CUSTOMER CASE STUDY

Morrow Generating Station

AVEVA APC increases plant efficiency and lowers carbon footprint with a 12-month project payback

Morrow Generating Station
Industry - Power

Goals

- Improve plant efficiency and lower CO_2 and NO_x emissions
- Increase net power generation
- Minimize system demands placed on the operator and achieve more consistent operations

Challenges

- Improve plant efficiency while maintaining steam temperatures and remaining within CO_2 and NO_x emissions
- Improve unit operation and availability when burning low-grade coal

Results

- Heat rate improvements in the range of 0.90 to 1.60%
- NO_x reductions of approximately 10% across the load range
- Over $330,000 in additional annual revenue

"Depending on the load, potential heat rate improvements up to 1.6% are expected. This benefit will provide a project payback of less than one year."
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Bill Poe,
AVEVA APC Consultant

Hattiesburg, Mississippi – Cooperative Energy (CE) is an electrical generation and transmission cooperative in Hattiesburg, Mississippi providing power to more than 427,000 homes and businesses. On November 9, 2016, the South Mississippi Electric Power Association (SMEPA) changed its name to Cooperative Energy. Plant Morrow began operation in 1978 with two 200 MW units fueled by Appalachian coal. The plant served as a stable, reliable source of electricity for Co-operative Energy Members for over 40 years.

Client challenge

In today's environment, power plant managers continuously face new challenges and requirements. Even a short list includes the need for higher efficiency, lower emissions, greater fuel flexibility, higher availability, lower operating costs, and a faster dispatch rate.

To meet these challenges, plant staff are continuously designing and installing equipment upgrades. The good news, however, is that these upgrades also create new opportunities for achieving performance and profitability improvements through advanced control.

At R.D. Morrow Generating Station, improving heat rate while maintaining low NO_x emissions was extremely important. The power plant consisted of two parallel boiler-turbine units with a capacity of 204 MW, with nominal steam conditions of 2400 psig, 1005 °F and 1,575,000 lb/hr.

Another major challenge was the wide variability in coal quality that hindered normal plant operation, particularly for lower grade coal.

Four steps to performance improvement

At the R. D. Morrow Station, a series of four evolutionary and interdependent efforts yielded significant fuel savings while lowering CO_2 and NO_x emissions. The improvements included:

- Optimization of the DCS (Distributed Control System) heat rate controls for both units
- Optimization of soot blower controls
- Optimization of over-fire air control system
- Optimization of cooling tower controls

Heat rate control optimization

Upgrade: A general upgrade of the DCS controls for the Units 1 and 2 boiler controls.

Objectives: The objective of the first optimization systems was heat rate improvement, CO_2 and NO_x reduction. A second objective was the implementation of a soot blower advisory system.

Approach: To this end, a supervisory control system was installed over the modern DCS to improve performance for their Riley turbo-fired units with ball mills. Both furnace and ball mill controls were optimized with coordinated multivariable control, achieving the following:

- Balance east and west boiler superheat and reheat steam temperatures to increase the average temperature while maintaining the higher side temperature at set point
- Extract more energy from the flue gas by achieving lower flue gas temperature, balancing furnace air distribution, and lowering overall air flow
- Balance side-to-side ball mill outlet conditions
- Improve ball mill balance and grinding performance for improved coal fineness and lower unburned carbon (LOI)

Results: The optimization systems met the objectives and provided additional benefits of improved unit ramp rate and increased maximum load generation. Unit performance while firing low grade coal was greatly improved, allowing faster dispatch rates and higher load generating capacity.

An extensive heat rate test comparing operation with and without the optimization system in service was conducted at the conclusion of the project with heat rate improvements approaching 1%. The success on the first unit led to rapid commissioning of the second unit which achieved similar benefits.

Soot blower optimization

Upgrade: New soot blower controls in the DCS replaced the original stand-alone relay and timer-based soot blowing system.

Objectives: The soot blower advisory system implemented in the first project required the operator to manually execute the actions suggested by the advisor and provide feedback on the system to acknowledge the action. The objective of this optimization effort was to implement an automated, "smart" soot blower system that would:

- Minimize the system demands placed on the operator
- Increase the average steam temperatures to the HP and IP turbines, thereby increasing cycle efficiency
- Avoid any negative impact on thermal performance arising from improper soot blowing procedures
- Maintain the reheat steam temperature at or above the load-based target

Approach: The boiler control system applies the highest side temperature as the measurement input to the steam temperature controls. Balancing side-to-side superheat and reheat steam temperatures minimizes the temperature difference and raises the average temperature to the turbines.

