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A COMPREHENSIVE APPROACH TO NO_X REDUCTION WITHOUT LOW NO_X BURNERS

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ABSTRACT

The traditional approach to reduce NO_X has been to retrofit and install commercially available "plug-in" Low NO_X burners. Typically, these use a combination of internal staging and are often used in conjunction with over-fire air to create off-stochiometric or staged combustion. That is, the complete combustion of the fuel occurs in several stages.

Often, well designed Low NO_X burners are installed without a comprehensive systems approach. The typical challenges associated with staged combustion are related to the fact that burner performance must be nearly perfect to complete combustion within the available residence time of the furnace. Specifically, attention to airflow measurement and control by use of reliable & repeatable venturis and with pulverizer performance optimization. To maintain or improve this unit's excellent reliability, a focus on optimizing the inputs and completing the combustion prior to the furnace exit was implemented.

The goals of this project were as follows:

1. NO_X Reduction from .78lb/mmBtu(full load) – 1.0#/mmBtu(low load) to less than 0.36 lb/mmBtu
2. Flyash Carbon Content less than 10%
3. Combustion Optimization
4. Minimal slagging
5. Maintain the same as baseline FEGT or reduce FEGT
6. Maximum Load Capability
7. Maximum Fuel Flexibility
8. Complete the project at the lowest cost per kW possible (with the best results)

All of the goals were accomplished. The technical success of this project is the results of applying a systematic and comprehensive approach beginning with raw coal feed to the pulverizers. The benefits of this total combustion optimization project is that later when additional NO_X reductions are required, they can be added as a complimentary change to the present system. For example, if this unit is later equipped with SNCR or SCR, reduced rates of ammonia will be required, there will be reduced "popcorn ash" production, and less SCR catalyst wear and overall unit improved performance and reliability.

INTRODUCTION

In January of 2003, intial Georgia SIP (State Implementation Plan) dictated that all coal fired plants above the 32nd parallel in Ga. Obtain 0.15 lbs/mmBtu NO_X by May 2005 during the ozone season (May-September). As an attempt to begin lowering the NO_X, Plant McIntosh researched the various strategies available. The results of this research was that typically units with no or standard over-fire air systems were not capable of achieving the desired NO_X levels without compromising unit deregulations, reliability and performance issues. Therefore, the goal of this program was to prove that NO_X reduction could be achieved without creating major performance & reliability issues. The plants NO_X reduction goal was to reduce the NO_X level to 0.35#/mmBtu **without** the installation of low NO_X burners by reducing NO_X with boosted & controlled over-fire airflow.

To remain competitive, the plant has undergone major fuel source changes and has implemented complimentary mechanical & operational changes. The primary changes are discussed within this paper. These changes utilize the 13 essentials of optimization as a punch list.

UNIT DESCRIPTION

McIntosh Unit No. 1 is located in Rincon, Georgia 26 miles NW of Savannah and is on the Savannah River. The unit consists of a 1968 vintage B&W front wall fired outdoor Carolina type radiant boiler with a balanced draft furnace 28' deep by 36' wide and 108' high from the roof to lower wall headers. This boiler design utilizes a 10'-0" deep division wall on the front side of the units separating the 4 wide x 4 high burner arrangement into two double columns of burners.

This front wall fired boiler is equipped with (4) MPS 67 coal pulverizers and has conventional circular register burners which were originally designed to maximize heat input with a small furnace volume with high turbulence and very high flame temperatures. The result of the burner and boiler design was the production of high levels of NO_X above 1.0#/mmBtu. It should also be known that prior to this project, the NO_X levels ranged from .78 (full load) – 1.0#/mmBtu (low load) while operating with a low full load excess O_2 set point of <2%. The unit as designed was for a MCR of 1,200,000lbs/hr. steam flow at 1990psi SH outlet pressure and with SH & RH temperatures of 1005°F supplied to a Westinghouse turbine rated at 175 MW output.

