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ACHIEVING SIMULATANEOUS NO_X & COMBUSTION IMPROVEMENTS ON A 90MW T-FIRED UNIT BY APPLYING THE FUNDAMENTALS

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ABSTRACT

Storm Technologies in cooperation with AES Westover Station implemented a total combustion optimization system approach, including a fan boosted over-fire air system on Unit 13 to reduce the emissions of NO_X while also improving and/or maintaining acceptable Carbon in Ash content levels on a daily basis.

Implementation of this total airflow & pulverizer performance utilized a fundamental and proven approach to performance optimization and the system has been installed now for over two years and continues to be successful. The results of this systems modifications was up to 60% NO_X reduction and payback in months by reducing the need for NO_X credits and simultaneously improving unit performance, reliability and fuels flexibility.

All of the goals of this program were accomplished and the technical success of this project is once again the results of applying a systematic and comprehensive approach addressing fundamental opportunities for improvement. The benefit of this total combustion optimization project was not only NO_X reductions, but also reliability and "fuels flexibility". Furthermore, foresight in this system was the ability to improve boiler efficiency, heat rate and reduce rates of ammonia when and/or if SCR or SNCR is installed.

Since the installation of the FBOFA System it should be noted that AES Westover has been able to consistently attain between .25-.30 lbs/mmBtu NO_X and single digit carbon in ash levels with no negative effects of the system installed.

The goals of this project were as follows:

1. NO_X Reduction from >.54lb/mmBtu(full load) – to ≤ 0.32 lb/mmBtu
2. Flyash Carbon Content less than 10%
3. Minimal slagging
4. Operations with a minimum of 2% Oxygen to maintain a "slag friendly" furnace without exceeding the NO_X limits
5. Maximum Load Capability
6. Maximum Fuel Flexibility
7. Total Combustion Optimization & Performance Preservation

INTRODUCTION

AES Westover Station, Unit 13 is a tangentially fired unit manufactured by Combustion Engineering originally rated at 560,000lbs/hr steam, now operates with a gross electrical generation of 88MW. The units furnace is approximately 24' – 10" deep by 25' – 4" wide and it has (4) elevations of (16) burners which are fired by (4) Raymond No. 533 deep bowl pulverizers.

PERFORMANCE OVERVIEW

Unit performance, operability, load response, reliability, and capacity issues are all very much inter-related. Therefore, the approach taken by Storm Technologies Inc. (STI) was to reduce NO_X while maintaining normal excess Oxygen and 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. Furthermore, to minimize water wall wastage in the lower furnace, air diverters were installed and the fuel fineness, distribution and airflows were tuned to minimize wastage in the sub-stoichiometric firing zones.

As with many of the performance optimization programs provided by STORM, the approach to combustion optimization was to incorporate the *essentials of optimum combustion* as a pre-requisite to the installation of a STORM® designed Boosted Over-Fire Air System.

The essentials completed were as follows:

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

COAL PULVERIZERS

For optimum combustion, it is the experience of the authors that fuel line fineness must be at least 75% passing 200 mesh and a maximum of 0.1% on 50 mesh. To achieve these results the following mill performance modifications were performed. For review, modifications included extended outlet skirts, extended exhauster blades, and corrected tolerances. Spring tensions were first checked and set to the proper tension ±200 Lbs. journal to journal. Classifier blade settings were checked and properly set to achieve the desired fineness. Fuel line orifice sizing was calculated and changes recommended to further improve “line-to-line” balance by the clean air method.

The following figure No. 1 details the critical tolerances applied to the Raymond 533 Mills.

