Process or Fired Heater Flue Gas Recirculation

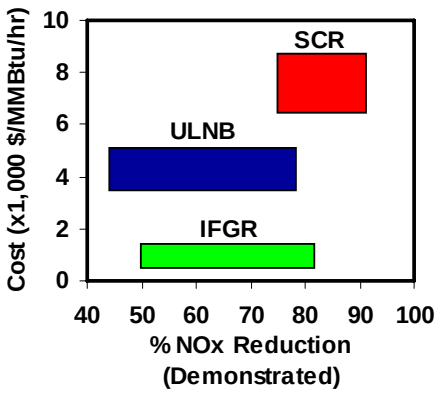
NOx Control for Process Heaters

Traditionally, Low NOx burners (LNB) have been thought to be the only solution for lowering NOx emissions from fired heaters. However, recent field experience with LNB has been a mixed one[i,ii,iii]. Due to limited success of LNB alone in achieving ultra low levels of NOx, most burner manufacturers have endorsed Flue Gas Recirculation (FGR). FGR has now become an essential component of all burners designed to achieve NOx levels below 50 ppmv.

There are two main techniques for recirculating flue gas: (i) Internal FGR, and (ii) External FGR. Internal FGR is commonly used in vertical fired heaters which have burners mounted in the floor firing upwards. Flue gas is induced from the furnace floor region near the burner throat and recirculates through the burner venturi using the energy of the high velocity fuel jets. Burners using internal FGR are referred to as Ultra LNB (ULNB) and are used mostly in natural draft units. Flue gas can also be externally recirculated. The most cost-effective method of recirculating flue gas is either by inducing the recirculation flow with the existing air fan (e.g., Induced FGR, IFGR) or by the fuel dilution method that uses the fuel as a motive force to draw the flue gas and mix it with fuel before combustion. The performance of fuel dilution and IFGR methods are very similar for a single burner system[iv]. However, for multiple burners, ducting for the fuel dilution method is challenging. IFGR technology is the best cost-effective application for forced (mechanical) draft heaters. Therefore, each method satisfies their niche and is very effective in reducing NOx.

The NOx control mechanism and the effect of FGR on heater performance for both types of FGR, internal as well as external, are identical. The only difference is in the mechanics of introducing flue gas into the flame zone. FGR controls NOx formation by introducing inerts in the flame zone, reducing peak flame temperatures and oxygen concentration. FGR does not substantially affect the overall combustion process. However, the division between the radiant-heat duty and convection-heat duty changes: FGR lessens the heat transfer in the radiant section by about 3% and, correspondingly, increases the heat recovery in the convection section[v]. In a typical FGR application, about 10 to 25% of the flue gases is recycled back to the combustion zone, resulting in lowering NOx emissions by up to 80%. For Internal FGR, the recirculation rates are typically less than 10%, resulting in lower NOx reduction. However, the NOx reduction capability of

combined LNB and internal FGR (e.g., ULNB) is similar to external FGR. Compared to external FGR systems, performance of ULNB in air pre-heated systems is poor. External FGR is ideally suited for air pre-heated systems.



In the 1990's, external FGR had not been popular in fired heater application due to the high costs associated with additional flue gas fan requirements. Since the NOx generation mechanism from forced draft systems (especially units with air preheat) is very similar to those from boilers, some NOx control techniques proven for boilers are equally applicable to fired heaters. FGR is one such technology that is well suited for fired heaters with air pre-heat. Most of the burners manufacturers now offer FGR as part of the package with expensive burner systems. Earlier references[vi,vii] have reported successful implementation of external FGR on fired heaters. Reductions as high as 75% with external FGR on fired heaters have been reported[7]. EPA's ACT document reports NOx levels of 0.012 lb/MMBtu to have been achieved with FGR on a 100 MMBtu/hr crude heater. External FGR is commonly used for NOx control on small hot oil heaters. *ETEC* engineers have optimized several of these hot oil heaters to bring NOx emission level down to 0.036 lb/MMBtu. *ETEC* engineers have also been involved in designing IFGR for a 16 MMBtu/hr heater (see photo). NOx reduction of 68% was achieved at this unit. IFGR had little impact on the heater performance NOx reduction results from standalone external FGR systems have been promising. However, progress in the implementation of the technology on fired heaters has been limited due to high cost of an additional FGR fan and low profit potential (for NOx control technology providers). *To reduce cost of external FGR for forced draft systems*, *ETEC* has developed IFGR technology that uses the existing forced-draft fan to induce flue gas into the combustion air at the fan inlet. Elimination of the FGR fan requirement has made the *IFGR system the most cost-effective NOx control technology on the market today!*