PERFORMANCE OVERVIEW

The overall unit performance, operability, load response, reliability, and capacity issues are all inter-related. The approach taken by Savannah Electric was to reduce NO_X without affecting unit capability, performance or reliability. To minimize secondary combustion and the potential consequent superheater and reheater tube metals overheating, steps were taken to optimize the furnace inputs. To minimize water wall wastage in the lower furnace, fuel fineness, distribution and airflows were tuned to minimize wastage in the sub-stoichiometric firing zones.

This systems approach was implemented with an overall goal of maintaining competitive power production costs. Pulverizer optimization was implemented to provide acceptable fuel fineness and distribution with the most difficult fuels (but least expensive), which were of low HGI and required high fuel fineness for acceptable flyash LOI. The approach to combustion optimization was to incorporate the *13 essentials of optimum combustion* as a pre-requisite to the installation of a STORM® designed Boosted Over-Fire Air System.

The 13 essentials are as follows:

1. Furnace exit must be oxidizing, preferably 2-3%.
2. Fuel lines balanced to each burner by "clean-air" test ±2% or better.
3. Fuel lines balanced by "Dirty Air" test, using a Dirty Air Velocity Probe, within ±5% or better.
4. Fuel lines balanced by fuel flows within ±10% or better.
5. Fuel line fineness 75-80% passing a 200 mesh screen and <0.1% on a 50 mesh screen.
6. Primary airflow shall be accurately measured and controlled within ±3% accuracy.
7. Primary air/fuel ratio shall be correct and accurately maintained when above minimum.
8. Boosted Over-fire air shall be installed & controllable
9. Fuel line minimum velocities shall be 3,300fpm
10. Mechanical tolerances of burners and dampers within ±¼" or better.
11. Secondary air distribution to burners within ±5% to ±10%.
12. Fuel feed to the pulverizers smooth during load changes and measured & controlled as accurately as possible. Load cell equipped gravimetric feeders are preferred.
13. Fuel feed quality and size should be consistent. Consistent raw coal sizing to the pulverizers is a good start.

FIRING SYSTEM CHANGES

BURNERS (figure 1)

1. New Fuel line orifices were installed and ±2% balance was achieved
2. New Burner shrouds were installed for windbox equalization & increased pressure
3. New High strength/temperature refractory throats with ±1/4" tolerances
4. New high grade coal nozzle & igniter extensions were installed
5. Flame holders were attached to the nozzle extensions
6. New spinner/spreaders replaced the existing 75° impellers

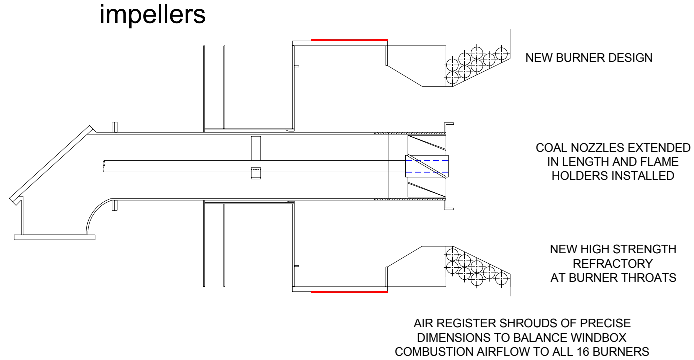


Figure 1: General burner overview

COAL PULVERIZERS (figure 2)

7. Coal pulverizer modifications

    a. Classifier and rotating throat modifications were made to allow operation with optimum air-fuel ratios and elimination of coal rejects.

    b. New primary airflow measuring venturis were installed for optimizing airflow measurement accuracy.

    c. New Gravimetric load cell coal feeder upgrades were installed for optimizing fuel flow measurement accuracy.