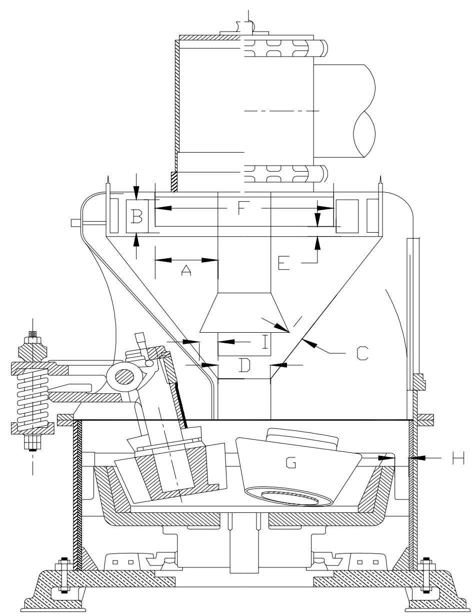


Figure 1: Pulverizer Critical Tolerances

BOOSTED OVER-FIRE AIRFLOW SYSTEM OVERVIEW

In an effort to reduce NO_X while also improving combustion, as STORM designed fan boosted Over-Fire Air (FBOFA) System was installed on Westover 13. As a basic system description, the over-fire air is drawn from the existing 600°F combustion air supply at the air heater exits and is ducted bypassing the burners to the booster fan and to the over-fire air-ports. Two venturis and dampers are provided to precisely measure, balance and control the total over-fire airflow. Manual dampers are provided to control the flow at the individual OFA ports.

The fan-boosted over-fire air system operates at the same design total airflow as original. The difference with the fan-boosted over-fire air system is that combustion is staged and controlled using more of the total furnace volume and height. The purpose of the Boosted Over-Fire Air is to provide proper staging of air and fuel to the furnace. This staging allows for NO_X reduction in the burner belt zone as well as the OFA system allowing oxygen to provide carbon char burn-out prior to exiting the furnace.

The concept of the eight OFA nozzles (two on each water wall) is to utilize the upper furnace for carbon char burnout. This upper furnace zone is where the flame temperatures are cooled to below the threshold thermal NO_X formation temperature of about 2,800ºF. This is shown on figure 2 (below).

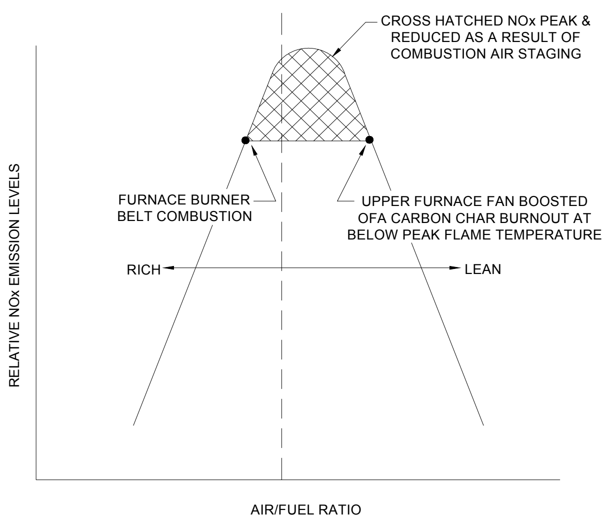


Figure 2

The previous NO_X formation graph shows the peak NO_X production at a slightly oxidizing environment. The principal purpose of the FBOFA system, is to stage combustion, so that most combustion is completed in the burner belt, at a low furnace stoichiometry. The heat energy is released in the burner belt and radiant heat transferred to the water walls, the upper furnace products of combustion will be reduced in temperature to below 2,800ºF. It is at this point that the high momentum over-fire air is injected to complete combustion of the carbon char. This final stage of the combustion process is to be completed below 2,800ºF in the lower furnace and therefore below the threshold temperature for thermal NO_X production.

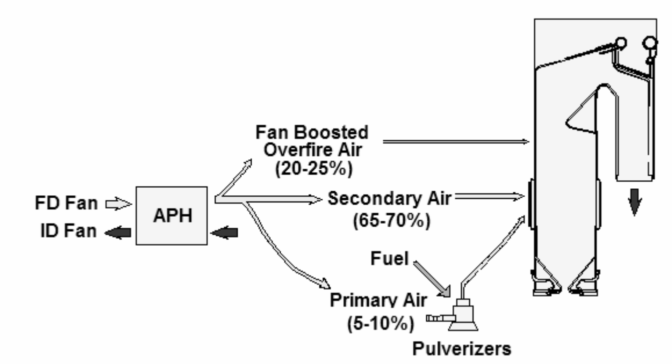


Figure 3

It is for this fundamental reason that the project is considered a "comprehensive combustion optimization," including significant pulverizer and burner improvements.

