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THE FATE OF ARSENIC IN WASTE-TO-ENERGY FACILITIES

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Project Description

Trace levels of arsenic contained in coal and liberated during combustion typically react with fly ash and are removed during flue gas treatment for particulate control in baghouses, electrostatic precipitators, and scrubbers (1, 2). If 100% copper chromium arsenic (CCA)-treated wood, which can contain up to 30% arsenic, is fired in an industrial stoker or waste-to-energy (WTE) facility, the existing flue gas treatment system may or may not remove all of the arsenic required to meet emission standards. In addition, elevated levels of CCA are expected to be present in the ash and may present ash management concerns. The project will determine the fate of arsenic by conducting a bench-scale combustion experiment in which arsenic removal efficiency from combustion flue gas will be measured across a baghouse and scrubber in the EERC's conversion and environmental process simulator (CEPS) (Figure 1), and CCA levels will be determined in the bottom ash and fly ash. The publication of results will provide crucial data for utilities, WTE facilities, and other industrial stoker furnace operations that may consider firing treated wood. The data will also be useful to regulators and solid waste officials looking for alternative disposal methods for treated wood.

Goal

The project goal is to determine the potential fate of arsenic from the combustion of CCA-treated wood and the impacts relative to emissions and ash management. Objectives are as follows:

1. Conduct a treated-wood combustion experiment and measure arsenic capture efficiency across pollution control equipment.

2. Analyze bottom ash and fly ash to determine the quantity of CCA.

3. Publish the experimental data for utilization by other research institutions, electric power utilities, industrial cogeneration facilities, WTE facilities, regulators, and solid waste officials.

