Project Status Report for: April 2000

Project Title: Ultra Low NOx Integrated System for Coal-Fired Power Plants

Project Number: 91890460 **Report Manager:** John Marion

Customer Name: U.S. DOE / Performance Projects **Project Leader:** Charles Maney

GOALS AND OBJECTIVES:

Develop low cost, retrofit NO_x control technologies to address current and anticipated, near term emissions control legislation for existing coal fired utility boilers. Specific goals include:

- Achieve < 0.15 lb/MMBtu NO_x for eastern bituminous coals
- Achieve < 0.10 lb/MMBtu NO_x for western sub-bituminous or lignitic coals
- Achieve economics at least 25% less than SCR-only technology
- Validate NOx control technology through large (15 MWt) pilot scale demonstration
- Evaluate the engineering feasibility and economics for representative plant cases
- Provide input to develop commercial guidelines for specified equipment
- Provide input to develop a commercialization plan for the resultant technologies

WORK PLANNED FROM PREVIOUS REPORT:

During the month of April, additional developmental and project management activities were planned to occur, focusing on test facility preparation, firing system design (burners and OFA / modeling), and control system & algorithm development. Specific planned task work included:

Task 2.1 – Test Fuels Characterization

- Select test fuels / obtain samples for bench scale analyses

Task 2.2 – Low NOx Pyrolysis Burners

- Complete engineering design of Low NOx Pyrolysis Burners for large pilot scale testing

Task 2.3 – Global Mixing Process Improvement

- Converge baseline case with particle radiation coupling to match measured furnace outlet temperature. Compare predictions with experimental measurements. Initiate execution of additional cases to investigate the impact of Separated Overfire Air (SOFA) velocity and location.

Task 2.4 – Advanced Control System Design

- Order coal flow meters and initiate Carbon in Ash sensor material procurement.
- Complete pre-test multi-variable analysis and preliminary neural net modeling activities based on the historical BSF data.
- Begin MatLab / Simulink air and fuel flow balancing controller modeling.

Task 3.1 – Test Planning & Facility Preparation

- Complete repairs to BSF water jacket and waterbed enclosures.
- Inspect / clean scale from the inside of the BSF hopper bottom.
- Perform a detailed evaluation of the status of all, required BSF Instrumentation and Control (I&C) systems and prepare an I&C project planning worksheet.

Additional related activities include completion of a plan to upgrade / replace the existing BSF DCS control system, and initiation of the related capital appropriation request.

Task 4 – Carbon Burnout System Evaluation

- Execute subcontract agreement with Progress Materials
- Select field unit for CBO™ system evaluation study.

Task 5 – Engineering Systems Analysis & Economics

- Initiate review of preliminary (proposal) economic evaluation of currently identified components to the Ultra-low NOx Integrated System.

Task 6 – Advisory Panel

- Schedule / confirm date for first Advisory Panel meeting.

ACCOMPLISHMENTS FOR REPORTING PERIOD:

Task 2.1 – Test Fuels Characterization

- *Select test fuels / obtain samples for bench scale analyses*

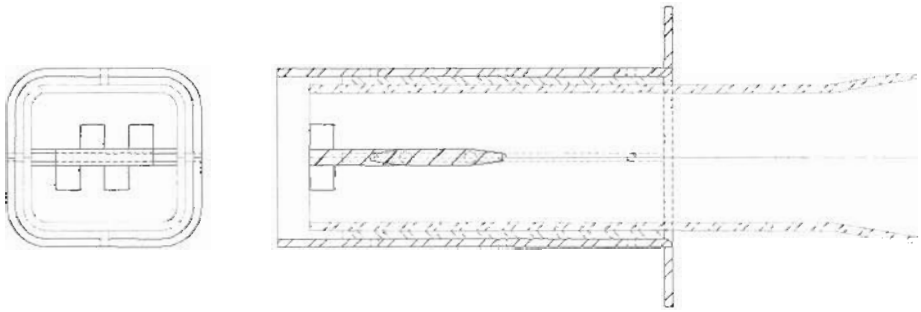
The schedule for selection of the test fuels was postponed to correspond to the timing for the first advisory panel meeting (May 24, 2000) in order to obtain advisory panel input on the selections.

Task 2.2 – Low NOx Pyrolysis Burners

- *Complete engineering design of Low NOx Pyrolysis Burners for large pilot scale testing*

An LNCFS™-P2 based low NOx pyrolysis burner design has been generated for use in the large pilot scale (BSF) test campaign. In all, three tip sizes will be fabricated to support testing a range of transport air to fuel ratios at constant nozzle exit velocity as a means to reduce near field stoichiometry for lower NOx.

