OHIO COAL DEVELOPMENT OFFICE

FINAL ANNUAL PROJECT ABSTRACT

AS OF AUGUST 2005

1. PROJECT SPONSOR:

The Ohio State University
College of Engineering
C/O Department of Chemical
and Biomolecular Engineering
140 W. 19th Ave.
Columbus, OH 43210

2. PROJECT MANAGER:

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3. OCDO GRANT NO: OCDO/D-98-18

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5. PROJECT TITLE: Ohio State Carbonization and Ash Reactivation Process Pilot Demonstration Project

6. PROJECT TERM: FROM: March 1, 2000 TO: December 31, 2005

7. FINAL REPORT

8. BUDGET:

CO-SPONSORS NAME	COST-SHARE
OCDO	$ 4,751,123
Ohio State University	$ 5,278,601
TOTAL PROJECT COST:	$ 10,029,724

ABSTRACT

9. OVERVIEW OF PROJECT & OBJECTIVES:

The OSCAR process created a tailored sorbent particle from new or spent calcium sorbents. The morphology of the created particles was tailored for the high efficiency dry removal of sulfur oxides from coal-fired flue gases, and the economics of the process suggested that high sulfur coal (Ohio coals) using the process may be economically superior to lower sulfur imported coals. The tailored particles are known to remove heavy metals, perhaps allowing the most cost-effective use of SCR control technologies.

The specific objectives of the project were to:

1) Demonstrate a novel ash/sorbent reactivation technique for increased SO_2 and arsenic removal from combustion of high-sulfur coals
2) Integrate the ash reactivation process with SCR technology
3) Analyze solid by-products under different desulfurization process configurations
4) Demonstrate effective utilization of solid by-products in various construction projects
5) Quantify commercial-scale economics
6) Gather operational and design data that will allow integration of this technology at commercial-scale

The project was to be performed by designing/building a pilot scale test facility integrated into the existing McCracken Power Plant.

The OSCAR process offers the probability that power utilities could utilize Ohio coals while meeting their emissions obligations under the 1990 Clean Air Act (the Acid Rain provisions). The technology offers the promise of being significantly less expansive than competing wet technologies, especially for existing power plants and somewhat less expensive than the alternate of switching to low-sulfur (and non-Ohio) coals. In addition, it appears that the use of OSCAR sorbents will allow power plants to meet future emissions limitations for mercury, without having to add further and quite costly control equipment. Finally, there are known value markets for the OSCAR fly ash material, which will help decrease the practice of landfilling of ash.

10. WORK DONE AND CONCLUSIONS:

Overall

The conclusion of the OSCAR field testing, and the subsequent evaluations leading to the final report, showed the following conclusions, which are elaborated on in the final report

1) Sorbent produced from lime is preferred to sorbent produced from lime spray dryer ash
2) Sorbent produced from lime is very effective in removing sulfur from flue gas, especially if the sorbent capture occurs after the economizer.
3) Sorbent produced from lime is very effective in removing mercury from flue gas
4) Lime-based sorbent can be a more cost-effective means of removing sulfur from flue gas than wet-scrubbing means. The advantages are increased in smaller power plants, in power plants that are land-locked (space limited), and in systems where removal efficiencies on the order of 75-90% are desired. Wet scrubbing is more cost effective for the very large (1000 MWe) power plants and where removal efficiencies have to be above 90%.

5) No barriers were found to the disposal of fly ash containing spent sorbent.
6) Observationally, no sorbent buildup was found on the pilot plant surfaces comparable to the superheat and economizer tubes in conventional power plants.

Based on these findings, a full scale test of the lime-based sorbent system was arranged for a 300 MWe power plant (scheduled 2005).

Project Management

The 2004 calendar year saw the end of the project testing. The 2002 testing had been delayed by an extensive coal boiler outage, which extended into 2003. The boiler was off through the fall and winter months, was placed into service on for late spring, and was shut down for the remainder of the year prior to June 2004. Final testing was concluded in that brief testing window: the final report was submitted and accepted.

