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Online Analytics Can Extract Context From Devils of Details

By: Brian Schimmoller, Contributing Editor

Performance optimization software has had a rocky history in the power industry. While the technology has always held tremendous promise for hands-free optimization of emissions, heat rate, combustion control, etc., implementation has been challenged by complex modeling requirements, wary operator acceptance and uncertain payback calculations. Further, the nonintuitive assortment of optimization approaches - from neural networks and fuzzy logic to expert systems and first principle models - muddy the waters even more.

There is no doubt, however, that a well-designed and well-implemented optimization system can provide substantial value. Faced with continuous pressures to maximize profit opportunity through cost reductions and revenue growth, asset owners are increasingly willing to consider optimization options. Efforts in this regard are significantly enhanced today through the availability of reams and reams of data from all over the plant. Most plants, for example, are now equipped with data historians such as OsiSoft's PI and with newer instrumentation that captures equipment health information in real time. Making sense of this data, however, is time-consuming, and the embedded trends containing critical process knowledge are typically subtle in nature.

"Any discussion with plant management, operational staff or information management system suppliers about the use of plant operating data quickly spawns a cliche like, 'We need to get the right data into the hands of the right people, so they can make the right decisions,'" said Mike Brown, application business manager with Matrikon, an Edmonton-based company that provides integrated intelligence solutions to a broad range of industries. "These cliches are right. The challenge with raw data, no matter how accessible, is that it is just data, and data still requires a lot of work before it can be turned into knowledge."

Recognizing and appreciating this inherent limitation is essential in considering optimization approaches for combustion control. At the ProcessLink Users Group Summit in September, more than 70 users of NeuCo's optimization software suite had the chance to get hands-on experience with NeuCo's suite of optimization modules, including the latest products and tools, and provided them with an opportunity to share their experiences and frustrations in implementing optimization systems.

Because optimization software can be applied at the unit, plant and fleet levels, NeuCo classifies the overall approach as enterprise asset optimization, and recognizes three main objectives:

1. Availability - having capacity available when the market price of electricity exceeds the generation cost.

2. Efficiency - producing this capacity at the lowest possible cost.

3. Emissions - generating the least costly byproducts and complying with all applicable emission limits.

"To outperform other assets in a given region, owners must capitalize on the wealth of data collected to identify ways in which to optimally meet these three objectives," said Curt Lefebvre, NeuCo president and CEO. "The problem is the data gap that exists at most facilities - too much data, most of which is redundant and which lacks the context to become useful information and subsequently provide actionable knowledge. Closing the gap requires online analytics."

NeuCo's optimization products range from unit-specific combustion control systems such as CombustionOpt to fleet-level load allocation systems such as DispatchOpt. CombustionOpt has accumulated the most time in action, and is currently installed at 96 locations. All of NeuCo's solutions are integrated through their ProcessLink technology platform, which was recently updated to significantly expand the product suite's capabilities and user friendliness.

Of course, an optimization system can only work if it is enabled, and convincing operators to leave the systems in closed-loop or to trust and react to the real-time, open-loop advisory capabilities is not an easy task. In fact, a majority of ProcessLink users at the NeuCo summit cited operator acceptance as a primary goal and a primary challenge. So while no single approach will work in every case, the overriding consensus was that the extremes didn't work. In other words, punitive implementation only encouraged outright opposition, while lenient implementation led to low utilization rates.

Several elements are important in facilitating employee buy-in. An on-site champion is essential in reinforcing the value of closed-loop optimization and in ensuring pressure is maintained on control room operators to keep the system enabled. Involving the operators in the decision-making process is essential - inviting operators to participate in the selection, design and implementation of the system goes a long way toward acceptance. Just as important, however, is a more immediate understanding of the optimization system's "thinking" process. Because the optimization system simultaneously manipulates up to 40 or more variables, some of the moves the system suggests can seem counterintuitive to experienced control room operators. "The complex interplay between mill performance and fuel distribution biasing between upper and lower mills changes over time as mills wear, and often leads to results in which unexpected bias combinations give best performance," said Rob James, senior applications engineer at NeuCo. "This is just one example of the way that relatively fixed characteristics like boiler design and mill configuration turn out to be only one component of actual process behavior, and why a truly adaptive approach is required."

Through their Clean Coal Power Initiative project with the U.S. Department of Energy, NeuCo will deploy and integrate five real-time, closed-loop NeuCo optimizers at Dynegy Inc.'s three-unit Baldwin Energy Complex. These optimizers will address com-

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bustion, sootblowing and SCR operations, overall unit thermal performance and plant-wide economic optimization. "When fully engaged, ProcessLink will manipulate biases and trims within the distributed control system that operators would not be able to focus on continuously, like the fuel and air biases in each unit's 14 cyclones," said David Webb with Dynegy Generation. Since implementation, preliminary data indicates reduced boiler NOx, reduced SCR reagent usage and higher SCR efficiency through more balanced combustion and without additional instrumentation.

