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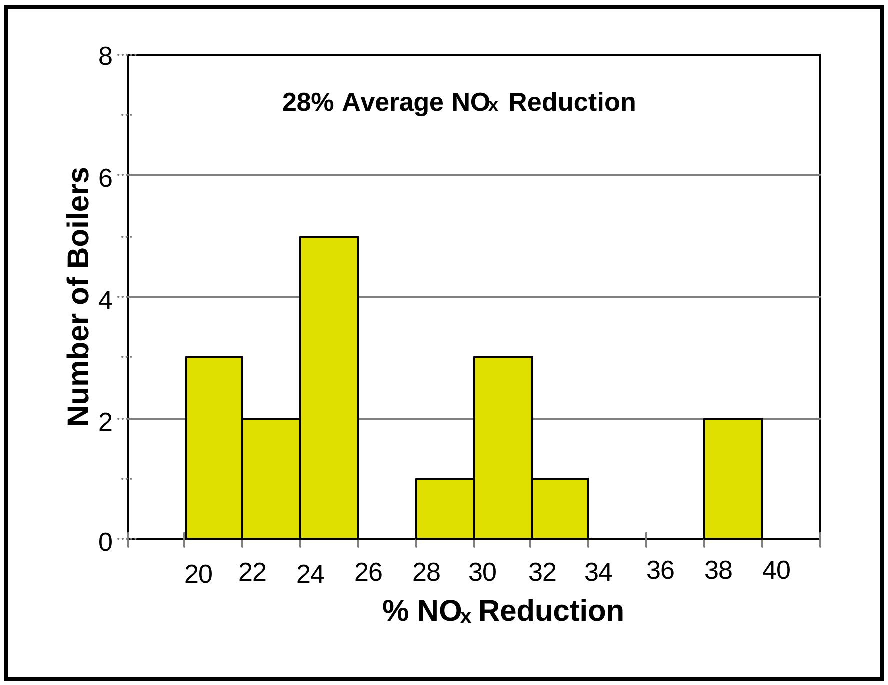
RESULTS FROM FIELD INVESTIGATIONS YIELD ANSWERS TO COMBUSTION OPTIMIZATION QUESTIONS

With tighter restrictions on NO_x emissions and increased competitive pressures to improve heat rate, electric utilities with coal-fired boilers are making greater use of intelligent software for optimization of boiler operations. In deciding whether to use combustion optimization software, utilities are faced with questions such as, "How much will we be able to reduce NO_x?", "What will happen to the heat rate?" and "How frequently will combustion need to be reoptimized in order to maintain low NO_x conditions?". Results, obtained by the Energy Research Center from a recent series of combustion optimization projects, answer many of these questions.

Key parameters such as NO_x emissions, unit heat rate, fly ash unburned carbon, stack opacity, and carbon monoxide are strongly influenced by boiler control settings. Combustion optimization is typically used for determining the boiler control settings needed to achieve a specific NO_x level or to minimize heat rate.

Several years ago, the Energy Research Center developed a combustion optimization software package, referred to as Boiler OP, to assist utilities in reaching their NO_x and heat rate goals. Boiler OP, which uses expert system and neural network methods to obtain the desired results, functions as an off-line advisor to the test engineer. The software guides the engineer through a series of boiler tests to generate data linking NO_x, heat rate, opacity and other parameters to boiler and unit operating conditions. Boiler OP then processes the data and recommends the best combinations of boiler control settings. Boiler OP can also be used as an on-line advisor, providing feedback to the operators on the impacts of the control settings they are using on NO_x and heat rate.



Achievable NO_x reductions through combustion optimization vary from boiler to boiler. Reductions from 20 to 40 percent have been achieved with Boiler OP.

To date, Boiler OP has been used to optimize combustion on 17 generating units. The software has been applied to both wall- and corner-fired boilers covering a range of boiler sizes, types of burners, firing geometries and fuel combinations.

According to John Sale, Manager of Program Development for the Center, "The question I'm asked most frequently about combustion optimization deals with expected levels of NO_x reduction. The amount NO_x can be reduced is very boiler specific. However, from the projects we've done using Boiler OP, we have found that we've been able to achieve NO_x reductions ranging from 20 to almost 40 percent. In addition, we find that in the process of reducing NO_x from some baseline level to a lower level, the heat rate will sometimes increase, sometimes decrease and, in other cases, stay essentially the same. In almost all cases, changes in heat rate that have occurred as a result of changing the boiler control settings have been in the range of 100 Btu/kWh or less."

Sale adds, "Utilities are also concerned with how frequently they will need to reoptimize combustion once the optimal boiler control settings are implemented. Indeed, we have found that NO_x levels can change over time. These changes can occur due to changes in coal properties, furnace sootblowing schedule and physical deterioration of instrumentation, burners and other boiler components. Despite this, we find that once the optimal control settings are established, NO_x remains fairly stable unless there are significant changes in fuel quality or in the maintenance condition of the boiler. In cases where changes in NO_x emissions are an issue, we program the DCS to automatically modulate the boiler control settings to reduce fluctuations in NO_x. The control logic for these changes in control settings is derived from the database of boiler test data previously generated by Boiler OP for that boiler."

Nenad Sarunac and Carlos Romero, research engineers with the Center, have both been heavily involved in combustion optimization projects in recent years. Sarunac notes, "Cooperation from the boiler operators is key to helping ensure low NO_x conditions over the long term. The operators, with their ability to override recommended control settings, need to be properly educated on how the way the boiler is operated affects NO_x emissions. They should also be provided with feedback on the impact of the settings they are using on NO_x and heat rate and on the financial bottom line. Boiler OP has an on-line feature, which we refer to as 'Operator Tools,' which is used to manage this flow of information back to the operators. Through computer displays, the emissions and performance data needed by the operators can be made available to them on-line on a continuous basis."

Romero adds, "One of the keys to achieving large reductions in NO_x through optimization is the ability to recognize which factors limit NO_x reduction on a boiler. In some cases it has been relatively easy to optimize combustion. In others, we have found that factors such as poor pulverizer performance, slag buildup in the boiler back pass and air and fuel distribution problems have severely limited the ability to reduce NO_x. When these situations develop, it is then necessary that efforts be made to balance the air and fuel distribution, or to give extra attention to pulverizer performance to ensure a sufficiently fine coal grind size is obtained, or to develop a sootblowing practice that prevents the furnace exit gas temperatures from increasing to levels which lead to convective pass slagging."

Romero continues, "In some cases, upgrades in instrumentation are also necessary in order to achieve the lowest possible NO_x levels. For example, we find economizer O_2 instrumentation is often inadequate. When this happens, steps should be taken to add additional O_2 analyzers. We have also had good success in using air flow signals from forced draft fan duct sensors to complement or substitute for the economizer O_2 measurements for combustion control."

According to Sale, "Boiler OP has been used successfully to reduce NO_x on both tangentially-fired and wall-fired boilers, burning a range of eastern and western coals and supplemental fuels. The boilers tested have been equipped with either conventional burners or a combination of low NO_x burners with overfire air or flue gas recirculation. The objectives of our combustion optimization projects have varied from utility to utility. This has included characterizing baseline performance and emissions, identifying minimum NO_x levels or minimum heat rate, reducing LOI and CO, and avoiding opacity excursions. While Boiler OP is an off-line code intended to provide advice to the plant engineer and operators, it does have several useful on-line features and we've had several projects which involve the deployment of Boiler OP for on-line use." •