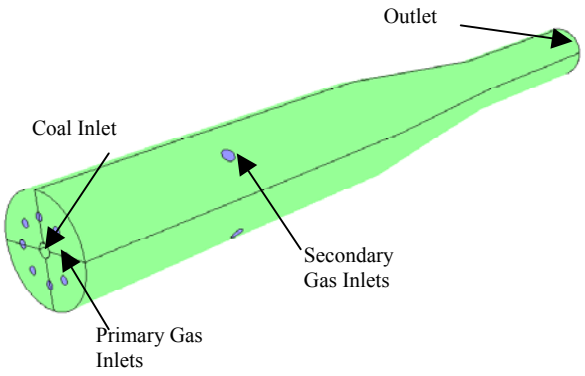

Figure 1. Modified gas-fired combustor design for the PC Preheat pilot-scale test

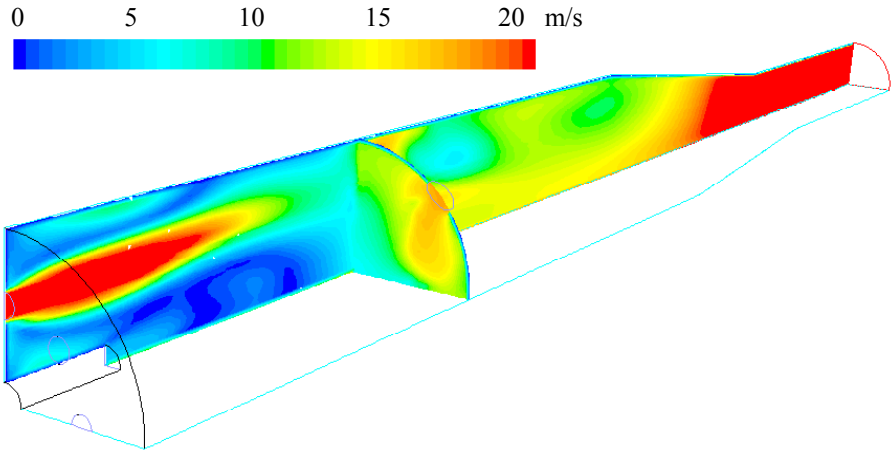

Figure 2. <u>Preliminary Results</u>: Velocity Contours for the Simulation of Quarter of the System

Task 1.3 *Pilot-Scale Equipment Fabrication and Installation*

<u>PCP Combustor Pretesting</u>

All work in this task is complete.

<u>Pilot Test Unit Installation at BBP</u>

Fabrication, installation and shakedown of the original pilot-scale PC Preheat system equipment are complete. Based on initial testing of this system, a modified gas-fired combustor design was

developed for the pilot test system. Fabrication of the modified combustor was completed during the reporting period.

Task 1.4 *Pilot-Scale Testing*

No testing was conducted during the reporting period while the previous test data was evaluated and modifications to the pilot unit were developed. The proposed sequence of steps to complete the pilot testing is as follows:

- Extend the existing gas-fired preheat combustor chamber to double the design residence time and add a tangential gas combustion stage about half way down the extended chamber to maintain elevated preheat temperature throughout the chamber. These modifications are complete.
- Conduct up to 3 days of testing with PRB coal to confirm proper operation of the modified combustor and characterize NO_x reduction.
- Modify the existing PC burner to provide a distributed, internally-staged flame
- Complete testing with remaining PRB coal to characterize NO_x reduction for the modified preheat combustor and burner system.
- Conduct PCP pilot tests with the other test coals, Central Appalachia, Southern Appalachia and Illinois Basin.

Task 1.6 Task 1 Management and Reporting

Work during the quarter included project review and planning correspondence with VTI and BBP, modification of the BBP subcontract to accommodate changes in the pilot test program, and preparation of the quarterly report.

Plans for Next Quarter:

- Execute the modified subcontract with BBP
- Install the modified gas-fired combustor and make combustion tests with PRB coal
- Initiate PC Burner modifications
- Present project results to date at the NETL SCR/SNCR conference in Pittsburgh, PA on May 15-16.

Milestone Status Table: The planned completion dates for all project tasks and major milestones are shown in the following table.

ID No.	Task / Milestone Description	Planned Completion	Actual Completion	Comments
♦	Kickoff Meeting	5/2/2000	5/2/2000	Complete
1.0	Technology Development			
1.1	Pilot-Scale Design	8/31/2000	12/31/2000	Complete
1.2	CFD Modeling-Pilot and Commercial Scale	6/30/2001		Modeling modified pilot-scale combustor and burner
1.3	Pilot-Scale Equipment Fabrication and Installation	11/30/2000	9/30/2001	Initial equipment installation complete
1.4	Pilot-Scale Testing	3/31/2001		PRB testing in progress
1.5	Pilot-Scale Data Evaluation	4/30/2001		PRB test data processing in progress.
1.6	Task 1 Management and Reporting	4/30/2001		Completion expected 9/2002
♦	Task 1 Report	4/30/2001		Completion expected 9/2002
2.0	Technology Validation			
2.1	Commercial Prototype Engineering Design	7/31/2001		
2.2	Baseline Data Review	7/31/2001		
2.3	Commercial Prototype Construction	10/31/2001		
2.4	Commercial Prototype Testing	2/15/2002		
2.5	Data Processing and Evaluation	3/31/2002		
2.6	Commercialization Plan Development	6/15/2002		
2.7	Design and Fabrication of Commercial Burner System	7/31/2002		
2.8	Task 2 Management and Reporting	8/10/2002		
♦	Final Report	8/10/2002		