A drawing of the selected test facility tip design is provided below.



LNCFS™-P2 Low NOx
Pyrolysis Coal Nozzle Tip

Task 2.3 – Global Mixing Prccess Improvement

- *Converge baseline case with particle radiation coupling to match measured furnace outlet temperature. Compare predictions with experimental measurements. Initiate execution of additional cases to investigate the impact of Separated Overfire Air (SOFA) velocity and location.*

The baseline TFS 2000™ model of US PPL's Boiler Simulation Facility (BSF) was converged using a grid of 430,000 cells, matching the measured furnace outlet temperature. A second, parametric case was also run with higher SOFA velocity. At approximately one CPU month each, the run time of these cases was, however, longer than desired for parametric evaluation of OFA system modifications.

Two strategies were employed to decrease the simulation time required for the parametric SOFA evaluations. First, a baseline simulation using a coarse grid of 155,000 cells was run to compare the impact of grid size on the penetration and mixing of the SOFA. The other approach was to generate a grid of the BSF starting at a plane between the main windbox outlet and the SOFA inlets. Then, the boundary conditions of the large baseline case were patched into the upper furnace model. This approach results in a more detailed model of the upper furnace that is approximately 1/2 the size of the baseline model.

Predictive accuracy and runtime for the new models will be compared to the original design and a selection made for use in the parametric runs in May.

- *Order coal flow meters and initiate Carbon in Ash sensor material procurement.*

A purchase order was placed for procurement of a PfMaster on-line pulverized fuel measuring system manufactured by ABB Kent Taylor for use in the large pilot scale test program. This system, which will include 12 x 50 mm (~2") pulverized fuel flow sensors, will measure the absolute transport line velocity and temperature, and relative pulverized fuel concentration to each of the 12 coal nozzles on the BSF. During testing it will be used to evaluate the effectiveness of transport air and fuel balancing on NOx, CO, and UBC emission as applied to the TFS 2000™ low NOx firing system.

PfMaster

- *Complete pre-test multi-variable analysis and preliminary neural net modeling activities based on the historical BSF data.*

Historical data from the 1995 / 1996 Low Emissions Boiler System (LEBS) BSF test campaign has been reviewed and analyzed. As there were only approximately one hundred data records and dozens of potential modeling parameters, this data has proved to be marginal for neural net development purposes. Consequently, this effort has been suspended pending retrieval of additional data via the planned combustion testing. In the interim, secondary approaches, including investigating the possibility of obtaining field (commercial) operating data will be considered to meet this need.

- *Begin MatLab / Simulink air and fuel flow balancing controller modeling.*

The MatLab/Simulink controller modeling and Simulink effort was initiated.

Task 3.1 – Test Planning & Facility Preparation

- *Complete repairs to BSF water jacket and waterbed enclosures.*

Repairs were made to BSF water jacket including repair of several access ports and one simulated economizer tube. The existing waterbed enclosures have been removed and surfaces have been prepared for installation of new components.

In addition, vendor quotes are being sought for replacement of the simulated superheater division panels, which were found to have failed since the last time the facility was used. Repairs to these panels must be finished before the hydro testing of the BSF water jacket can be completed.

- *Inspect / clean scale from the inside of the BSF hopper bottom.*

The inside of the BSF hopper bottom was inspected and 2 of 12 sections were cleaned. In lieu of completing this work, it was decided to begin repair on the main test facility flue gas heat exchanger to take advantage of down time in the operation of a related pilot scale test facility in April. The remainder of the hopper clean-up work will be performed in May.

- *Perform a detailed evaluation of the status of all, required BSF Instrumentation and Control (I&C) systems and prepare an I&C project planning worksheet.*

A detailed evaluation of the status of required BSF Instrumentation and Control (I&C) systems was performed and an I&C project planning worksheet was generated. Preparatory activities including evaluation of the status of all required, existing sensing and control systems has begun.

Additionally, a capital request was completed to upgrade and replace the existing DCS in order to provide more efficient and effective control for the combustion testing. The capital request was approved at all necessary levels and purchase orders for the DCS parts and graphics conversions were made.

Task 4 – Carbon Burnout System Evaluation

- *Execute subcontract agreement with Progress Materials*

Final agreement was reached on the terms of the CBO™ system evaluation work scope and a requisition was written to Progress Materials to cover their costs.

- *Select field unit for CBO™ system evaluation study.*

Pursuant to the terms of the subcontract, CE and Progress Materials will select a mutually agreed to field unit on which to perform the CBO™ system study during the month of May.