The following figure No. 2 details the MPS 67 Modifications

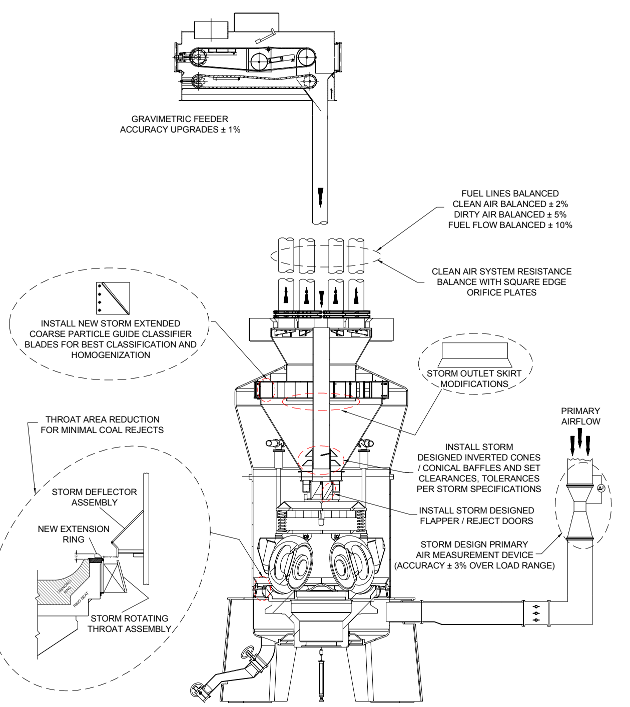


Figure 2: Pulverizer Optimization System Overview

BOOSTED OVER-FIRE AIRFLOW SYSTEM OVERVIEW

The key factor in combustion is to have sufficient oxygen to complete the combustion of the carbon in the ash, before carbon char is quenched below the ignition temperature in the boiler convection pass. Because most coal boilers were designed for 20% excess air, which is roughly a stoichiometry of 1.2, or about 20% additional air than the amount required to burn all of the hydrogen to water, and carbon to CO_2.

The key is having sufficient excess air in the furnace, consistent with the level of air/fuel balancing in the burner belt. Poorer balance requires more excess air to make up for the fuel rich zones in the furnace. Because of this, the 13 essentials previously noted are truly essential and put more of a demand on improving the "inputs" for combustion. In order to reduce NO_X to the goal of less than .36#/mmBtu's, a **F**an **B**oosted **O**ver-**F**ire **A**ir (FBOFA) system was installed. This was implemented in two phases. Phase I consisted of the upper ductwork and over-fire air ports as a traditional over-fire air system. Phase II was added one year later and incorporated the booster fan and control and measurement devices. A general overview of the FBOFA system is as follows:

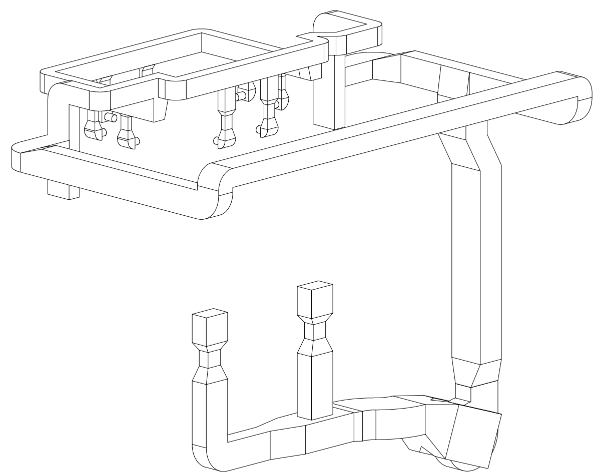


Figure 3: McIntosh Plants Boosted Over-fire Air System Overview

In it simplest form, this system takes pre-heated combustion air from the wind-box or secondary air ducts and boosts the air to strategically located nozzles. The nozzles are located above the burner zone. The airflow is metered and controlled for optimizing combustion and NO_X tuning. The following figure (no.4) shows how the dampers and venturis for each of the nozzles can be manipulated.

