Obtaining Improved Efficiency and Reduced LOI Using Advanced Combustion Optimization on a Boiler Operated in Load-Following Mode

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Introduction

Advanced empirical optimization software is being used on a wide variety of coal-fired boilers to reduce NO_X, increase boiler efficiency and lower LOI. Optimization is a never-ending process and enhancements are constantly being sought to obtain ever better performance from existing generation units. Previous experience with combustion optimization was limited to the operation of boilers that remained at stable loads for an hour or more. Allegheny Power Service is sponsoring a Tailored Collaboration Project (TC) with Electric Power Research Institute (EPRI) to investigate the benefits of optimizing a unit with enhanced controls and when operated in load-following mode with continuous load changes the norm. Ultramax Corporation is providing the unique transient optimization capability in its ULTRAMAX® Dynamic Optimization software.

The boiler designated for the TC is Unit 1 at Allegheny Armstrong Power Station (APS). It is a Foster Wheeler opposed-wall, coal-fired boiler equipped with IFS Low NO_X burners and rated at 180 MW. A Westinghouse WDPF Distributed Control System (DCS) provides the control and data acquisition for the unit.

Allegheny wishes to optimize Unit 1 for maximum boiler efficiency and reduced LOI while controlling NO_X emissions consistent with Allegheny's compliance plan. Ultramax is integrating its optimization technology with the Westinghouse DCS to enable both advisory and closed-loop optimization. It will collect transient data, model the boiler and provide predictions while load varies as well as during stable load conditions.

ULTRAMAX Dynamic Optimization

ULTRAMAX Dynamic Optimization is the leading software technology for empirical optimization of boiler combustion and other plant processes. It has been applied to more than 90 boilers of al types, manufactures, sizes and fuels. The software "learns" and models directly from boiler data, and rapidly discovers control settings that deliver maximum performance for each load and operating condition. Typical improvements are 1% to 5% in heat rate, 15% to 30% in NO_X and 25% to 50% in LOI.

ULTRAMAX software combines Bayesian statistics and proprietary weighted regression algorithms to build locally accurate, goal-oriented models. This modeling basis enables it to safely extrapolate beyond the range of its current database to discover control settings that produce better results. It performs intelligent exploration while it builds accurate models using information-rich data from control-setting adjustments recommended by the software. Because it updates its models dynamically, it keeps the process operating at its optimum as conditions change over time. Unlike neural network approaches, ULTRAMAX requires no historical data to begin optimizing and build models. There is no need to anticipate all future operating

conditions and objectives, or depend on static models that become obsolete.

Project Scope

The overall objective of the project is to determine how much additional benefit can be derived from utilizing enhanced controls and from optimizing when the furnace is in a transient condition. It is believed that this refined optimization will yield valuable improvements in the cost of operation versus operating at control settings that are a compromise relative to load and burner configurations. The tentative plan to accomplish the project objectives is to perform optimization using ULTRAMAX Dynamic Optimization according to the following four-step sequence:

1. Establish the performance baseline of Unit 1 at its standard control settings while operating at full load. It is necessary to establish reference levels for comparison as the new capabilities are added.
2. Optimize Unit 1 at full load in stand-alone, online advisory and closed-loop modes before including the new control enhancements.
3. Optimize Unit 1 using the enhanced control capabilities
4. Optimize Unit 1 while operating in load-following mode using the transient organization feature of ULTRAMAX.

Results to Date

Steps 1 and 2 were completed in the fall of 1998. Unit 1 was operated at full load for the days necessary to perform the initial optimization. First the baseline was established by taking repetitive readings over a two-hour period of boiler efficiency, NO_X, CO, LOI, opacity, gas temperatures and other important parameters. Then, optimization runs were performed using ULTRAMAX in stand-alone mode. In stand-alone mode, the software is not yet interfaced with the DCS. Hourly adjustments were made to control parameter settings following the recommendations of the software. Data, averaged over a 15-minute interval, were fed back to the software at the end of each run. It updated its models and gave a fresh recommendation as "learning" and optimization proceeded. After two weeks of testing near full load, the key results achieved are the following:

- Boiler efficiency was increased from 0.25% - 0.5% compared to baseline.
- LOI was reduced by 35% from baseline.
- NO_X remained comfortably below its specified operational constraint.
- CO remained comfortably below its specified operational constraint.

After this initial optimization, the team refined the selection of control parameters and expanded them to include the enhanced controls that will be available for the next step. Many more parameters can be considered when settings are adjusted and data acquired automatically.

Plans for the Future

ULTRAMAX Dynamic Optimization software will be interfaced with the Westinghouse DCS through the PI data historian to enable automatic acquisition of data and adjustment of boiler control parameter settings. The ULTRAMAX solution will operate in both advisory and closed-loop modes. When models are sufficiently robust at designated loads, Unit 1 will be operated in its normal load-following mode and optimization will continue using the transient feature. This project hopes to establish that optimization of a load-following generation unit is feasible and that utilization of enhanced control capabilities provides significant benefits over the less refined methods used previously. This would greatly expand the number of generating units in the U.S. power industry that can achieve greater improvements in efficiency, LOI and NO_X emissions.