Quarterly Technical Progress Report
for the period ending September 30, 2001
METHANE de-NOX[®] for Utility PC Boilers

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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 the quarter included completion of the equipment fabrication and installation efforts for the 3-million Btu/h pilot system at BBP's Pilot-Scale Combustion Facility (PSCF) in Worcester, MA. Final selection of the first two test coals and preliminary selection of the final two test coals were also completed.

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 by 2002-2003 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 N₂. 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.

Status:

EXPERIMENTAL

Task 1.1 Pilot-Scale Design

The pilot-scale system design development was completed and reported during the 4th quarter of 2000.¹

Task 1.2 CFD Modeling

Development of a CFD model of the PC preheater was completed during the 4th quarter of 2000, along with the modeling study of the 3-million Btu/h pilot-scale PC Preheat combustor. Modeling of the 100-million Btu/h PC Preheat prototype system, including the PCP gas combustor, the coal burner and the BBP test furnace, will be started once pilot-scale operating data is available.

Task 1.3 Pilot-Scale Equipment Fabrication and Installation

PCP Combustor Pretesting

Proof-of-performance testing of the pilot-scale natural gas-fired PCP combustor in IGT's combustion laboratory was successfully completed during the 2nd quarter of 2001². The PCP combustor was then disassembled, shipped to and installed at BBP's research facility in Worcester, MA for integrated testing with pulverized coal.

Pilot Test Unit Installation at BBP

Fabrication of the of the PC separator (Figure 1) for the pilot scale PC Preheat test unit was completed during the current quarter. The PC separator will be used in a later stage of pilot-scale testing simulating direct-fired PC systems typical of U.S. PC power plants. As of the end of the quarter, all pilot-scale equipment and controls have been delivered to BBP's Pilot Scale Combustion Facility (PSCF) and installation on the refurbished 3-million Btu/h test furnace was nearing completion (See Figure 2). An updated P&ID for the pilot unit is shown in Figure 3. Details of the PC Preheat pilot unit installation status are as follows:

1. All equipment (see attached P&ID) has been located and placed in the facility.
2. Primary air fan piping is complete and insulated.
3. F.D. Blower piping is complete and insulated.
4. PC Preheater Fan piping is complete (no insulation required).

¹ Quarterly Technical Progress Report for the period ending December 31, 2000
"METHANE de-NOX[®] for Utility PC Boilers," DE-FC26-00NT40752

² Quarterly Technical Progress Report for the period ending June 30, 2001
"METHANE de-NOX[®] for Utility PC Boilers," DE-FC26-00NT40752

5. Rotary Airlock installation is complete.
6. Mixer (Item #1) installation is complete.
7. Compensator (Item #2) is installed; packing is not yet installed.
8. NG Combustor (Item #3) is installed and all piping interconnections (flexible hoses) prepared. TE installation and insulation remains to be done.
9. 1st Preheater (Item #4) is installed and cooling air connections complete. TE installation is underway. Two additional TEs will be added to monitor metal skin temperature.
10. 2nd Preheater (Item #6) is installed. Three additional TEs will be added to monitor metal skin temperature. TE installation is underway. Anchor support at base of 2nd Preheater is in place.
11. PC Burner (Item #7) installation is complete. TE installation in progress.
12. Nitrogen gas supply completed to NG Combustor ports.
13. Natural Gas piping is complete. Electric power wired to safety shutoff valves and solenoid.
14. All system transmitters are mounted; pressure impulse lines are installed; signal cables are routed and terminated.
15. TE installation as noted is currently in progress. TEs are to be mounted so that the element's tip is flush or slightly protrudes into the pipe inside surface.

Figure 1. PC separator components for direct-fired testing of the 3-million BTU/h PC Preheat test unit at BBP's Pilot Scale Combustion Facility (PSCF) in Worcester, MA

Figure 2. Gas-fired PCP combustor installed at the PSCF with natural gas and air piping and controls

The major effort thus far has concentrated on installation of the PC Preheat equipment and control hardware. The balance of pilot plant equipment such as coal handling and flue gas conditioning components are also ready to operate. Final functional checks will be completed during the week of October 1.

Configuration of control logic and data acquisition is practically complete. BBP provided sample displays for GTI comment. All data is handled through the data logger, which via a digital link transmits process values to a PC. PC displays are updated every 3 seconds with instantaneous data; archived data stored on the hard disc consists of 1 minute averages (i.e. an average of 20 instantaneous values). BBP's data handling also includes generation of test report sheets. BBP's software permits selection of test periods ranging from 3 to 15 minute intervals. A test data report consists of a summary of key operating and performance data and a listing of average process values.

The control of the pilot scale facility is performed in a manual mode. A minimum of 4 to 5 operators are envisioned to run a test (at least initially); one in the control room, one monitoring the furnace and flue gas conditioning operation, two monitoring the PC preheat system and another to monitor system data in the control room.

Sample provisions currently include the furnace exit gas, which is located after the furnace cooler (350°F). Accessibility to preheater sample ports is available at the center via movable platforms.

Task 1.4 Pilot-Scale Testing

Pilot operation of the PCP unit with two modes of pulverized coal delivery, a bin storage delivery system and a direct-fired delivery system will be evaluated. Key operating variables to be tested are coal type, preheat temperature and coal residence time at temperature prior to the coal combustor.

Shakedown and initial testing will be conducted with a non-caking PRB coal. GTI located a source for PRB coal from Hennepin Power Station in northern Illinois. This coal is Rochelle/North Antelope from the Wyodak-Anderson seam in Wyoming and has a Free Swelling Index of 0.0.

Following shakedown and testing with PRB coal, testing will be conducted with a Central Appalachian coal from SW Virginia. Samples of this coal were obtained for analysis in BBP's lab.

An analysis was obtained for a Southern Appalachian coal, which showed a volatile matter content in the range of 30%, similar to the Central Appalachian coal. It was decided to look for a coal with a lower volatile matter content - on the order of 20%. It was also decided to use a medium to high sulfur coal such as Illinois No. 5 for the fourth test coal.

Task 1.5 Pilot-Scale Data Evaluation – No Activity

Task 1.6 *Task 1 Management and Reporting*

Work during the quarter included project review and planning correspondence with VTI and BBP, follow-up with the DOE COR for a scheduled increase in the project's funding obligation, increasing the BBP and VTI subcontract funding obligations, and preparation of the quarterly report.

Plans for Next Quarter:

October 1-5: Complete coal feeder calibration, leak check piping, zero and span XTs, verify TE signals, bump motors, stroke control valves, tag instruments/valves, test igniter, zero and span gas analyzers, issue operating procedure, verify operational readiness of water jacket flows and conduct cold flow tests.

October 8-12: Light off NG Combustor and igniter, finalize start up procedure, finalize operator displays and comments to data acquisition system, calibrate coal feeder.

October 15: Start pilot tests with PRB coal. A total of 24 days of testing is planned with the selected coals. Testing is expected to continue through most of next quarter, with personnel from GTI, BBP and VTI participating.

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		Pilot-scale modeling complete
1.3	Pilot-Scale Equipment Fabrication and Installation	11/30/2000	9/30/2001	Equipment installation complete
1.4	Pilot-Scale Testing	3/31/2001		Testing to start 10/2001
1.5	Pilot-Scale Data Evaluation	4/30/2001		Completion expected 1/2002
1.6	Task 1 Management and Reporting	4/30/2001		Completion expected 1/2002
◆	Task 1 Report	4/30/2001		Completion expected 1/2002
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		