The Over-fire air system uses a booster fan to increase the supply pressure of the OFA to approximately 10-15" w.c. using 600°F+ air so proper penetration velocities can be obtained through each of the eight water wall openings (shown in Figure 4). This penetration velocity is critical to maintain acceptable flyash LOI and exit gas carbon monoxide (CO) levels**.**

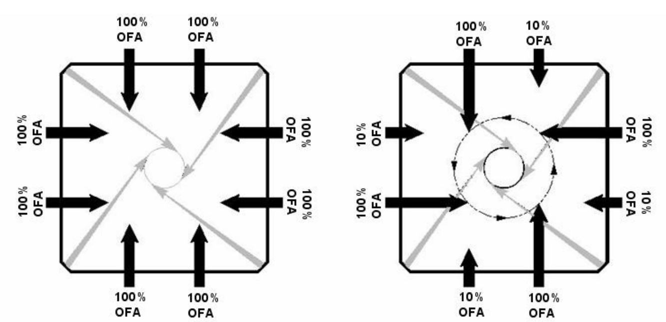


Figure 4: Overview of OFA System Distribution & Manipulation Capabilities

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 .32#/mmBtu's, a **F**an **B**oosted **O**ver-**F**ire **A**ir (FBOFA) system was installed. A general overview of the STI FBOFA system is as follows:

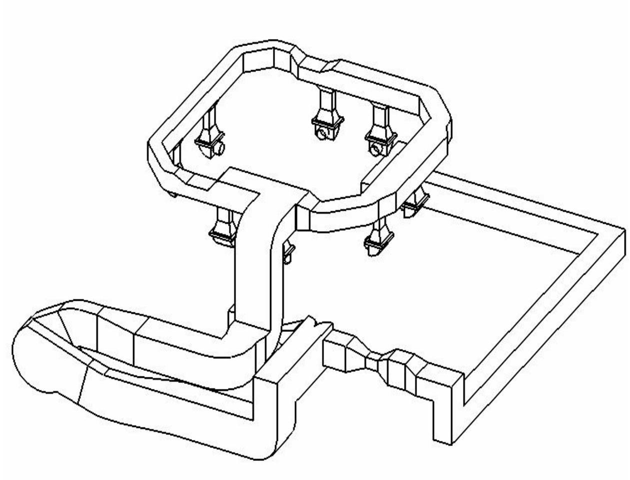


Figure 5: Westover 13's Installed Fan Boosted Over-fire Air System Fan & Ductwork Arrangement

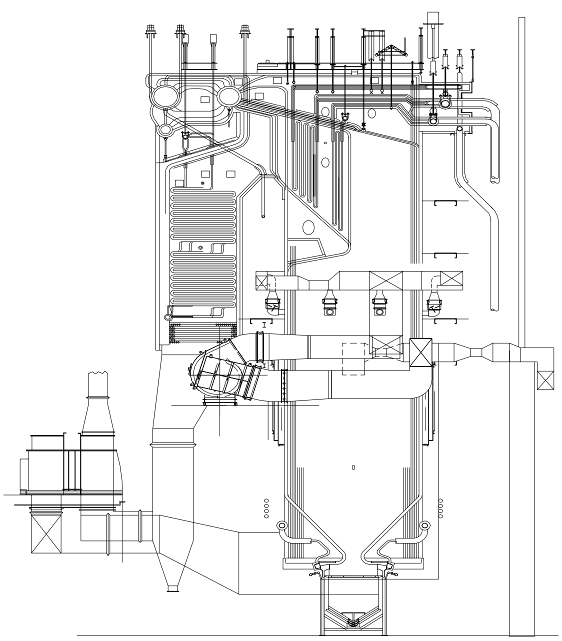


Figure 6: Westover 13 Side Elevation drawing show the Fan Boosted Over-fire Air System Fan "as installed."

PROJECT RESULTS

A summary of the major project results thus far are as follows. First of all table 1 below shows previous full load data showing the correlation between Excess air, LOI, and NO_X.