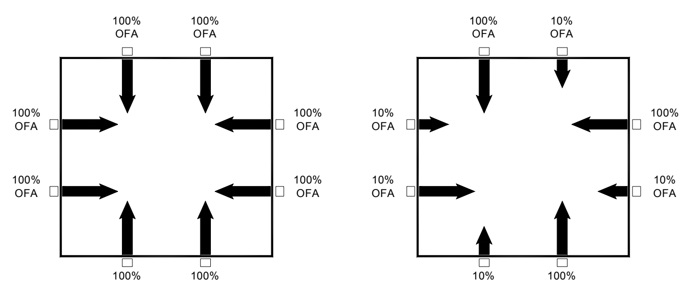


Figure 4: Overview of OFA System Distribution & Manipulation Capabilities

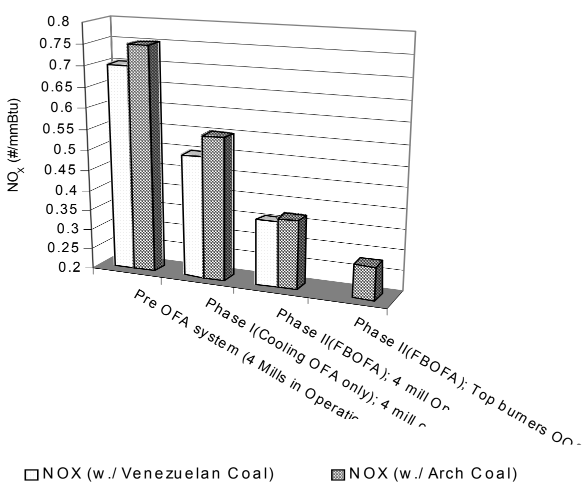
PROJECT RESULTS

A summary of the major project results thus far are as follows:

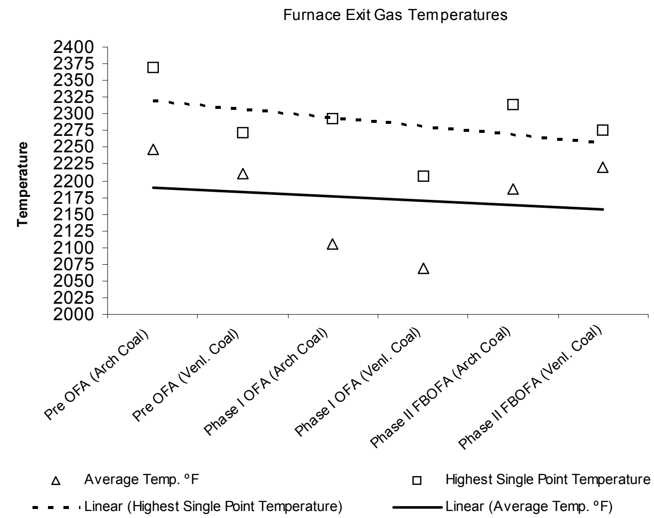
	Pre-NO_X Project (Full Load)	Post Phase II of NO_X Project (Full Load)
Coal Fineness	50 - 60% passing 200 Mesh (w/ <42 HGI)	75-80% passing 200 Mesh (w/ <42 HGI coals); Except "C" mill (at about 60% passing 200Mesh) - this mill has not been re-built with new components
Clean Airflow Balance	Distribution imbalances 5 - 10%	< 2%
Fuel Flow Balance	Distribution imbalances ±20%	Within or very near acceptable parameters of ±10%
Air-Fuel Ratios	Airflow & Fuel Flow measurement accuracy was inconsistent and A/F ratios were all >2.0lbs of air per lb of fuel across the mills load range	1.8lbs of air per lb.of fuel (after minum airflow is satisfied); All but "C" mill which is not yet modified.
Flyash LOI (%)	16% - 22% (w/ Eastern Bituminous Coals)	< 10% w/ Eastern Bituminous Coals & less than 15% LOI w/ low ash Venezuelan Coals
Furnace Exit Gas Temperatures	Very near 2,400°F peak temperatures with Averages at about 2,250°F	2,300°F peak temperature (w/ averages<2200°F)
NO_X	.78 - 1.0#/mmBtu	<.36#/mmBtu(4 mill operations); .28#/mmBtu(3 mill operations)