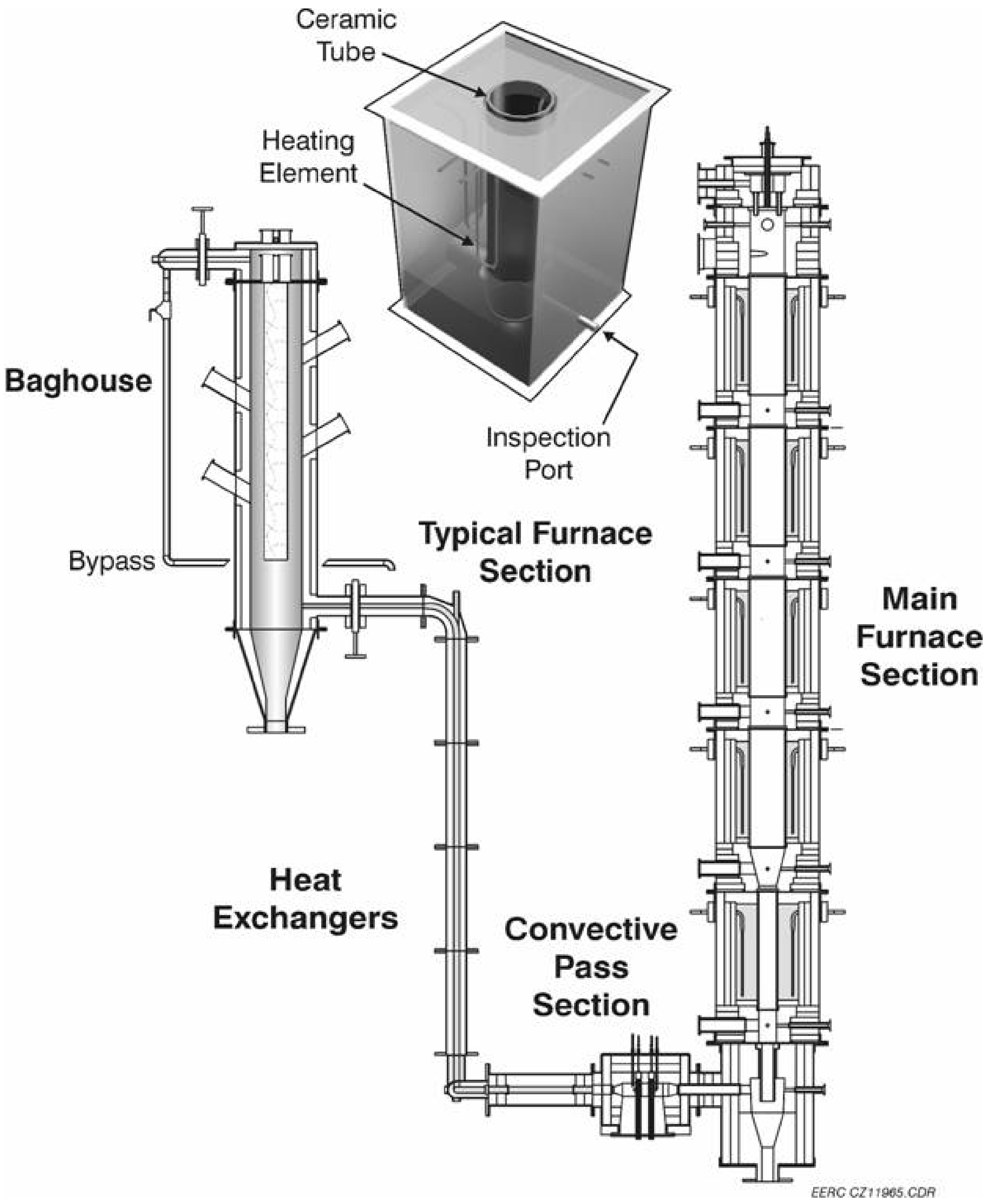

Figure 1. Conversion and environmental process simulator.

Rationale

Arsenic is a common compound widely dispersed across the globe, found in water and sediment as a trace composition. The toxic effects of arsenic have been known for centuries. Arsine (AsH_3) and arsenic(III) halogenides are more toxic than other inorganic arsenic compounds. Arsenic has not been produced in the United States since the closure of the last remaining copper smelter plant in 1985, because of the high cost of compliance for sulfur and, to a lesser extent, arsenic emission regulations. The historic demand for arsenic grew between 1910 and 1920. Since that time, the U.S. demand has remained between 10,000 and 25,000 metric tons per year (3). In recent years (1998–2003), domestic consumption has been slightly decreasing. Between 1970 and 1980, the utilization of arsenic shifted from agricultural uses to wood preservatives. Today, wood preservatives are the primary use for arsenic, and all production is imported. Arsenic trioxide is produced from roasting arsenopyrite and from the by-products of copper, lead, and gold smelters. Imports are mostly supplied by China. The global reserve base is expected to be 20 to 30 times current annual production (4). Global demand for arsenic is expected to decrease by about 30% as the wood-preserving industry has voluntarily eliminated arsenic from residential treated wood; however, nonresidential arsenic treatments remain in use.

Treated wood is a significant solid waste issue and a challenge for recovery and toxic emission control. The use of CCA has increased by a factor of 7 since 1970 in the United States. Once representing 16% of the wood preservative market in 1970, CCA represented about 80% of the market in 1996 (5). The volume of wood treated with CCA by 1970 was 36 million cubic feet and by 1996 increased to 470 million cubic feet. Since CCA-treated wood has a life span of about 25 years, it is projected that the wood waste stream will mirror the production statistics of CCA-treated wood, and amounts of CCA-treated wood being disposed of will multiply. Based on these numbers, about 1.2 million tons/yr could be going into our nation's landfills. Nonarsenic alternatives to CCA are being provided for residential wood; however, plywood, utility poles, and marine applications are continuing to use arsenic treatments. The alternatives typically contain high compositions of copper and may provide for attractive recycling. Treated wood containing arsenic and nonarsenic wood remain difficult to separate. Residential arsenic-treated wood will be a disposal issue for the next 25 to 50 years, and arsenic from treated wood will continue to be a disposal issue beyond 50 years for utility, industrial, and marine applications.

The project will determine the fate of arsenic in combustion systems when firing relatively high concentrations of treated wood. The project is intended to find alternatives to treated-wood disposal.

