DOE/PC/91337--T4

An Experimental Study of NO_x Recycle in the NOXSO Flue Gas Cleanup Process

DE-AC22 91PC 91337

Quarterly Technical Progress Reports

Submitted to
U.S. Department of Energy
Pittsburgh Energy Technology Center

October 1 through December 31, 1992

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

Prepared by

NOXSO
CORPORATION
P.O. Box 469
Library, PA 15129

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED JR

MASTER

DISCLAIMER

Portions of this document may be illegible in electronic image products. Images are produced from the best available original document.

TABLE OF CONTENTS

- 1.0 Summary**
- 2.0 Introduction**
- 3.0 Project Description**
- 4.0 Project Status**

Prepared by

NOXSO

CORPORATION

P.O. Box 469

Library, PA 15129

1.0 SUMMARY

All the tests planned were completed. NO_2 injection tests showed higher NO_x reduction than that of NO injection at similar testing conditions. The NO_x reduction efficiency for the NO/ NO_2 mixture injection is higher than that for NO injection and lower than that for NO_2 injection separately. The NO_x reduction efficiency is independent on the amount of injected gas (NO, NO_2 , or NO/ NO_2), but affected by the exit O_2 . The optimum injection location which gives higher NO_x reduction efficiency is the primary air duct. The NO_x reduction efficiency increases with the percentage of total NO injected into the primary air duct when injecting NO into both primary air duct and secondary air duct simultaneous.

Test data reduction is in process. A meeting was held between NOXSO and B&W about test data reduction. B&W has submitted a draft of final report to NOXSO which includes the description of the testing facility and reducing test data. It is under review by NOXSO and some corrections need to be made. The NOXSO's final report is under preparation and the draft will be submitted to DOE by March 1.

2.0 INTRODUCTION

NO_x recycle is one part of the NOXSO process. In this process, 90% of the acid pollutants (NO_x and SO_2) can be removed simultaneously by adsorption on the surface of a sorbent material. The sorbent is subsequently regenerated by heating and contacting the hot sorbent with a reducing gas followed by steam. The NO_x is removed in the heating process, and the SO_2 is removed by the chemical reaction of the reducing gas and steam. The NO_x stream produced is returned to the combustion process with combustion air, which is called the NO_x recycle. The NO_x is reduced in the flame to N_2 , H_2O , and CO_2 .

The NO_x recycle concept operates by means of two different mechanisms. The first relies on the thermodynamic and kinetic conditions in the flame. When NO_x is fed to the coal combustor at concentrations greater than the equilibrium concentration, a portion of the recycled NO_x is reduced to N_2 and O_2 to approach the equilibrium concentrations (from high to equilibrium value). The kinetic rate of NO formation also decreases due to the high initial recycled NO concentration. The second mechanism relies on the reducing nature of the combustor flame. Free radicals generated at flame temperatures react with the NO_x species reducing them to N_2 and H_2O or CO_2 . Therefore, reaction equilibrium and the reducing atmosphere in the flame both serve to destroy recycled NO_x species.

NO_x recycle will be implemented at the full-scale commercial demonstration plant at Niles. The concept of NO_x recycle has been tested previously at DOE-Pittsburgh Energy Technology Center (PETC) using a 500 lb/hr coal combustor used for the 3/4 MW tests and also using a tunnel furnace capable of being fired with a variety of fuels including gas, fuel oil, coal, and coal-water mixtures. The results were very promising and demonstrated the destruction of NO_x compounds when fed to the combustion system. The data also indicate that the extent of NO_x reduction is determined by the location of the NO_x injection and the combustor design.

This current project is pilot-scale testing of NO_x recycle. The objectives are to provide further fundamental understanding of the NO_x destruction mechanisms and to help with the

implementation of NO_x recycle at the Niles station. A Babcock & Wilcox 6 million Btu/hr Small Boiler Simulator (SBS) (see Figures 1 and 2) was chosen to perform the tests. The SBS is the same type of cyclone furnace as that at Niles and simulates a large cyclone unit very well (see Table 1).

The project involves conducting a series of tests which include injecting NO, NO₂, N₂O, and a simulated NO_x recycle stream respectively. The work performed during this reporting period focused on completing all the tests and reducing testing data. The tests conducted included NO₂ injections into the primary air duct, NO₂ injections into the secondary air duct, NO/NO₂ mixture injections, NO simultaneous injections, and NO/CH₄ injections. The preliminary data analysis showed that the NO_x reduction efficiency was higher for the NO₂ injection than NO injection. For the NO simultaneous injection tests, the higher percentage of NO injected into the primary air duct, the better the NO_x reduction efficiency. The addition of CH₄ into the NO injection demonstrated a little effects on the NO_x reduction efficiency.

3.0 PROJECT DESCRIPTION

In order to provide further fundamental understanding and practical information for NO_x recycle implementation at the Niles station, the following four tasks have been defined to be performed in this project:

Task 1: Project management and reporting. This includes overall management of the project, preparation of monthly reports, preparation of draft and final project work plan, supervision of tests performed by B&W, and final report preparation.

Task 2: Experimental Testing. This has been subcontracted to B&W. It involves site preparation and testing. A schematic diagram of the NO injection and sampling system is shown in Figure 3. Pure NO gas from the gas cylinder goes through a rotameter and is injected into the combustion air duct a short distance from the furnace. The sampling probes for the inlet NO

and NO_x measurement are installed downstream of the injection location and before the cyclone. Both inlet and stack NO and NO_x concentrations are measured by continuous NO/NO_x analyzers. The tests consist of shakedown, baseline, simulated NO recycle, simulated NO₂/N₂O recycle, and novel concept tests. The NO, NO₂ and N₂O will be injected separately to investigate their effects on the NO_x destruction in the furnace. The injection of a simulated NO_x recycle stream will also be tested. The injection location will be in the primary air alone, secondary air alone, and both primary air and secondary air together. The parameters varied during the tests are furnace load, outlet oxygen concentration, and the amount of injected gases which are multiples of the baseline NO_x production levels.

Task 3: Data Analysis. The collected data will be analyzed. Data will be compiled into tables and graphs. The test data will be compared with previous NO_x recycle test results using pulverized coal combustor (performed at PETC) and recommendations for burner operation and NO_x recycle will be prepared.

Task 4: Comparison of B&W's pilot scale boiler to Ohio Edison's commercial boiler at Niles, Ohio. The end result of this task will be a comparison of the two units and suggested conditions for the NO_x recycle tests.

4.0 PROJECT STATUS

All the tests planned have been completed. Test data reduction is in process. A meeting was held between NOXSO and B&W about test data reduction. B&W has submitted a draft of final report to NOXSO which includes the description of the testing facility and reducing test data. It is under review by NOXSO and some corrections need to be made. The NOXSO's final report is under preparation and the draft will be submitted to DOE by March 1.

**Table 1. Comparison of Baseline Conditions Between
the SBS Facility and Commercial Units**

	SBS	Typical Cyclone-Fired Boilers
Cyclone Temperature	> 3000°F	> 3000°F
Resident Time	1.4 sec. at full load	0.7-2 sec.
Furnace Exit Gas Temperature	2265°F	2200°-2350°F
NO_x Level	900-1200 PPM	600-1400 PPM
Ash Retention	80-85 %	60-80 %
Unburned Carbon	< 1 % in Ash	1-20 %
Ash Particle Size (MMD; Bahco)	6-8 microns	6-11 microns

Figure 1 Small Boiler Simulator (SBS) Schematic

Figure 2 Cyclone Furnace

Schematic of NO Injection and Sampling System

Figure 3