DOE/PC/94221--TH

TECHNICAL PROGRESS REPORT

(April 1, 1995 through June 30, 1995)

Prepared

for the Project

CONTROL OF TRACE METAL EMISSIONS DURING COAL COMBUSTION

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July 1995

Prepared by
LAMAR UNIVERSITY
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for the
U.S. DEPARTMENT OF ENERGY
PITTSBURGH ENERGY TECHNOLOGY CENTER
under Grant No. DE-FG22-94PC94221

U.S. DOE PATENT CLEARANCE NOT REQUIRED PRIOR TO PUBLICATION OF THIS REPORT

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Project Title: **CONTROL OF TRACE METAL EMISSIONS DURING COAL COMBUSTION**

DOE Grant Number: DE-FG22-94PC94221
Principal Investigator: Thomas C. Ho, Lamar University
DOE Project Officer: Mike Baird, PETC

ABSTRACT

Emissions of toxic trace metals in the form of metal fumes or submicron particulates from a coal-fired combustion source have received greater environmental and regulatory concern over the past years. Current practice of controlling these emissions is to collect them at the cold-end of the process by air-pollution control devices (APCDs) such as electrostatic precipitators and baghouses. However, trace metal fumes may not always be effectively collected by these devices because the formed fumes are extremely small.

The proposed research is to explore the opportunities for improved control of toxic trace metal emissions, alternatively, at the hot-end of the coal combustion process, i.e., in the combustion chamber. The technology proposed is to prevent the metal fumes from forming during the process, which would effectively eliminate the metal emission problems. Specifically, the technology is to employ suitable sorbents to (1) reduce the amount of metal volatilization during combustion and (2) capture volatilized metal vapors. The objectives of the project are to demonstrate the technology and to characterize the metal capture process during coal combustion in a fluidized bed combustor.

The project was started on July 1, 1994 and this is the fourth quarterly technical progress report. Specifically, the following progress has been made during this performance period from April 1, 1995 through June 30, 1995:

1. **Preliminary Experiments** - Preliminary experiments were conducted in the constructed quartz fluidized bed combustor to establish procedure and identify potential problems.

2. **Contractor's Review Conference** - A conference of the Principal Investigators working on projects under the University Coal Research program was held at Tennessee State University, Nashville, TN on June 13 through 14, 1995.

3. **DOE Fossil Energy Program Review** - A DOE Fossil Energy Advanced Research Program Review was conducted in Nashville, Tennessee on June 13, 1995. This project was reviewed under Topic 19 - Combustion Ash and Byproducts.

4. **Conference Presentations** - Three presentations reporting our current metal capture study were made at three international conferences during this period. The details are described in the report.

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EXECUTIVE SUMMARY

Toxic (or potentially toxic) trace metallic elements such as barium, beryllium, boron, cadmium, chromium, lead, mercury, nickel, selenium, strontium, vanadium, zinc and zirconium are usually contained in coal in various forms. These metals will either stay in the ash or be vaporized during high temperature combustion. Portions of the vaporized metals may eventually be emitted from a combustion system. Most of the emitted metals will be in the form of metal fumes or particulates with diameters less than 1 micron and are potentially hazardous to the environment. The U.S. EPA has reported that metals account for almost all of the identified risks from waste incineration systems.

Concern over toxic trace metal emissions from coal-fired combustion sources is growing, especially as the result of the passage of the 1990 Clean Air Act Amendments (CAAA). To address the concern, the U.S. DOE has recently co-sponsored a workshop jointly with the Electric Power Research Institute (EPRI) and the Energy and Environmental Research Center (EERC) on Trace Elements Transformations in Coal-Fired Power Plants. The objective of the workshop was to evaluate the current level of understanding on metal behavior during coal combustion and to identify potential technologies for improved metal emission control.

Current practice of controlling trace metal emissions during coal combustion employs conventional air pollution control devices (APCDs), e.g., venturi scrubbers, electrostatic precipitators, baghouses etc., to collect fly ash and metal fumes. This type of control is essentially a cold-end control because metals are allowed to vaporize and condense before being controlled. The control may not always be effective on metal fumes due to their extremely fine sizes.