Technical Advisory Board

The Technical Advisory Board was established. The third and last TAB meeting occurred in October 2004.

Permitting

Completed

Process Design/Construction

Completed

Testing

Testing during 2003 was performed with LSD ash as the source of the lime for the creation of the morphologically tailored sorbent identified as "OSCAR". That testing found that the sulfur captured by the LSD ash (predominately sulfite) was being re-liberated in the conditions of at the sorbent injection point, and the re-liberation of sulfur was confounding the ability to understand the performance of the sorbent. To be sure, sorbent that was carried through the system (and cooled) was nearly fully reacted, as desired, but the sorbent that was removed at injection temperature showed confusing findings. While numerous attempts were made to find a method of removing sulfite materials or oxidizing them to sulfate, nothing was found that could be accomplished without at the same time oxidizing the OSCAR sorbent.

LSD ash contains 20-25% free lime, and the rest of the ash was considered to be essentially inert with respect to sulfur removal. Injection of OSCAR, therefore, at levels necessary to make significant impacts on sulfur removal, therefore also entails the injection of a large mass of inerts (4-5 times the mass of the active sorbent) which could foul and/or erode boiler surfaces, and which would impose a large load on solids removal and handling equipment. During 2003, numbers of conversations were held with utility representatives, and the general sense from these conversations was that utilities would not consider injecting that type of material into a boiler system.

Economics analysis was also being performed in 2003. As LSD ash is essentially "free", and lime is ~$100 per ton, a first cut analysis considering materials cost only would certainly show that OSCAR produced from LSD ash is less expensive that the comparable amount of precipitated calcium carbonate (PCC) produced from lime. However, the economic analysis

needs also to consider the costs of material handling. In 2003, we determined that the equipment handling costs of OSCAR production and use were several multiples of the costs of PCC production and use (considering both the materials/equipment cost in the sorbent production system and materials/equipment/disposal cost at the power plant).

Finally, the use of LSD ash in the preparation of sorbent was found to have numerous and unforeseen issues arising from the nature of the LSD ash. For example, that ash, mixed with water alone, hardens into a cementitious solid by the reaction of calcium with the aluminates, silicates, and iron oxide present in coal fly ash. That reaction caused material in storage bins and solids feeders to solidify, as well as slurries and solids in all of the process lines up to the final drying step. It was physically very difficult to operate the production system in conjunction with the power plant and its spotty operations: power plant down time generally resulted in some requisite OSCAR facility repair.

For all of these reasons, testing during 2004 focused on the use of lime rather than LSD ash. That testing session, though shortened by power plant unavailability, found much fewer problems of sorbent production, and enabled a better understanding of sorbent reactions. We concluded that it is better for all of the reasons noted to create the sorbent from lime than from LSD ash.

Economic Analyses

Begun in early 2002, the economic analyses were based upon extant cost models by EPRI and EPA, modified to accommodate the OSCAR design and performance characteristics. Early results from the economic analyses showed that the cost of the sorbent, as produced from purchased lime, was in the lower range of published costs for precipitated calcium carbonate (a commercial material produced in various qualities for use in paper-making), as expected.

Using the same economic analysis methods, the cost of sorbent as produced from (free) lime spray dryer ash was actually more expensive, and rendered the process less economically feasible. The economic analysis used considers both the cost of the raw materials, and the cost of materials handling and storage. As sorbent from LSD ash also contains fly ash and calcium sulfate, there that sorbent is only about 20-25% active material, and the rest is essentially inert (for sulfur). Consequently, the facility (capital equipment) to produce sorbent from LSD is 4-5 times larger than a comparable facility to produce sorbent from lime, and the increased capital costs (and capital-associated labor associated) more than offset the material cost advantages of the free lime in LSD.