Though designed for closed-loop control, real-life operation often dictates that some or all of the manipulated variables will occasionally be taken out of service, such as when operators take the feeders or mills out of service due to wet coal or emergent mechanical constraints. In this case, ProcessLink can provide off-line advice and useful diagnostic analysis. In addition, continuous background simulation modeling is performed to determine the benefits of enabling manipulated variables, relaxing constraints on objectives and manipulated biases, or otherwise modifying configuration parameters such as objective priorities and optimization step sizes.

Another way to facilitate operator acceptance is to tie pay or performance payments to implementation. While such a carrot approach may not be appropriate for asset owners implementing optimization systems for the first time, it can work for facilities that have gained experience. For example, at Deseret Power's Bonanza Station, employees are eligible for an incentive of up to 10 percent if capacity factors targets are achieved. Year-to-date capacity factor at Bonanza has been 96.116 percent, according to Larry Jorgensen, senior shift supervisor.

Bonanza provides an interesting example of what optimization software can do in difficult-to-control environments. Bonanza's 485 MW boiler has an open windbox and no overfire air, complicating control efforts for NOx control. Coal quality is also widely variable, fluctuating from 9,300 Btu/lb to 10,300 Btu/lb over an 18-month period. Before implementing CombustionOpt, Bonanza had average NOx emissions of 0.43 lb/MMBtu; since implementing CombustionOpt in closed-loop control, NOx emissions have fallen to 0.35 lb/MMBtu. Concurrently, CO emissions have fallen 50 percent, and heat rate has increased by 1 percent. The optimization system uses 47 manipulated variables to modify combustion conditions. Deseret Power is also currently working with NeuCo to develop an optimization system for its flue gas desulfurization system. Because limestone addition is so small in relation to overall limestone slurry volume - 35 gpm versus about 50,000 gallons volume - response time is slow, so limestone usage can be less than optimal. The solution under development will rely on NeuCo's neural network capabilities to optimize limestone addition (and reduce consumption costs) by focusing on two control parameters: limestone addition and reclaimed water addition. Savings will be achieved by preventing swings and/or over-feeding of FGD modules.

Process optimization has broadened significantly in recent years. Early combustion optimization software systems were based predominantly on neural network technology, which employs data-driven models that continuously "learn" from process behavior. Newer generation optimization products, such as NeuCo's SootOpt, PerformanceOpt and MaintenanceOpt, capitalize on other optimization technologies, such as first principles and heuristics, in addition to neural networks. "To solve the spectrum of generator optimization challenges, we need to use hybrid approaches," said Lefebvre. "If you know the math, write the equations; when experts have key knowledge, capture the rules; and when the problem is complex and poorly understood, learn from it using inductive techniques such as neural networks. The bottom line is that you can't force fit a technology on a problem. You need to understand the problem and apply whatever combination of technologies and expertise are required to solve it."

NeuCo, of course, is not the only optimization vendor in town. Pegasus Technologies, Emerson Process Management and Clyde Bergemann are some of the other vendors that offer comparable or equipment-specific optimization solutions for coal-fired power plant operators. Pegasus, for example, has developed post-combustion optimization applications that can work stand-alone or in conjunction with their combustion optimization solutions. DeltaE3 FGD Optimizer enables owners of wet flue gas desulfurization (FGD) systems to improve SO2 removal efficiency, prevent limestone blinding and decrease operational costs while maintaining gypsum purity.

The FGD Optimizer improves upon operator and control system performance. It uses a neural network to determine optimal setpoints for damper position, pH, oxidation air and operational state of the recycle pumps. A 2-5 percent improvement in SO2 removal efficiency is possible with DeltaE3 FGD Optimizer, potentially saving a 600 MW coal-fired unit more than $1 million annually. Through advanced nonlinear dynamic models, the optimizer can be implemented to actively control the FGD on a minute-to-minute basis, allowing it to operate closer to the significant constraints of the process, such as stack temperature and gypsum quality.

Benefits include:

- Increased SO2 Removal Efficiency: By operating closer to either the stack temperature or gypsum quality constraints, the SO2 removal efficiency can be improved approximately 5 percent.
- Decreased Operational Cost: Advance optimization and control techniques can be used to control limestone usage and reduce power consumption up to 15 percent.
- Prevention of Limestone Blinding: Unexpected high levels of SO2 in the coal can lead to high amounts of sulfite in the reaction tank. If operators do not recognize this condition, limestone blinding can occur. The DeltaE3 FGD Optimizer automatically senses this condition and responds by increasing oxidation air and potentially turning off recycle pumps to prevent limestone blinding.
- Consistent Operations: DeltaE3 FGD Optimizer provides stable, consistent operation of a wet FGD, freeing operators to concentrate upon other tasks. Consistent operation can improve SO2 removal efficiency and prevent production of off-specification gypsum.
- Maintenance: Problems with pH probes or limestone particle size can be identified by comparing predictive models with plant operations. By immediately identifying problems, pH probes can be replaced or balls can be recharged in the ball mill before a problem occurs.

Selecting among optimization software vendors involves a plant-specific evaluation that considers a host of factors: cost, capabilities, existing control system, installation complexity, fuel used, required instrumentation upgrades, operator familiarity and many others. In the end, the decision boils down to a question of whether the plant, in its regional energy marketplace, would benefit from more rigorous data analysis and system optimization. In most cases, the answer will be yes.