

**ANNUAL PROJECT REPORT  
AS OF DECEMBER 1999**

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| 3. <u>OCDO Grant No.</u> OCRC-99-A.4.2.  | 4. Project Update <u>X</u> or Final Report  |
| 5. <u>Project Title:</u> <u>Role and Fate of Sulfur during Reburning for NO<sub>x</sub> Control</u>          |   |
| 6. <u>Project Term:</u> From: September 1, 1999 To: August 31, 2000  |   |
| 7. Budget  |   |
| <u>Name</u>  | <u>Cost Share</u>   |
| OCDO   | \$70,106  |
| Ohio University  | \$48,140  |
| Total Project Cost   | \$118,247   |

**I. ABSTRACT**

8. Overview of Project and Objectives

NO<sub>x</sub> control has become an especially immediate concern to coal-fired utilities due to the pending 22 state SIP call limits, which may reduce emissions to 0.15lb NO<sub>x</sub> per million Btu. While SCR/SNCR may be a favored control option, post-combustion control improves if NO<sub>x</sub> is limited during combustion. One technique for combustion-based NO<sub>x</sub> control that also offers lower CO<sub>2</sub> emissions is natural gas reburning, reducing both thermal and fuel NO<sub>x</sub>. This research addresses implications of SO<sub>3</sub> formation, both as a corrosion (and heat rate) and PM<sub>2.5</sub> precursor concern, when using gas reburning to control NO<sub>x</sub> emissions from the combustion of Ohio coal. This project centers on the investigation of SO<sub>3</sub> formation, mitigation (or reduction), and a simple parametric investigation of its role in NO<sub>x</sub> control during gas reburning. Objectives include quantifying the extent to which sulfur conversion occurs as a function of time as function of SO<sub>2</sub>, O<sub>2</sub>, and CH<sub>4</sub> concentrations; using pulverized coal (instead of pure SO<sub>2</sub>) as the pollutant source to examine more complex interactions; a parametric examination of the reduction of NO<sub>x</sub> emissions as a function of SO<sub>3</sub> concentration; and determination of the kinetic parameters of the proposed SO<sub>2</sub> to SO<sub>3</sub> conversion mechanisms.

9. Work Done and Conclusions

Experimental data suggests a strong inverse relation of SO<sub>3</sub> conversion percentage with SO<sub>2</sub> level. In other words, the more SO<sub>2</sub> in the gas stream, the smaller the percentage will be converted to SO<sub>3</sub>. It could be concluded from this and other data that SO<sub>2</sub> is a major consumer of O atoms, which are necessary to homogeneously (without catalysts) convert SO<sub>2</sub> to SO<sub>3</sub>. Further, the experimental data collected to-date indicate that reburning promotes

a greater level of conversion of SO<sub>2</sub> to SO<sub>3</sub> than simple combustion, because it produces more O atoms. This is likely because the reburning process promotes a high percentage of CO formation, which leads to the formation of O atoms when it (CO) is burned.

Analytical results have been somewhat inconclusive, but one factor has become apparent. The thermal destruction (or decomposition) of SO<sub>3</sub> plays a larger role at low temperatures than previously thought. However, even with this larger role, it appears that SO<sub>3</sub> lifetimes are greatly extended by something in the reburning process. This is somewhat disturbing, because SO<sub>3</sub> carryover to the economizer or air heaters from the boiler would lead to increased corrosion and associated tube or part failures.

#### 10. Plans for Coming Year

Several tasks are proposed for this year. First, experiments started in Year Three to measure the conversion and duration of SO<sub>2</sub> to SO<sub>3</sub> in sub-stoichiometric (fuel rich) conditions would be completed. Next, SO<sub>3</sub> measurements would be performed to examine the effects of O<sub>2</sub> (especially in the 0-2% range), SO<sub>2</sub>, and CH<sub>4</sub> concentrations, and residence time under lean-based NO<sub>x</sub> reburning conditions. Pulverized coal would also be used (instead of pure SO<sub>2</sub>) under the same experimental conditions to examine SO<sub>3</sub> concentrations. Devolatilization models developed at Brigham Young University and the University of Illinois will be used to determine devolatilization species. Separately, experiments would be performed with varying levels of SO<sub>3</sub> (using catalytic conversion) to examine potential NO<sub>x</sub> reducing effects of the SO<sub>3</sub>. This would only be a brief parametric study. Finally, analytical work would be done throughout the year to examine the kinetics of the assumed reaction mechanisms.

### **II. HIGHLIGHTS/ACCOMPLISHMENTS**

11. We believe that this work has found some unique kinetic data, especially in the thermal decomposition of SO<sub>3</sub>. It is hoped that this information will lead to a process that can mitigate the formation of SO<sub>3</sub> from the combustion of Ohio Coals when using reburning to control NO<sub>x</sub> emissions.

### **III. ARTICLES/PRESENTATIONS**

12. One paper has been accepted for publication, but has not yet been printed. It is

Bayless, D.J., Khan, A.R., Tanneer, S., and Birru, R., "An Alternative to Additional SO<sub>3</sub> Injection for Fly Ash Conditioning," accepted for publication in the *Journal of the Air and Waste Management Association*, schedule to appear in February 2000.