**TITLE:** Heterogeneous Reburning by Mixed Fuels, Phase II

**PI:** Wei-Yin Chen

**STUDENT:** Benson Gathitu, Quang Shi

**INSTITUTION:** Department of Chemical Engineering
Anderson Hall
University of Mississippi
University, MS 38677
Phone: (662) 915-5651 Fax: (662) 915-7023
E-mail: cmchengs@olemiss.edu

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## ABSTRACT

**OBJEVTIVE:**
The objective of the Phase II study is to bring the mixed fuel concept developed earlier to a technological fast track. This objective is achieved by simultaneously demonstrating the concept on a larger scale unit, and by acquiring additional scientific information critically needed for process optimization. Specifically, we plan to address the following issues:

1. design of mixed fuels for effective NO reduction,
2. measurements of rate constants of NO reduction on young chars,
3. construction of a semi-empirical kinetic model,
4. reaction mechanisms in burnout zone, and,
5. demonstration of the mixed fuel concept on a pilot-scale down-fired furnace.

**ACCOMPLISHMENTS TO DATE:**

A multi-functional, mixed fuel containing natural gas for NO reduction, and lignite ash for reducing the reburning intermediate, HCN, has demonstrated remarkably high efficiency in reburning (*AIChE J.*, **47**, 2781 (2001); *Fuel*, **85**, 1781 (2006)). While the price of natural gas has increased and fluctuated significantly in the last five years, there is an incentive to find substitutes for natural gas. Effective substitute for lignite ash is also desirable because of the large quantity required for the target HCN conversion.

Several combinations of hydrocarbon substances and minerals have been chosen as the main reburning fuel and the HCN reducing agent in a reburning apparatus, respectively. This apparatus includes two furnaces in series, one for simulated reburning, and, the other, for combined reburning and burnout stages. For the investigation of reburning intermediates, HCN and $NH_3$, only one furnace is kept at temperatures from 1150 to 1400°C with residence time 0.2

s. When burnout stage is used for the investigation of overall NO reduction efficiency, the second furnace is kept at 1150°C. The stoichiometric ratios of reburning (SR2) and burnout zone (SR3) vary in the ranges 0.8 to 1.0 and 1.1 to 1.3, respectively.

Results indeed show that a wide range of mixed-fuels possess remarkably high overall NO reduction efficiency, up to 85%, from the two-stage experiments at high reburning stoichiometric ratios, 0.95. The nitrogen speciation in both stages is very similar to natural gas. Both components are widely available waste materials. An efficient HCN conversion catalyst is identified. About 60 to 200 metric ton of this catalyst is needed for a 172 MW bituminous coal-fired power plant, depending on the main constituent in the reburning fuel, and it does not cause fouling or slagging problems in the coal-fired boilers. Both components of these substitutes are widely available at low costs. For the fuels showing low overall NO reduction efficiencies, char-nitrogen conversion to NO in the burnout zone is a limiting factor.

**FUTURE WORK:**

We plan to continue the tasks discussed in the Objective section.

**LIST OF PAPER, INVENTIONS AND PRESENTATIONS IN THE PAST YEAR:**

***Journal Papers:***

Chen, W.Y., and B. B. Gathitu, "*Design of Mixed Fuel for Heterogeneous Reburning,*" Fuel, **85**(12-13), 1781-1793 (2006).

Gathitu, B.B., and W.Y. Chen, "*Post-Combustion Reduction of Nitrogen Oxide from Stationary and Mobile Sources,*" completed for patent application, to be submitted to Industrial and Engineering Chemistry Research (August, 2006).

Su, Yaxin, Gathitu, B.B., and W.Y. Chen, "*Heterogeneous Reburning by Natural Gas Substitutes,*" in preparation.

***Inventions:***

Chen, W.Y., and H. Sarv, "*In-Furnace Reduction of Nitrogen Oxide by Mixed Fuels Involving A Biomass Derivative,*" Patent application, Serial No. 11/426,906, June 27, 2006.

Chen, W.Y., "*Post-Combustion Reduction of Nitrogen Oxide from Stationary and Mobile Sources,*" invention disclosure submitted to the University of Mississippi, August, 2006.

Chen, W.Y., Y. Su, and B. B. Gathitu, "*Efficient and Cost-Effective Reburning by Mixtures of Industrial By-Products,*" invention disclosure to be submitted to the University of Mississippi, 2007.

***Presentations, Conference Proceedings and Invited Seminars:***

Chen, W.Y., "*Effective Reduction of NO for Coal-Fired Boilers by Mixed, Multi-Functional Agents,*" Proceedings of the Sino-American Technology and Engineering Conference, Beijing, China, pp.53-60, October 16-24, 2006.

Chen, W.Y., "*Reduction of NO from Coal-Fired Boilers*," Journal of Overseas Chinese Environmental Engineers and Scientists, **23**(2), 51-56, 2006.

Su, Y., Gathitu, B.B., and W.Y. Chen, "*Cost-Effective and Efficient Method for NO Reduction*," presented at the Sigma Xi Poster Symposium, the University of Mississippi, March 26, 2007.

Su, Y., Gathitu, B.B., and W.Y. Chen, "*Novel Reburning using Wastes*," to be presented at the Mid-South Area Engineering and Sciences Conference, Oxford, MS, May 17-18, 2007.

Su, Y., Gathitu, B.B., and W.Y. Chen, "*Cost-Effective Reburning by Natural Gas Substitutes*," to be presented at the 2007 International Conference on Coal Science and Technology, Nottingham, United Kingdom, August 28-31, 2007.

Chen, W.Y., "*Effective Reduction of NO for Coal-Fired Boilers by Mixed, Multi-Functional Agents*," Mississippi State University, Mississippi State, MS, October 6, 2006.

Chen, W.Y., "*Coal Combustion Research at the University of Mississippi*," University of Wyoming, Laramie, Wyoming, MS, February 18, 2007.