Several speakers at the Symposium of Technology for Reducing Emissions in Texas (University of Houston, May 21, 2002) endorsed IFGR claiming it to be "the most cost-effective technology for NOx Control."

IFGR technology is ideally suited for boilers and process heaters with mechanical draft. *ETEC*'s IFGR technology has several advantages: minimum downtime for installation, only minor modifications needed for ductwork, little to no impact on system performance, and elimination of existing flame impingement problems. Unlike other NOx control technologies, all IFGR modifications are external and the unit can be restored to original operation by merely closing a damper! Thus, installation of IFGR will have little or no impact on present furnace operation. IFGR technology offers the lowest risk option for lowest NOx emission at lowest cost.

ETEC has established a niche by offering FGR based systems without the need for new burners. *ETEC was the first to demonstrate IFGR technology on a utility boiler and has pioneered the establishment of IFGR as "the technology of choice" in the retrofit boiler market. ETEC's* Extractor and Inducer technologies (patent pending) have proven to be instrumental in our success. *Success of ETEC's IFGR technology has caused at least one major burner manufacturer to offer IFGR in lieu of low NOx burners. ETEC* is the leading provider of IFGR technology having installed over 36 IFGR systems representing heat duty of over 80,000 MMBtu/hr! *ETEC's* IFGR are the only IFGR systems that have demonstrated NOx reductions in excess of 80%!

NOx control is an expense that has little potential of generating revenues, therefore; the goal should be to achieve compliance with the most cost-effective option. *ETEC* has been very successful in helping clients reduce NOx control costs by as much as 75%! Several of our clients have commented that *ETEC* has been responsible for significant savings in their compliance cost.

Another potential client recently mentioned that including *ETEC* in their bidders list resulted in lower bids from our competition!

IFGR NOx control technology has been acknowledged by our clients to be the most cost-effective technology on the market. For the price of a study, we can install a NOx control system to achieve compliance!

To determine if IFGR, Slip-Stream FGR, C-Mods, or other NOx reduction technologies are suitable for your needs, or if you need additional information, please visit us at http://www.etecinc.net, call us at (281) 807-7007, or e-mail us 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), Selective Catalytic Reduction (SCR) and combustion optimization technologies. Combining *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 the cost. *ETEC*'s technologies are very effective in controlling NOx, with typical reductions of 50 to 90%. The installed cost for IFGR in retrofit applications is about one-tenth the cost of low NOx burners, and can be installed in less than a week! *ETEC* NOx reduction technologies require only minor modifications and have relatively little or no impact on existing performance and operation. Unlike other combustion control systems, *ETEC* systems improve fuel and air mixing and improve energy efficiency. Over the years, *ETEC* engineers have implemented various combustion control technologies and have saved its customers over $52 million by avoiding expensive alternative control technologies. Some of our clients include leading companies such as Reliant Energy, Entergy, TXU, Lower Colorado River Authority, Brazos Electric, Exxon Mobil, BASF and Celanese.

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[i] R.M. Smirnoff, 2001 NPRA Meeting, Austin, TX.
[ii] J. Ellis, Petroleum Technology Quarterly, Spring 2002.
[iii] EPA, Petroleum Refinery Tier 2 BACT Analysis Report, January 2001.
[iv] R.K. Agrawal, Hydrocarbon Processing, September 2001.
[v] A. Garg, Chemical Engineering, November 1992.
[vi] EPA-453/R-93-034, September 1993.
[vii] Canadian Petroleum Products Inst., Report No. 91-1, November 1990.