Approach

Experimental Apparatus

Arsenic removal efficiency from combustion flue gas was measured across a baghouse and scrubber in the CEPS (Figure 1), and CCA levels were determined in the flue gas by EPA Method 29 and analyzed in bottom ash and fly ash.

Test Plan

The CEPS was utilized in its present configuration to fire treated wood. CCA-treated wood, with retention of 0.4 pcf, was obtained and prepared for the experiment, as shown in Figure 1. Test runs were conducted utilizing an EPA Method 29 trace element-sampling train located at the inlet and outlet of the baghouse and scrubber. Bottom ash was collected from the CEPS, and fly ash was collected from the baghouse. Samples were submitted for analysis to determine the quantity and speciation of arsenic, copper, and chromium.

Progress

This project has been completed.

Combustion of CCA-treated wood in a WTE facility is a technically feasible alternative for disposal. Flue gas emissions are not expected to exceed federal regulatory limits with implementation of maximum achievable control technologies at WTE facilities; however, high arsenic levels may cause combustion ash to be classified as hazardous waste. The combustion conditions (1100°–1300°C) had a significant effect on the fate and recovery of metals during combustion of CCA-treated wood. The high volatility of arsenic and affinity for small particles, allowing for efficient removal by flue gas-conditioning devices, generated fly ash concentrations over 10%. The low volatility and recovery of copper and chromium at the experimental operating conditions suggest formation of slag materials within the combustion unit.

A low cofire rate to control ash metal concentration below hazardous waste characterization is recommended. An average cofire rate of 23% was estimated to maintain nonhazardous combustion waste from CCA-treated wood processing. Approximately 19 WTE facilities would be required to consume the national quantity of treated wood disposed of under this scenario. Incineration of CCA-treated wood at a hazardous waste facility is an alternative option for recovery, and recycling of CCA metals from combustion ash presents a viable approach for avoiding domestic disposal in landfills, creating value from a waste material and eliminating environmental liability for corporations using CCA-treated products.

Challenges to the combustion of CCA-treated wood in WTE facilities include public concerns over arsenic leaching into groundwater from landfilled ash and occupational exposure to arsenic, as well as stringent state or local regulations for classification of hazardous waste. Public issues can be addressed through educational efforts, maintaining inert waste, and implementing proper safety procedures to minimize occupational exposure to metals. Treated wood is accepted in at least one WTE facility responding to EERC inquiries, maintaining regulation compliance, further proving technical viability and public acceptance of treated-wood combustion in WTE facilities.

Quality Assurance/Quality Control

Based on previous work, it was determined that the detection and quantification of arsenic would be extremely difficult. The experiments that were performed were designed such that the highest likelihood of a good mass balance closure could be achieved.

Measurement/Data Acquisition

EPA Method 29 sampling was utilized for the quantification of particulate and arsenic, while data acquisition was used to gather information on feed rate, gas composition, and other operational conditions.

Assessment and Validation

Based on the analysis of Method 29 and the data acquired, an arsenic mass balance was satisfactorily performed.

Status

The project began in April 2005 with initial work to set up contracts with other partners including the Electric Power Research Institute and the EERC's Jointly Sponsored Research Program with the U.S. Department of Energy. Actual work started in July. Testing was conducted in February and a final report completed October 3, 2006.

Potential Applications and Benefits

Potential Users and Real-Life Applications

The most likely benefactors are utilities, WTE plants, and cement kilns.

Technology Transfer

Technology will be transferred through publication.

Technical, Economic, and Fundamental Benefits

Treated wood is a significant solid waste issue and a challenge for recovery. Over 1 million tons of treated wood is estimated to enter landfills annually nationwide. Until recently, CCA was the most common treatment used for wood preservation. Any arsenic utilized for production of preservation treatments has been imported into the United States for the past two decades. Because landfilling is the predominant method for disposal of CCA-treated wood products, an accumulation of arsenic in U.S. soils is anticipated, creating a global imbalance of the metal.

References

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