As an aside to this analysis, we considered that in all likelihood a power plant would not want to operate the sorbent production process. That is a chemical plant with skill needs not typically found in power plants. During the last several decades, the PCC industry had been built up at lime manufacturing plants, and subsequently paper companies built their own. As a consequence, there is an excess PCC capacity at lime plants, providing an opportunity for merchant production of the desired sorbent at existing facilities.

Finally, the economic analyses showed that the use of the lime-based sorbent, with its lower injected mass, was less expensive than the use of the LSD-ash based sorbent.

11. PLANS FOR COMING YEAR:

No plan for the coming year since the project was finalized.

12. HIGHLIGHTS/ACCOMPLISHMENTS:

The major highlights of 2004 were the completion of the testing program. Findings continued to demonstrate excellent sulfur and metal capture by the sorbent materials that traveled through and cooled down with the flue gas, and less than favorable capture by the sorbent removed at the end of the (hot) riser reactor.

13. ARTICLES/PRESENTATIONS:

Drs. Butalia and Thomas presented a paper at the 14th International Coal Ash Consortium in January 2001, titled "Tailored Calcium Oxide Sorbent Reactivation Process and Its Effects on Solid Byproduct Properties". The report was co-authored by Fan, Butalia, Agnihotri, Walker, Weavers, and Thomas.

Dr. Thomas presented a paper entitled "Development and Testing of Structured Calcium Sorbents for Flue Gas Treatment" at the March, 2001 Clearwater conference. The report is co-authored by Fan, Agnihotri, and Thomas.

Dr. Thomas presented a paper on the applicability of OSCAR to smaller systems at a Coal Utilization conference in Kentucky on April 18, 2001.

Dr. Walker et al presented results of the variability study at the 2001 International Ash Utilization Symposium in Lexington, Ky. in October 2001.

Dr. Thomas presented a paper on the use of the OSCAR sorbent as a mercury control at the March 2002 Clearwater conference. This paper provided an update on the OSCAR system as well.

Ping Sun, et al presented "Investigation of Polycyclic Aromatic Hydrocarbon Compounds(PAHs) on Flue Gas Desulfurization By-product" at a poster session at the NETL Unburned Carbon on Utility Fly Ash Conference in May, 2002

Dr. Thomas presented the OSCAR project to the first Ohio Air Quality Conference, Toledo, Ohio, October, 2002.

Ping Sun and Linda K. Weavers will present "Investigation of polycyclic aromatic hydrocarbon compounds (PAHs) in flue gas desulfurization (FGD) by-products" at the 225th National American Chemical Society Meeting, March 2003, New Orleans, La.

Dr. Thomas presented paper on the findings of effectiveness of the OSCAR sorbent March 2003 Clearwater conference.

L.-S. Fan, T. Thomas, H. Gupta, L. Xu, P. Gupta, M. Iyer, A.-H. A. Park, "Pilot Scale Demonstration of the OSCAR (Ohio State Coal Ash Reactivation) Process: Enhanced SO_2 Removal by High Temperature Non-Catalytic Gas-Solid Reaction with Tailored High Reactivity Mesoporous Calcium Carbonate Particles," AIChE annual meeting, San Francisco, CA, November 16-21, 2003.

T. Thomas, L.-S. Fan, H. Walker, T. Butalia, H. Gupta, "Initial Heavy Metal Capture Findings from the OSCAR (Ohio State Coal Ash Reactivation) Pilot Scale Process," Track/Session#EI-2i, Proc. A&WMA's 97th Annual Conference and Exhibition, June 22-25, 2004, Indianapolis, IN.

L.-S. Fan, T. Thomas, H. Gupta, M. Iyer, A.-H. A. Park, P. Gupta, "Pilot Scale Demonstration of the OSCAR (Ohio State Coal Ash Reactivation) Process: Furnace Sorption Injection (FSI) Studies on SO_2 Removal by Dispersant Modified Mesoporous $CaCO_3$," AIChE annual meeting, Austin, TX, Nov. 7-12, 2004.