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Establishment of an Environmental Control Technology Laboratory with a Circulating Fluidized-Bed Combustion System

Quarterly Technical Progress Report

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ABSTRACT

This report is to present the progress made on the project “Establishment of an Environmental Control Technology Laboratory (ECTL) with a Circulating Fluidized-Bed Combustion (CFBC) System” during the period April 1, 2006 through June 30, 2006. Substantial progress was made on the development and application of software for the effective operation and safe control of the Circulating Fluidize-Bed (CFB) Combustor, as well as for the display and logging of acquired data and operating parameters.

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1. EXECUTIVE SUMMARY

Substantial progress on the Data Acquisition and Process Control systems has been made. Computer interface components that provide for the gathering and recording of system operating data and for establishing operating parameters has been specified, ordered, and received. In addition, the interface components are used to control the operating parameters necessary for the safe and efficient operation of the Circulating Fluidized-Bed Combustion (CFBC) System.

2 EXPERIMENTAL AND RESULTS

2.1 Design and Manufacture of CFBC Facility

The Institute for Combustion Science and Environmental Technology (ICSET) has an electrical engineer employed on staff who is well experienced in computer programming. The staff electrical engineer has been assigned to develop an operator interface consisting of a visual display and control panel for the Circulating Fluidized-Bed (CFB) Combustor. Associated with this assignment is the development an operating program that acquires, displays on multiple screens, and records operating data. Additionally, the operator interface provides for establishment of set points for operation and provides feedback as operational limits are approached.

A computer work station and computer interface components that provide for the gathering and recording of system operating data and establishing of operating parameters has been specified, ordered, and received. Computer programming has been coordinated to make the best use of these interfaces and the various sensors and actuators that are employed. These interface components, for example, enable temperatures at many critical points throughout the CFBC System to be measured, displayed, and recorded. Pressures and many flow rates, such as fuels, bed material, ash, all combustion air supplies, and coolants are acquired in a similar manner.

Referring to Figure 1, 13 analog-to-digital (ADC) interface modules are shown that accept direct sensor signals from, for example, thermocouples or pressure transducers. Also, these interfaces apply control signals to, for example, variable speed motor drives or to solenoid valves. Each of the interface modules is located in the vicinity of a group of sensors and actuators, which are in turn located at various points along the CFBC system. Sensor and control data are communicated digitally from each ADC module to a computer work station located in the control room where an operator supervises the operation of the CFBC System.

Figure 2. A First Stage of Control Program Developed under Visual Basic®

An easy to understand Windows type operator interface, utilizing visual display tables of the acquired operating data. This interface permits the adjustment of operating parameters by mouse controlled buttons and sliders as shown in Figures 3 and 4. The setting of certain parameters is password protected to enhance system-operating safety and component reliability.

Figure 3 Electrical Engineer/Programmer at Development Computer

Figure 4 CFBC Control Panel (one of six operator screens)

Another example of steps taken to provide personnel safety and equipment reliability is the installation of a 10 KVA uninterruptible power supply (UPS). Although a natural gas fired generator supplies electricity to many critical subsystems of the CFBC System in the event of a power outage, the UPS insures that there is absolutely no fault inducing power surge or drop that could result in control equipment failure from such an event.

During this period, the following progress was made on the design and erection of CFBC Facility:

- The advanced computer work station has been used in development of CFBC System operating software and in conducting simulations employing the data acquisition interfaces, and in establishing data transfer rates and the number of such interfaces required.
- Test equipment for creating and measuring voltage levels and waveforms has been purchased and employed in simulations for verifying the performance of

the data acquisition components.

- c. All data acquisition and control interface hardware and inter-connecting data signal cables have been received and employed in the simulation tests to verify its suitability for the application.
- d. Motors and drives for fuel/bed material input metering have been received.

Photos of the Riser and of the Primary and Secondary Cyclones, showing floor grating and cargo opening are shown in Figures 5-8.

Figure 5. Typical Riser section with heat exchanger. Cargo lift-way in background.

Figure 6. Thermal Expansion Joint on 6th Floor

Figure 7 Riser and Lower Part of Primary Cyclone with Multiple Heat Exchangers. Stack outlet in background.

Figure 8. CFBC Primary and Secondary Cyclones. Cargo Lift Guard Railing in foreground.

3. CONCLUSIONS

During this quarter, the following progress has been made:

- ◆ Design of process control and development of data acquisition system for CFBC Facility is nearing completion.

4. FUTURE WORK AND UPDATED PROJECT SCHEDULE

4.1 Future work

During the next quarter, work will focus on the following tasks:

- ◆ Continue installation of the CFBC Facility including bubble cap/distributor plate, downcomer, thermal expansion joints, flue ducts, loopseals, and thermal insulation.
- ◆ Specify, order, and install I.D. Fan and variable speed drive.
- ◆ Specify, order, and install secondary combustion air supply blowers, variable speed drives, and power supplies.
- ◆ Design, specify, order, and install bed preheater/ignition system and controller.
- ◆ Design, specify, order, and install entire cooling system internal loop
- ◆ Design, specify, order, assemble, and install water treatment system for providing supply of cooling water.
- ◆ Design and install the process control and measurement system for CFBC Facility.
- ◆ Complete the specification and ordering of any sensors not yet on hand, including field wiring between sensors and data interfaces, as well as the design, specification, ordering, and installation of water treatment and cooling system components.
- ◆ Investigate Polycyclic Aromatic Hydrocarbons (PAHs) emissions from the co-firing of chicken waste with coal in a laboratory-scale fluidized-bed combustor (FBC).
- ◆ Continue to investigate the effects of combustion flue gas components on mercury oxidation in the drop tube reactor.

4.2 Updated Project Schedule

Based on the current status of the project, the updated schedule for the remainder of the project is shown in Table 1.

Table 1 Updated Project Schedule

Task	Updated Schedule
Complete the installation of the CFBC Facility	December 31, 2006
Complete the installation of the process control and measurement system of the CFBC Facility.	December 31, 2006
Complete investigation of effects of combustion flue gas components on mercury oxidation in a drop tube reactor	August 31, 2006
Complete investigation of PAHs emission from co-firing of chicken waste with coal in a laboratory-scale fluidized bed combustor (FBC).	September 30, 2006
Based on the experimental data obtained from the laboratory-scale FBC Facility, determine the investigation of the optimal conditions for co-firing waste materials with high sulfur coals in the CFBC Facility.	November 30, 2006
Complete the study to determine the effect of air staging, fuel feeding position, and limestone feeding on the gaseous emissions in the CFBC Facility.	February 15, 2007
Complete the investigation of mercury emissions from co-firing of waste materials with high sulfur coal in the CFBC Facility.	April 30, 2007
Submit Final Report	September 15, 2007

ACRONYMS AND ABBREVIATIONS

CFB	Circulating Fluidized Bed
CFBC	Circulating Fluidized Bed Combustor
DOE	U.S. Department of Energy
ECTL	Environmental Control Technology Laboratory
FBC	Fluidized-Bed Combustor