THE EFFECT OF DYNAMIC MODELING AND OPTIMIZATION TECHNOLOGY ON SNCR PERFORMANCE

An Interim Report

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The Situation:

Ultramax has been successful in using its optimization method and modeling technology on over 70 different kinds of boilers using coal, oil, gas and combinations of each over the past three years to reduce NOx by as much as 40%, LOI by 25-50% and Heat Rate up to 5%. Most recently at the Mercer station of Public Service Electric & Gas of New Jersey (PSE&G) Ultramax was asked to see what it could do over a two week period to improve heat rate while also reducing NOx. The results of two week's work was a heat rate improvement of over 1% while reducing NOx by 10%. (PSE&G) then decided to ask Ultramax to find out what could be done on their SNCR unit to improve its performance.

Ultramax Corporation was asked to provide its Dynamic Optimization service in order to evaluate the use of empirical modeling and optimization technology on the SNCR unit at its Mercer station. The work is being funded through a tailored collaboration with EPRI. The objective of the work is to determine what performance improvement for NOx reduction and Ammonia use efficiency can take place over a two week period using the Ultramax empirical modeling and optimization technology.

The tests were to be run in the presence of the Nalco technical service personnel who are responsible for the operation of the SNCR unit at Mercer.

Ultramax would lead the team and be on site for the two weeks using a laptop computer to implement ULTRAMAX® for the optimization work.

The Ultramax Method™ and Optimization Technology

There is a disciplined approach used on each application of ULTRAMAX. This approach is called the Ultramax Method. The Technology also used on each application is an empirically based approach to learning how to model a process's behavior in order to understand the cause and effect relationship of the controlled inputs, uncontrolled inputs on the process and the desired results so that the best combination of control settings can be determined. The models then are integrated into the control system in use in order to automatically update them and provide the customer with the capability of immediately adjusting to changes that effect performance, emission compliance and overall profitability.

The following steps show how the Method and Technology is used to improve the performance of a process:

1. Confirm the business objective driving the project.
2. Characterize the SNCR unit to make sure everyone understood what was to be optimized and what control adjustments were available to accomplish the work.
3. Complete the Decision Diagram which is used to define the outputs which will be measured to determine progress, the controlled inputs which will be adjusted to effect the results, the uncontrolled inputs, if any, which effect the results but cannot be controlled, the constraints for all variables, if any, the prior knowledge of where the unit typically has operated within and finally the timing and role responsibilities for getting the information back to ULTRAMAX to model and predict results from.
4. Run replicates to determine how much "noise", if any, is present in the system. (Unexplained variation in the performance of the control system.) This data is then averaged and used as the first data entry for ULTRAMAX to consider to get started.

5. Use ULTRAMAX to conduct Dynamic Optimization runs which are made up of asking for an advice on all of the recommended settings for the controlled inputs, adjustments are then made to the controls, the process is allowed to settle out, results are measured, fed back to ULTRAMAX and ULTRAMAX updates the models and is ready to offer the next advice for the next round of optimization. This cycle continues until the process reaches a relative optimum.
6. When the process reaches a relative optimum use the "What If" analysis function of ULTRAMAX to help determine what can be done to change the process or inputs to it to effect the next level of performance improvement.
7. Make the appropriate changes and use ULTRAMAX as an ongoing part of continuous improvement in order to learn what changes need to be made, if any, to the control settings in order to take the process to the next level of desired performance.

The Mercer Station Project Work in Progress Summary:

The Mercer SNCR project had to be broken up into two, one week optimization runs due to some scheduling problems at the plant site. The results of the first week's work are being reported at this time with the balance of the project to be completed by June 1, 1997.

The Game Plan used to conduct the optimization work is shown in Exhibit A. The Game Plan is a summary of the main project objectives, the outputs being measured to determine progress and the controlled inputs which are to be adjusted that effect the process, the SNCR, and the results. This Game Plan had 9 controlled inputs to adjust, no uncontrolled inputs and 13 outputs which were measured in order to determine the progress being made. The primary objective was to reduce NOx while not violating operating constraints on the other inputs and outputs. The secondary objective was to try to improve NOx reduction and the overall efficiency of the use of the amount of ammonia and the amount escaping up the stack.

Next the Ultramax engineer established the "noise level" in the SNCR by running five replicates keeping the controlled inputs constant. It was determined that the level of "noise level", the amount of unexplained variation, was acceptable enough to begin the evaluation. The replicates were then averaged and loaded into ULTRAMAX as the first set of data to be used to being the optimization journey. (See Exhibit B to show the "base points", the replicates, and run # 66's outcomes. This is only an interim point so we can only report on tendencies.)

The sequence of events that took place starting with the first ULTRAMAX run were as follows:

- ULTRAMAX was asked to provide an advice. (The first set of actual recommended settings to make to the inputs to begin to improve.)
- The operator has the option to accept the advice or change it to meet his experience. (If changes are made to the recommended advice, those changes are noted in ULTRAMAX.)
- The SNCR unit is allowed to settle out and respond to the changes.
- The output variables are then measured and provided to ULTRAMAX. (The Ultramax engineer loads the data into ULTRAMAX and asks for it to learn, update the models and provide a new advice for the next round of optimization.)
- ULTRAMAX provides the next advice and the cycle repeats. (This optimization run cycle took approximately 30 minutes to complete.)

During the first 10 or 15 runs it is customary to find that certain inputs which were thought to be key when the Decision Diagram was completed by the optimization team are not and these inputs are replaced by inputs which were thought initially to have less impact to find out if they should be included in the model building. This application did not have any inputs that needed replacing.

We have noticed so far that the most significant input changes were:

> Zone 6 H_2O is up 16 psi, Zone 8 H_2O is up 9 psi and Zone 8 Urea is down 21 gallons per minute. All other inputs are relatively unchanged at this time. The Urea reduction, if it continues, will generate about 8% savings in usage while also reducing the amount going up the stack by 90%.

When the second week of work is done and the project completed, we will be able to more completely summarize our findings. Right now there is an indication that we will in fact reduce NOx, the use of Ammonia and the amount which goes up the stack.