ELECTRIC LIGHT & POWER

Should IT play a role in NO_x compliance?

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The 21st Century power plant is a chemical plant that happens to produce electricity.

"Why would I use software to do my hardware's job?" is a question I frequently get asked when broaching the topic of IT's role in NO_x compliance. It is commonly assumed that if a utility invests in NO_x reduction hardware, such as a selective catalytic reduction (SCR) system, there is no role for a software solution. Experience and data gathered over the past five years proves this assumption false. In fact, using software for incremental boiler NO_x reduction can provide many additional benefits to those of the SCR, including better catalyst management, less ammonia usage, improved plant availability, and sophisticated balancing of the complex chemical, thermodynamic and emissions tradeoffs.

Additional hardware = increased complexity

Fossil fuel burning power plants, driven by ever-changing emissions regulations, are becoming increasingly complex. NO_x emission regulations are driving investments such as low NO_x burners, over fire air, SCR, selective non-catalytic reduction (SNCR) and ammonia-on-demand (AOD) processing. Sulfur emission regulations have warranted scrubbers within the boiler. Each one of these additions moves the generating unit farther from its original design state and creates tradeoffs with efficiency and operational tolerance and complexity.

Each of these systems interacts with one another and changes with time and fuels. Take as an example the interaction between the SCR and flue gas desulfurization (FGD). The high dust variety of SCR found in the U.S. requires the SCR exit gas and all of its contents to pass through the electrostatic precipitator (ESP) and FGD. This introduces a number of complexities. For instance, the catalyst blends typically used in the SCR to reduce NO_x to N_2 (in the presence of ammonia) also oxidizes SO_2 into SO_3. The rate of this reaction is strongly temperature dependent and, at higher temperatures, can convert more than 1 percent of SO_2 to SO_3. High-sulfur U.S. coal generates anywhere from 2,000 to 3,000 ppm of SO2 in the boiler, and therefore can result in 20 to 30 ppm of SO_3 out of the SCR. The problem is that as much as 50 percent, or 10 to 15 ppm, of the SO_3 coming out of the SCR will make it past the scrubber and out of the stack. At about 8 to 10 ppm, depending upon particulate concentration, SO_3 becomes visible as a blue plume.

Adding to the complexity, SO_3 is not always avoided since dual flue gas conditioning (FGC) adds SO_3 to maximize the effectiveness of electrostatic conditioners. The amount of SO_3 added in FGC is on the same order of magnitude as the amount of SO_3 that can be synthesized by the SCR when high sulfur coal is burned.

The role of IT

Unlike hardware, IT can be used to achieve delicate balances in complex systems, where dozens of variables can impact an objective (such as minimizing heat rate or maximizing catalyst efficiency) or a constraint (such as keeping stack SO_3 less than 8 ppm or keeping boiler CO less than 200 ppm). Software solutions, such as neural network optimization, can manage the tradeoffs to achieve changing objectives while adhering to changing constraints.

Only an IT system that constantly learns and adjusts its responses has the flexibility to control the operations of a plant's dynamic environment. Developments in neural optimization technology including retraining, retuning, and committee-based control have enabled optimization systems to automatically and constantly relearn and adjust to meet these requirements.

Controlling variable operating costs

SCRs have been operational in Europe and Japan for more than 10 years, which has enabled important exploratory iterations of catalyst blends, coal type impact, catalyst longevity and change out scheduling, catalyst operational temperature tolerance, ancillary catalytically enhanced reactions, and a host of related operational issues. The oldest operational SCRs in the U.S. have just recently had their first catalyst bed change out. Because catalyst is so sensitive to coal constituents and chemistry, catalyst management in the U.S., while educated by European best practices, will undoubtedly need to find its own way.

Among the key concerns will be variable operating costs such as ammonia usage and catalyst replacement costs. To remove one ton of NO_x from the furnace exit gas requires approximately $250 worth of ammonia. For a base-loaded 650 MW coal-burning unit generating 13,000 tons of NO_x per year, ammonia costs can run about $3 million per year. Catalyst costs can be comparable, with current pricing at about $\$400/ft^3$. Since the volume of catalyst required in a high-dust SCR can easily be 25,000 ft3, the initial charge can run $10 million. Assuming one-third of the total catalyst volume is changed out every three years, catalyst change out costs can easily run $1 million per year.

IT can play a role in controlling these operational costs. Reducing boiler NO_x through neural optimization reduces ammonia consumption by an equivalent percentage. A 15 percent reduction in boiler NO_x and thus ammonia in the unit described above is worth over $0.5 million per year in variable operating dollars. In the case of plants using AOD, the value of a 15 percent reduction should be even higher, due to the increased cost of generating ammonia.

Reducing boiler NO_x also has a dramatic impact on catalyst longevity. Current catalyst management best practice is to use ammonia slip as the metric for catalyst change out. A fresh charge of catalyst is most effective at removing NO_x from the furnace gas. As catalyst poisoning and masking occur, the amount of exposed active catalyst drops and the net ability to remove NO_X degrades. If less NO_X is removed, less ammonia will be consumed. While hundreds of ppm of ammonia are added upstream of the SCR and react with NO_X, ammonia slip of just 5ppm is the usual catalyst change out constraint. By decreasing boiler NO_X, neural optimization enables a smaller amount of exposed catalyst to meet the NO_X reduction goals for which the SCR was designed, thereby extending the catalyst life. A 15 percent reduction in boiler NO_X can delay hitting the ammonia slip limit by 9 months, worth about $200,000 per year.

Extending the benefits

Reducing boiler NO_X with optimization opens up a variety of other catalyst management strategies. For instance, instead of extending catalyst longevity, reduced boiler NO_X could be used to drive the stack NO_X levels lower than the initial SCR design values call for, thus allowing greater NO_X credit attainment. In this scenario, a 15 percent drop in boiler NO_X from combustion optimization could manifest itself as an additional net 4 percent NO_X removal by the SCR beyond its design setpoint. A 4 percent increase in NO_X credits (at $4,500/ton NO_X) for the 650 MW unit described above is worth about $1 million per year.

Mounting emissions regulations in the power industry are pressuring fossil fuel burning generators to operate in increasingly complex and inefficient ways for which they were not designed. Managing the ever-growing complexity and competing objectives, such as heat rate, sulfur emissions, NO_X emissions, opacity, and catalyst and hardware longevity will only get harder.

Over the past five years, neural optimization systems have been used successfully in the power industry to reduce boiler NO_X, unit heat rate, and stack opacity. The same optimization systems are now integrating new SCR- and sootblowing-related data into the plant objectives in order to maintain control over all the critical plant processes.

With a challenge as complex as NO_X compliance, the solution with the greatest payback is an integrated hardware/software strategy. The benefits include better control of variable operations costs like ammonia and catalyst usage, as well as NO_X, SO_X, and opacity emissions credits. The greater the hardware complexity, the greater the value of IT. ELP

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