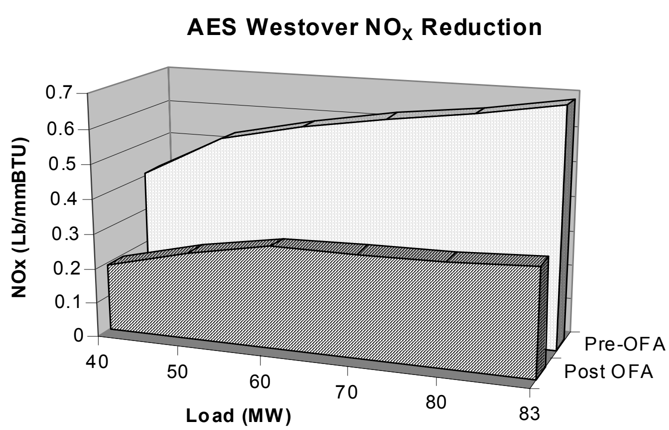
Year	Average LOI	NOx (Lb/mmBTU)
1989	3%	.61-.92
2002	>20%	.27-.54
Present	5-7%	.19-.33

Table 1: LOI vs. NO_X

The following data shown below are average data points collected following installation of the OFA and tuning period. However, currently, the boiler has been demonstrated much lower NO_X levels from operators tuning the system across the entire load range (0.18 - 0.20 Lb/MMBTU at 36 MW and 0.28 - 0.32 Lb/MMBTU at 88 MW's).

Net Load	Gross Load	OFA		Pre-OFA (2002 Ozone Season)		% Reduction	
MW	MW	lb/hr	lb/mmBtu	lb/hr	lb/mmBtu	lb/hr	b/mmBtu
40	43.0	124.8	0.304	159.7	0.409	21.8%	25.6%
50	53.5	155.5	0.309	226.8	0.441	31.4%	30.0%
60	64.0	186.2	0.313	293.8	0.474	36.6%	33.9%
70	74.5	216.9	0.318	360.9	0.506	39.9%	37.3%
80	85.0	247.6	0.322	428.0	0.539	42.1%	40.2%
83	88.0	256.4	0.323	447.1	0.548	42.7%	41.0%

Table 2: NO_X Project Performance Overview



STAGING OF FUEL AND AIR

The fuel and air were staged within the furnace both vertically and horizontally to utilize the entire furnace area. Staging vertically was performed by progressively setting the burner tilts downward, as shown below in Figure 6 showing a typical burner tilt arrangement.

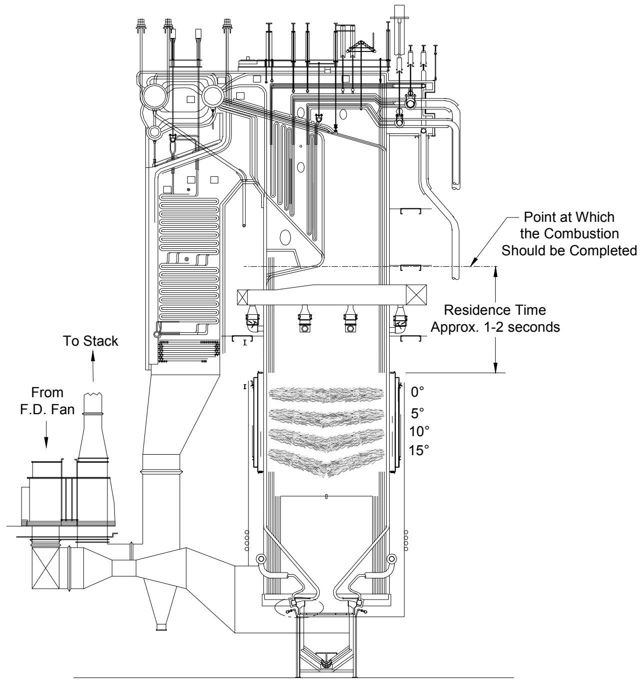


Figure 6

In order to achieve horizontal staging within the furnace, STORM Air Diverters were installed on the auxiliary air buckets. It is essential to maintain an oxidizing environment on the waterwalls to prevent waterwall wastage from occurring. By diverting a percentage of the secondary air toward the furnace walls both farther staging of the fuel and air and wastage prevention was achieved. The figure below shows the separation of the fuel and air required for staging for NO_X reduction.

CLOSING

All of the goals of this program were accomplished and the technical success of this project is once again the results of this joint efforts program in applying a systematic and comprehensive approach towards NO_X Reduction. Storm Technologies, Inc. would like to recognize the entire AES Westover team for excellence and commitment to this project.

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