An alternative technology for metal emission control is to minimize the formation of metal fumes at the hot-end of the coal combustion process, i.e., in the combustion chamber. The technology proposed is to prevent the metal fumes from forming during the process, which would effectively eliminate the metal emission problems. Specifically, the technology is to employ suitable sorbents to (1) reduce the amount of metal volatilization during combustion and (2) capture volatilized metal vapors. The objectives of the project are to demonstrate the technology and to characterize the metal capture process during coal combustion in a fluidized bed combustor.

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Review was conducted in Nashville, Tennessee on June 13, 1995. This project was reviewed under Topic 19 - Combustion Ash and Byproducts.

4. **Conference Presentations** - Three presentations reporting our current metal capture study were made at three international conferences during this period. The details are described in the report.

DETAILED PROGRESS REPORT

1. Preliminary Experiments

Additional preliminary experiments were conducted in the constructed quartz fluidized bed coal combustor to establish experimental procedure and identify potential problems. For initial testing, 12 gram of a specific coal was burned in the bed of a specific sorbent at 900°C. The sorbent amount was also 12 gram and the sorbent height was approximately 50 mm. The combustion itself was observed to be very smooth. However, because the ratio of coal to sorbent is very low (1:1), the increase of metal concentration in the sorbent was not significant enough to provide accurate measurements on the metal capture efficiency. To solve the problem, the amount of coal in each experiment was increased from 12 gram to 60 gram. Although we expected to have the problem solved, another problem was created. This time, because 4 times the amount of coal was involved, bed ash accumulation became excessive. The bed height was raised to near double the original height making some of the bed material fluidizing in a cold freeboard area. Apparently, the combustor needs to be modified to correct the problem.

Our current efforts are to convert the coal combustor system to be housed in a tube furnace instead of a regular furnace. The modification will provide the combustor with additional 6 inches of heated height and should solve the problem. Regular experiments will then be conducted.

2. Contractor's Review Conference

A conference of the Principal Investigators working on projects under the University Coal Research program was held at Tennessee State University, Nashville, TN on June 13 through 14, 1995. The conference was well-organized and well-attended. Although this project was not required to make an oral presentation nor a poster presentation, it was very beneficial to attend the conference to learn from other researchers and to meet PETC program officers.

3. DOE Fossil Energy Program Review

A DOE Fossil Energy Advanced Research Program Review was conducted in Nashville, Tennessee on June 13, 1995. This project was reviewed under Topic 19 - Combustion Ash and Byproducts. The review process began with a 30 minutes presentation session by the principal investigator and followed with a 45 minutes questions and answers session by a panel of nine experts in the research area. The review for this project went very smoothly with friendly discussions between the principal investigator and the panel members. One of the constructive

suggestions from the panel members is to start the project by burning simulated combustible fuel with controlled metal concentration (e.g., wood pellets spiked with controlled metal concentration) instead of burning coal. The reason behind this is to avoid the problem of non-uniform metal concentration in coal. I consider this an excellent suggestion and will following their advice during the next series of experiments.

4. Conference Presentations

Three presentations describing our current metal study were conducted at three international conferences during this report period. They are listed below:

(1). "Transformation of Chromium from Cr(III) to Cr(VI) in a Simulated Wet Scrubber," paper presented at the 1995 International Incineration Conference held in Seattle, Washington, May 8-12, 1995.

(2). "Lead and Cadmium Capture by Various Sorbents during Fluidized Bed Combustion/Incineration," paper presented at the 8th International Fluidization Conference held in Tours, France, May 14-19, 1995.

(3). "Effect of Additives on Metal Volatilization during Thermal Treatment," paper presented at the 4th International Congress on Toxic Combustion Byproducts held at the University of California, Berkeley, June 5-7, 1995.

The abstracts of the presentations are included in the ATTACHMENT.

FUTURE WORK PLANNED

The work planned for the next quarter will be to conduct metal capture experiments in the modified quartz fluidized bed coal combustor. Wood pellets containing metals will first be involved in the experiments as suggested by the review panel as discussed in DETAILED PROGRESS REPORT. The metal concentrations in the wood pellets will be controlled to the same level as in typical coal. Metal concentrations in the original wood pellets and in the combustion residue under various combustion conditions will be measured to characterize the capture efficiency. The experiments will be switched back to coal combustion after the wood pellets experiments are completed.

ATTACHMENT

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