Experiences with an Advanced Combustion NO_x Control System To Minimize NO_x and Unburned Carbon

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Introduction:

Since the passage of the original Clean Air Act of 1971 utility boiler NO_x regulation has become progressively more stringent. Currently, NO_x regulations require emission reductions to the point where many boilers may be required to utilize supplemental NO_x controls such as: SCR, SNCR and reburning. As a result, it has also become advantageous for a particular power plant to install more effective NO_x controls in order to allow higher load to be obtained without exceeding NO_x limits, to obtain NO_x credits, or to bubble an area.

The most cost-effective means of minimizing NO_x emissions and, where applicable, the capital and operating cost of supplemental controls is through the use of advanced combustion NO_x controls. The most important component of which is the low NO_x burner (LNB).

A new low NO_x burner, developed by Advanced Burner Technologies, began commercial operation in 1997 and has been installed on several large utility steam generators in response to the needs outlined above. To date ABT has installed, or has under contract, over 5,000MW of capacity. NO_x was reduced up to one-third from the levels emitted by the OEM's burners, while UBC remained in the same range as previously attained, on the boilers that were upgraded from the OEM-supplied LNB's to ABT's Opti-Flow^{TM} low NO_x burner design. Three of these experiences are discussed in this paper.

Although the following discussion describes burner and overfire air retrofits performed on boilers equipped with Foster Wheeler burners, ABT also has burner and overfire air system designs applicable to other OEM burners and boilers. Several boilers of other OEM design and manufacture are currently being retrofitted with ABT combustion technology.

The boilers discussed here range from a high temperature pre-NSPS unit of 1970 vintage to two NSPS units with the larger, cooler furnaces of mid-1980's boiler design.

The following table summarizes the three units' key parameters:

Parameter	Unit A	Unit B	Unit C
	NSPS	pre-NSPS	NSPS
Capacity(MW)	440	660	550
Circulation Type	Nat. Circ.	Supercrit.	Nat. Corc.
Configuration	Opposed	Opposed	Opposed
Number of Burners	20	24	24
No. of Mills/type	5/MBF(FW)	6/Ball(FW)	6/RP(ABB)
OEM LNB	CF/SF[1]	IFS[2]	CF/SF[1]
OFA	None	Yes	Yes
ABT Retrofit Date	5/97	10/98	9/98
ABT Scope	Fuel Inject. Reg. Mods.	Fuel Inject.	Fuel Inject. Reg. Mods.
ABT OFA Installed	no	no	yes
Reasons for Retrofit	---------------- Lower NO_x -----------------		
	-------------Improved Reliability----------		
	-------------Elimination of Eyebrows------		
	-----------------Cleaner Furnace-------------		
	Incr. MCR	-	Minimize SCR

[1] : FW Controlled Flow/Split-Flame; [2] FW Internal Fuel Staged

Opti-Flow™ Low NO_x Burner Features:

ABT's combustion NO_x control philosophy can be succinctly summarized as follows:

- The primary NO_x control element is a stable, highly effective low NO_x burner.
- Overfire air can be used, where necessary, as a secondary NO_x control element while maintaining burner stoichiometry(S) > 1.

Optimizing other variables, such as burner line fuel/air balance, coal fineness, wind-box air distribution, etc, all affect how well the primary and secondary NO_x controls function. The more sophisticated the burner design, the more effective will be the optimization of these non-burner variables.

The following is a summation of the salient features and benefits provided by the Opti-Flow low NO_x burner:

- Nearly uniform fuel distribution around the burner nozzle's circumference is obtained, which provides significant aid in attaining minimum NO_x and UBC simultaneously.

- A highly stable, very bright flame is produced that is also adjustable so that it can be used in either tight, high temperature pre-NSPS furnaces or larger, low temperature NSPS units without compromising furnace performance.

- The pressure drop across the fuel injector is lower than in more conventional designs, which allows coal pipes to be orificed without increasing system resistance.

- In some cases, conversion of the existing low NO_x burners to the Opti-Flow configuration requires only the installation of the Opti-Flow fuel injector inside the existing dual register. The burners that have been converted in this manner have attained NO_x reductions of up to 30-35%.

- Coal layout and the resultant coking and burner fires have been completely eliminated.

Opti-Flow™ Overfire Air Features:

ABT has developed an OFA system that relies on a novel, single throat, port design to attain maximum mixing between the OFA flow and the furnace gases rising from the burner zone.

- OFA port aerodynamics produce good penetration while simultaneously generating mixing zones between adjacent burner columns in order to mix air with the gases rising between the burners.

- Only a single damper is used to control the flow to the OFA port, and a single pitot can be used to provide accurate flow to each port. Dual register/dual throat assemblies are not necessary.

The NO_x reduction attained with overfire air is a function of OFA injection elevation above the top burner deck: the greater the distance between OFA and the top burners, the longer the residence time of the low-stoichiometric furnace gases. Long residence time at low S conditions results in lower NO_x levels. However, for a given NO_x level, a more effective low NO_x burner design will require less OFA flow (allowing higher burner S) and less distance between the OFA ports and the top burner deck(yielding reduced residence time).

When ABT's OFA system is used in conjunction with the Opti-Flow low NO_x burner, optimum combined burner/OFA performance can be obtained. ABT's OFA system offers the following advantages:

1. Low OFA flow volume(S>1) results in:
   - Smaller OFA ports = fewer tube welds = lower cost
   - Smaller OFA ducts/dampers = lower cost
2. Water-cooled throats are used thereby eliminating problematic refractory.
3. Booster fan is not required.
4. Installation is possible at either the existing OFA elevation or the top of the burner windbox on boilers without as existing OFA system.
5. Probability of lower furnace slag formation and corrosion is minimized due to burner stoichiometry >1.

In ABT's retrofits, including Unit C with OFA ports open, furnace slagging and burner eyebrows have been nearly eliminated. This has resulted in a significant improvement in boiler reliability, a decrease in maintenance costs, and the elimination of load reductions for slag shedding.

The following table summarizes the pre- and post-retrofit NO_x data(at MCR or VWO)

	Unit A	Unit B	Unit C
Pre-retrofit(no OFA)	0.55-0.6	0.5-0.55	0.55-0.65
Post-retrofit(no OFA)	~0.4	~0.4	0.35-0.40
Post-retrofit(with OFA)	N/A	---	<0.30*

*ABT burners and OFA system at 1.0<S<1.1

The NO_x reductions attained are entirely due to the new burner's effectiveness since the pre- and post-retrofit data were obtained under the same operating conditions: load, excess air, mills in service, etc. The significance is that NO_x has been substantially reduced from levels attained with an older, commercial low NO_x burner without degrading either boiler performance or efficiency.