Table 1: NO_X Project Performance Overview

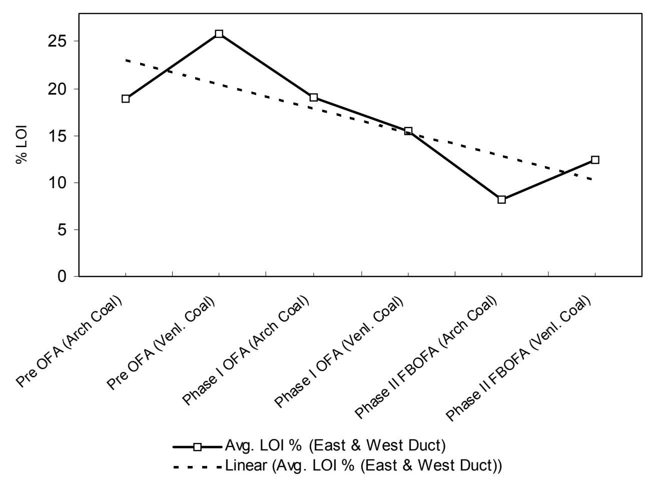
As stated within the table, the accomplishments & goals of the program was to reduce NO_X by greater than 50% without the installation of low NO_X burners while improving LOI with low Hard Grove Index(HGI) coals and without increasing the furnace exit gas temperatures. This was accomplished at a greatly reduced cost compared to other low NO_X options. A graphical overview of these major results can be seen in the three following graphs.



Graph 1: Phases of NO_X reduction



Graph 2: Furnace Exit HVT Data
(Al data collected at full load)



Graph 3: LOI Trend

SYSTEM OVERVIEW

In addition to the previous modifications, the plant has taken the initiative to implement numerous other modifcations to insure optimization from a systems approach. For example, some other recent system components installed at the site are as follows:

- FD fan cross over damper for secondary airflow distribution improvements if the APH differential affects air distribution into the Air heaters.
- CO monitors at the Economizer Outlet
- Furnace viewing Cameras
- Online FEGT Monitors

Combustion Optimization and performance preservation is an ongoing & continuous program. The plant is investigating phase III which will posibly consist of fuel blending with PRB and/or installation of SNCR to lower the levels to at least 0.15#/mmBtu.

Due to the plant having such a synergistic team of capable technical personnel, Savannah Electric was able to install the existing Low NO_X modifications at a very low cost per kW This low cost, but high performance system was the most effective for reliability and environmental friendliness.

For review, a total system overview drawing is as follows:

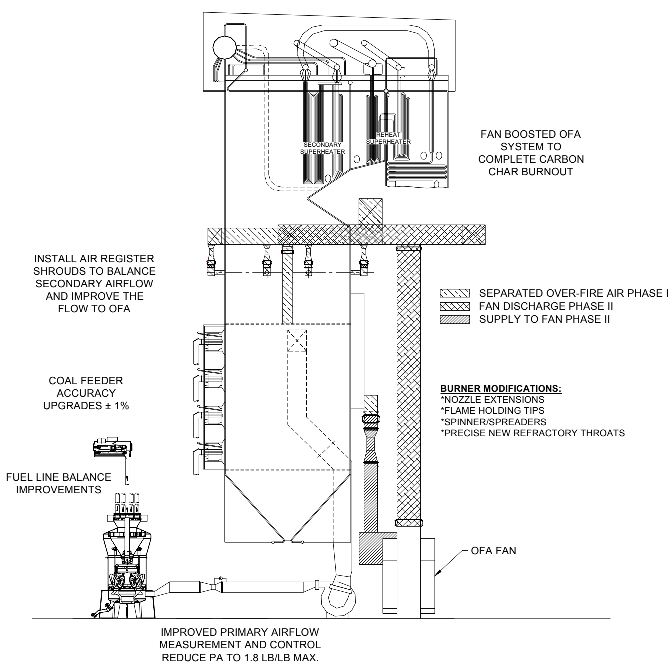


Figure 5: Total System Overview Drawing

ACKNOWLEDGMENTS

The experience of the authors is such that some of the major challenges in the power industry seem to be controllable by human performance and the ability of plant management, engineering, operations & maintenance personnel to understand the fundamentals & essentials of optimizing combustion & overall plant performance.

Storm Technologies recognizes that Savannah Electric was wholly committed to this project. The operational results and cost effectiveness of the system reflect this commitment.

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