Cost-Effective NOx Control for Combustion Systems with Air Preheat

New advancements in combustion control technologies, such as flue gas recirculation (FGR) and low NOx burners (LNB), have made it possible to achieve ultra low NOx levels without using expensive post-combustion flue gas clean-up technology. For some natural draft units it may be possible to meet the most stringent of the NOx regulations with cost-effective combustion control technologies. For forced draft (mechanical draft) units it may not be possible to achieve efficient NOx control with LNB. This is because most forced draft systems have air preheat that results in a higher baseline NOx emissions. Increased air preheat temperature results in higher adiabatic flame temperatures and LNB technology is ineffective in reducing flame temperatures. NOx formation is an exponential function of adiabatic flame temperature (see Chemical Engineering, Feb 2001). Any increase in combustion air temperature results in increasing the adiabatic flame temperature, which in turn increases NOx formation. Increase in NOx emission as a function of air preheat temperature is demonstrated in Figure 1.

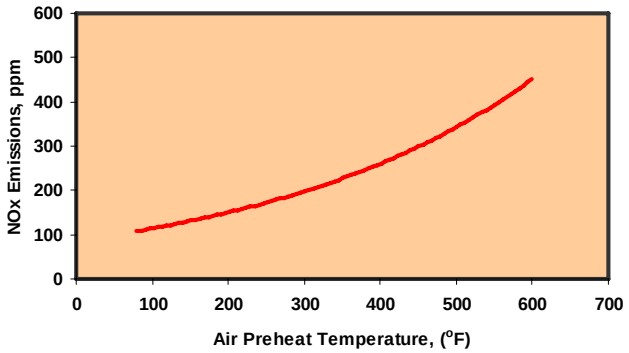

Figure 1. NOx Emissions a function of Air Preheat Temperature.

Air preheat systems have been used in the past to improve energy efficiency. Air preheaters recover energy from hot exhaust gases and transfer it to the incoming combustion air. A 40°F increase in air preheat temperature corresponds to energy efficiency improvement of 1% (see Chemical Engineering Progress, May 1994). Thus, air preheaters in the past have proven to be a very valuable method for improving energy efficiency. Due to environmental regulations, in most new plants, air preheat systems are being replaced with economizers. Economizer recover energy from the hot exhaust gases and preheats the incoming feed to the combustion unit. Thus, economizers are environmentally a more effective method to improve energy efficiency. Replacing existing air preheaters with economizers is one option to reduce NOx without sacrificing the energy efficiency. However, re-routing existing feed lines and modifying flue and combustion air ducts requires significant downtime and can be a very expensive option. Field experience indicates that modifying the ductwork is challenging and ***it is extremely difficult to reproduce combustion performance after modification***. Units modified in such a fashion have often required re-tubing or even furnace replacement to return to the earlier performance. Replacing air preheater with an economizer to merely deal with NOx emissions or to install LNB is a very expensive and unnecessary proposition, especially when more economical alternatives are available.

The most cost-effective approach for reducing NOx from air-preheated systems is by flue gas recirculation (FGR). FGR systems have been extensively used since early 1970's and have proven to be very effective in reducing NOx emissions. In the FGR NOx control process, a portion of the exhaust flue gas is recycled back into the combustion air stream. Recycling the flue gas helps in reducing NOx emissions by up to 90%, depending on the recirculation rate. Typical NOx reduction as a function of FGR rate from an air preheated system is shown in Figure 2. Clearly, FGR systems are very efficient means of reducing NOx from air-preheated units.

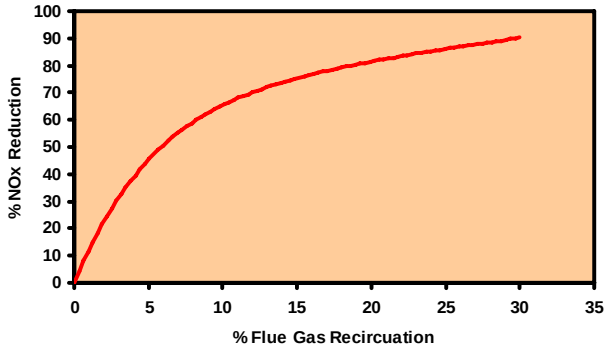

Figure 2. NOx Reduction as a function of Flue Gas Recirculation Rate for Air Preheated Systems.

