



## ashes to energy



Coal utilization results in the creation of large amounts of ash. The ash contains several components. These include: carbon char which is incompletely burned coal; bottom ash, a coarse cinder-like material obtained from the bottom of the furnace; and fly ash derived from the fine glass-like material, which is collected from of the flu gas.





## ashes to energy

*continued*

These are all either mixed with water and pumped to a pond, or moistened and deposited in a landfill. New pollution reduction technology to reduce NO<sub>x</sub> emissions has resulted in lower combustion temperatures and therefore, more carbon in the ash, making the ash less useful for other purposes.

CAER is demonstrating a technology to recover wasted fuel and useful aggregates from the coal combustion waste ponds at Western Kentucky Energy's Coleman Power Station in Hawesville, Kentucky. The Coleman Station is a 520 MW power plant on the Ohio River that provides power for nearby aluminum and manufacturing facilities as well as wholesale residential power. The facility generates approximately 100,000 tons/year of combustion ash that is stored in lined pond areas adjacent to the power plant. Preliminary studies conducted by CAER estimated that the Coleman site

contains approximately 3.4 million tons of ash and the storage area is very close to full capacity. New landfill space will be needed soon, unless uses are found for the material already stored. The high-quality fuel is very low in sulfur. Its recovery and use will increase the overall efficiency of the power plant. Some of the carbon recovered is so high in quality that it may be useful as a low-cost adsorbent for environmental clean up.

The technology was developed by researchers at CAER over the past 10 years and recovers a variety of marketable products from stored coal combustion ash. Pond ash is excavated and fed into the process and mixed with water. Coarse ash (larger than 9.5 mm) is removed by screening and is readily marketable as a lightweight aggregate



PHOTOS: FORREST PAYNE

for road building and other purposes. The ash that is smaller than 9.5 mm is sized in a hydraulic classifier. The medium sized material (smaller than 9.5 mm and larger than 0.15 mm) is separated by density using spiral concentrators to recover both a block-sand product and a coarse carbon fuel. A fine carbon fuel is recovered from the smallest ash size (less than 0.15 mm) by froth flotation. The remaining fine ash is returned to the pond for storage.

The project has broad potential, as there are about 1.5 billion tons of ash in the U.S. that have been landfilled. Little of this material is ever recovered, resulting in a long-term environmental and economic liability. This project is the first serious effort by a utility to recover multiple products from its waste. Its success will pave the way for projects in many other parts of the country.

## ammonia in fly ash

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### working toward a solution

Ammonia injection into flue-gas streams has been adopted by the utility industry as the method of choice to meet federally mandated reductions of  $\text{NO}_x$  emissions from coal-fired utility boilers. Some of the ammonia, however, is retained on the fly ash, which is marketed as an extender for Portland cement. This has a negative impact on the marketability of the ash since workers could be exposed to noxious fumes of ammonia as water is added when concrete is poured. The projects described here illustrate two facets of exploration conducted at the CAER concerning ammonia-related problems in fly ash.

Concrete and cement are the biggest markets for fly ash today. Of the approximately 65 million tons of fly ash produced annually in the U.S., roughly 10-11 million tons are utilized as an admixture in Portland cement-based products. If companies that purchase fly ash for use in cement and concrete are wary of the effects of ammonia on their products and workers, it could be disastrous for the ash marketers.

The effect of increased ammonia in fly ash is of serious concern to companies that sell ash to the concrete and cement industry. Two important questions need to be answered: 'How does the ammonia affect the concrete over the long term?' and 'What are the guidelines for allowable amounts of ammonia within the fly ash?'



## ammonia in fly ash working toward a solution (cont.)

The CAER teamed up with fly ash marketers Boral Material Technologies Inc., ISG Resources Inc., LaFarge North America, and Southern Company Services to help answer these important questions. The companies are providing financial support and technical guidance. With their contributions and a grant from the U.S. DoE, the CAER is currently studying ammonia to establish potential guidelines for allowable amounts of ammonia in fly ash and how rapidly the ammonia will diffuse out of the concrete.

In addition to the detriment of the smell of ammonia in fly ash, the Occupational Safety and Health Administration (OSHA) has established limits on ammonia exposure in the work place. In certain cases, the ammonia released in the air could potentially be unsafe for workers placing the concrete. Consequently, the first goal of the project is to establish guidelines for maximum permissible ammonia concentrations in fly ash, which will meet OSHA exposure limits.

CAER scientists have embarked on experiments in the laboratory and in the field. They are making concrete in the lab doped with various levels of ammonia,

and measuring the amount that diffuses from the concrete in the parts per million (ppm) range. Eventually these studies will be taken to an intermediate-scale. Plans are to pour a concrete slab in a controlled atmospheric space that is instrumented to measure the release of ammonia.

To determine how long it takes the ammonia to be freed from the concrete, researchers will calculate the ammonia liberated for several months and extrapolate the results using the rates they obtain from earlier studies.

During the final phase of this project, the researchers will scale-up yet again - this time to full-size (concrete truck-scale) pours. In these tests, they will prepare the concrete as large slabs, measure the ammonia loss, and correlate the data collected from the lab with the bigger pours. In this manner, they will not be required to perform as many of the large-scale experiments. Assuming the data correlates well, they can say with a high level of confidence that the lab test data are applicable to the real world. On this basis they can determine the maximum allowable limits of ammonia in fly ash used as admixtures in the cement and concrete industry.

In a separate project, it is hoped that a better understanding of the fly-ash components responsible for ammonia retention can lead to methods of eliminating the problems associated with utilization. Accordingly, the focus of this work was to define the influence of the primary  $\text{NO}_x$  control technologies, selective catalytic reduction (SCR) and selective non-catalytic reduction (SNCR) processes with respect to identifying the

chemical state of the adsorbed ammonia. In other words, does the ammonia react with specific fly-ash components to form salts (e.g., ammonium sulfate, ammonium bisulfate or ammonium chloride) or is it simply physically adsorbed onto unburned carbon particles?

To address these questions, a thermo gravimetric – mass spectrometer (TG-MS) analyzer was used to study the thermal-release properties of ammonia from an SCR and an SNCR ash. The TG-MS was employed to generate thermal-release profiles for ammonia as well as other gas-phase species. The release profiles revealed substantial differences in the initial temperature (onset) as well as the temperature of maximum release (peak) of ammonia. Specifically, ammonia release exhibited both higher onset and peak temperatures and evolved over a narrower temperature range for the SCR than for the SNCR ash. Further, it was found that ammonia evolution from both ashes was associated with a concurrent release of sulfur dioxide, suggesting that ammonia in the fly ash was likely present as either a sulfate or sulfite salt. However, close examination of the differences in the ammonia release profile indicated that ammonium sulfate was the primary ammonia-containing species in the SCR fly ash, whereas the SNCR ash appeared to favor the capture of ammonia as ammonium bisulfate, a less thermally-stable species.