Task 5 – Engineering Systems Analysis & Economics

- *Initiate review of preliminary (proposal) economic evaluation of currently identified components to the Ultra-low NOx Integrated System.*

Work on developing a preliminary cost comparison between various low NOx control systems has started. The systems currently under considerations are:

1) Base case,
2) TFS 2000™,
3) TFS 2000™ plus advanced control system,
4) TFS 2000™ plus advanced control system plus coal reburn,
5) TFS 2000™ plus advanced control system plus coal reburn plus SNCR,
6) TFS 2000™ plus advanced control system plus coal reburn plus SCR,
7) TFS 2000™ plus SCR,
8) SCR only, and
9) CBO™ only and in combination with select cases from above.

Task 6 – Advisory Panel

The first advisory panel meeting is scheduled to occur on Wednesday May 24, 2000 in Windsor, CT. The agenda for the meeting, and a list of panel members is as follows:

Agenda:

9:00 am	Introductions
9:15 am	Project Overview
10:30 am	Break
10:45 am	Product(s) and Technology(s) Resulting from Project
12:00 pm	Lunch
1:00 pm	Tour of US Power Plant Facilities
2:00 pm	Case Study Selections
3:30 pm	Open Issues/ Discussion

Panel Members:

Ian Andrews, PacifiCorp,
Janos Beér, Massachusetts Institute of Technology,
Ed Bowes, Virginia Power,
James Topper, Consumers Power,
Peter Hay, Progress Materials, Inc.,
Robert Hilton, ABB Environmental Systems,
Soung Kim, United States Department of Energy,
Jerry Piskorowski, Indianapolis Power & Light,
Chris Smith, Performance Projects, ABB Alstom Power, and
Jerry Urbas, Sithe Energy

WORK PLANNED FOR NEXT REPORTING PERIOD:

Task 2.1 – Test Fuels Characterization

- The test fuels (one bituminous and one subbituminous) will be identified in May as part of the initial Advisory Panel meeting.

Task 2.2 – Low NOx Pyrolysis Burners

- A draft layout of the main windbox compartment nozzles arrangement and separated overfire air elevations for use in the arge pilot scale testing will be generated in May.

Task 2.3 – Global Mixing Process Improvement

- Evaluation of the two reduced run time modeling approaches will be completed in May. In addition, the SOFA modeling matrix will be finalized and parametric case runs initiated.

Task 2.4 – Advanced Control System Design

- Secondary approaches to obtain data for neural net model development will be investigated
- Continue MatLab / Simulink air and fuel flow balancing controller modeling
- Complete engineering design of fuel and air flow control system for large pilot scale testing

Task 3.1 – Test Planning & Facility Preparation

- Pursuant to Milestone #5, General Test Facility Preparation, check-out of the BSF plumbing / mechanical and electrical systems will be completed in May. Planned work includes:

  Plumbing / Mechanical

  - Remove rust accumulation from the BSF hopper bottom,
  - Complete the integrity testing of the "V – Hopper,"
  - Refurbish waterbed compartments,
  - Remove, clean, & lubricate the 18" secondary air windbox dampers,
  - De-scale the windbox plenums & compartment ducting,
  - Inspect and lubricate main windbox compartment dampers,
  - De-slag BSF water jacket ports for next "hydo-test,"
  - Initiate the replacement of the superheater division panel tubes,
  - Inspect the main secondary air flow ducting (FD fan to BSF),
  - Inspect all air & water utility plumbing systems,
  - Inspect the coal transport lines,
  - Cleaning the coal feeder (Thayer) & housing in preparation for future maintenance,

  Electrical

  - Test individual DCS I/O blocks,
  - Test main power circuits to BSF / related equipment,
  - Inspect / operate electronic dampers (air heater, and secondary air flow control)
  - Inspect / operate facility fans (FD & ignitor)
  - Schedule vendor for direct fired air heater (Maxon), coal feeder (Thayer) and soot blower maintenance / check-out

Task 4 – Carbon Burnout System Evaluation

- The field unit for CBO™ cost / performance evaluation will be selected. In addition, preliminary CBO™ cost and performance data will be transferred from Progress Materials to CE.

Task 5 – Engineering Systems Analysis & Economics

- Continued development of a preliminary cost comparison between various low NOx control systems will be performed. Design parameters for the systems will be developed. Methodology for economic analyses will be proposed.

Task 6 – Advisory Panel

- The first advisory panel meeting will be held in Windsor, CT on May 24, 2000.