Traditional FGR systems use a separate fan to move the flue gas from the air preheater exit to the combustion air stream downstream of the forced draft fan. The additional fan requirement adds to the cost of traditional FGR. *ETEC* has developed a more cost-effective process referred to as Induced Flue Gas Recirculation (IFGR). *ETEC's* IFGR

technology (patent pending) uses the existing forced draft fan to induce flue gas into the combustion air at the fan inlet. Elimination of the fan requirement has made the ***IFGR system the most cost-effective demonstrated NOx control technology available in the market today!*** A major advantage of *ETEC*'s IFGR system over the economizer option is that it not only maintains high-energy efficiency of the system but also reduces NOx to levels approaching SCR reduction (see Figure 2). For solving NOx issues from air-preheated systems, IFGR is the most ideal solution. Another major advantage of the IFGR technology is that it can be used in combination with other control technologies to lower NOx emissions even further.

In a typical IFGR application, about 5 - 25 % of flue gas (equivalent to operating the fan with extra 1 - 4 % O_2 in flue) is recycled back into the combustion air. *ETEC* has demonstrated NOx reduction as high as 80%, or even greater reductions for higher uncontrolled emitters. Thus, NOx levels that can be achieved from "newer" burners can also be achieved by IFGR, but at a significantly lower cost and without limiting the turndown capability of the unit! For air preheat systems, IFGR performance is superior to that of LNB. The installed cost of IFGR in retrofit application is a fraction of the cost of low NOx burners. This makes IFGR technology the most cost-effective technology available in the market today. *ETEC's* IFGR technology has several advantages: minimum downtime for installation, very minor modification, relatively little or no impact on performance and operation, and, eliminates existing flame impingement problems. Unlike other combustion control systems, *ETEC's* IFGR system improves fuel and air mixing inadequacies and in certain cases improves the energy efficiency. For fan limited units, *ETEC* offers several low cost de-bottlenecking options to accommodate IFGR flow. *ETEC's* IFGR designs are now being used in over 80% of working IFGR systems.

For operators of natural draft units planning on installing SCR technology, *ETEC* provides a modified IFGR technology called Slip Stream FGR technology (patent pending), where a slipstream from downstream of SCR fan is recirculated back into the flame zone to obtain high levels of NOx reduction. A combination of *ETEC*'s FGR based systems with post-combustion SCR technology is more cost-effective compared to application of only SCR technology (see Chemical Engineering, Feb 2001). This is because when SCR is used in combination with *ETEC*'s FGR systems, the costs associated with catalyst requirements (such as: equipment size, structural steel, etc.) and ammonia-handling systems are significantly reduced due to lower NOx concentration. In certain situations, reduction in ammonia usage alone payback *ETEC* technology cost in less than 6 months.

For units with multiple burners, *ETEC* also offers hybrid of IFGR and C-Mods technologies that achieves SCR NOx levels for a fraction of cost. C-Mods technology is similar to Burners-Out-Of-Service and replicates the performance of LNB and Over Fire Air. When compared to competing NOx control technologies like SCR, *ETEC's* IFGR+C-Mods hybrid technology is expected to result in cost savings of 5 to 20 million dollars depending on the size of the unit.

In the HGA area, several companies are retiring boilers and planning to import steam from a third party operated cogen facility. Depending on a third party for plant utilities not only limits operating flexibility, but eliminates the option of burning waste gas stream that were burned in the boilers. Cost-effectiveness of *ETEC's* systems make it possible to continue operating the boilers while achieving significant NOx reduction with minimal cost implications.

To evaluate if IFGR, Slip-Stream FGR or C-Mods technologies is suitable for your needs, or if you need additional information on *ETEC*, IFGR, Slip-Stream FGR, C-Mods and other NOx reduction technologies, please visit us at http://www.etecinc.net or contact us at (281) 807-7007 or by e-mail at: info@etecinc.net.

About Entropy Technology & Environmental Consultants, Inc. (*ETEC*): *ETEC* is the leading provider of cost-effective and innovative NOx control technologies including: Induced Flue Gas Recirculation (IFGR), Slip Stream FGR, Combustion Modifications (C-Mods) and combustion optimization technologies. Hybrid of *ETEC's* Slip Stream FGR with SCR is estimated to reduce SCR costs by as much as 65%. *ETEC* also offers a hybrid of IFGR and C-Mods technologies that achieves SCR NOx control levels for a fraction of cost. *ETEC*'s technologies are very effective in controlling NOx (typical reduction 50 to 90%); installed cost in retrofit applications is about one tenth of low NOx burners; and, can be installed in less than a week! *ETEC* technologies require very minor modification and have relatively little or no impact on performance and operation. Unlike other combustion control systems, *ETEC* systems improve fuel and air mixing inadequacies and improve the energy efficiency. *ETEC*'s technologies are best suited for gas and low sulfur oil fired units. Over the years, *ETEC* engineers have implemented several combustion control technologies and have saved its customers millions of dollars by avoiding expensive alternative control technologies.

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