To balance these temperatures the optimizer applied a mix of two technologies:

- Smart logic system to evaluate key performance measurements, unit fouling conditions, and equipment status
- Programmable sequence blocks to implement timers and permissive

Results: Soot blowers perform the essential task of removing deposits on the furnace walls and tubes that can significantly imbalance energy distribution. Consequently, activating appropriate soot blowers can improve thermal performance while avoiding serious adverse effects on thermal performance that can last for several hours.

This system reduced the mean west/east superheat and reheat temperature differences to 2.5 °F and 3.4 °F over the observation period. Generally, there was a marked increase in the average superheat and reheat temperatures, yielding higher unit efficiency.

Over-fire air optimization

Upgrade: New damper drives provided secondary air regulation to each burner while maintaining full over-fire air flow capacity above each burner. New DCS controls modulated these secondary air dampers. This provided the means to adjust secondary air distribution in the furnace and achieve greater effectiveness of the over-fire air.

Objectives: The objective of this effort was further reductions in NO_x emissions.

Approach: The optimization system applied dynamic multivariable control and neural net models of the newly modified secondary air dampers effects on the measured furnace parameters. These parameters included furnace O_2 distribution, stack NO_x and CO, and steam temperatures.

The multivariable control system also included new virtual sensors representing key burner zone parameters. These virtual sensors track the load, coal mill shifts and fuel quality changes. Constraints on these virtual sensors limited the secondary air damper modulation to a range that is effective in achieving NO_x reduction while ensuring satisfactory furnace conditions.

Results: The system sustained NO_x reductions of approximately 10% across the load range. The system also achieved the additional benefit of increased heat rate improvement through the balance of O_2 distribution. Since the control system applied the lowest side O_2 measurement in the O_2 controller, a side-to-side difference increased the average O_2 through the furnace. Balancing the O_2 distribution further lowered the average O_2, and thereby reducing furnace dry gas losses.

Cooling tower optimization

Upgrade: This upgrade rebuilt the two cooling towers providing the cooling water for the units. New fiberglass members replaced the prior wooden structure with a new water distribution system using four circulating pumps, retaining the sixteen 2-speed cooling fans.

Objectives: The temperature and flow rate of the cooling water influence condenser performance, steam turbine exhaust pressure, and turbine power generation. Maximum cooling minimizes water temperature and turbine exhaust pressure and maximizes the turbine load generation from the available steam flow. However, maximizing cooling also exponentially increases the auxiliary load on the unit, and significantly lowers the net load generation available for the grid.

The objective of this effort was to balance the amount of cooling versus the associated auxiliary load to maximize net load generation.

Approach: The relationships for the performance of the cooling tower and the turbine efficiency are all highly non-linear and vary with ambient conditions. Due to the complexity of the optimization problem and because the cooling tower fans and circulating water pumps are on a stand-alone hard-wired control system, the solution took the form of a cooling tower advisory system within the NO_x and heat rate optimization system.

This optimization system balances the impact of the increasing number of pumps in service and fan speed on each condenser's backpressure and each turbine's MW production against the incremental power consumption of the pumps and fans to seek the optimum condenser performance.

Results: A comparison of a 24-day period for the same month a year apart, with the Cooling Tower Optimization system in service indicated an average hourly savings of 1205 KW at a value of ~$1,120 /day in salable power. Assuming an average of 1000 KW benefits year-round, the optimization system can be expected to provide over $330,000 in additional annual revenue.

Effective and secure technology for increasing plant efficiency

For this application, Model Predictive Control has provided an effective technology for increasing boiler efficiency while maintaining steam temperatures and remaining within NO_x specifications. Operator acceptance has been excellent due to the stable performance of the system and the smooth interface with the existing controls on the boiler.

AVEVA APC runs in a separate platform so that the security of the existing DCS is not compromised. The solution described here was designed to revert to the DCS based control seamlessly, with minimum disruption to the process, in case the operator decides to "take over" control.

Conclusion

A series of equipment upgrade projects at the R.D. Morrow Station have been coupled with optimization systems to gain performance benefits in the form of fuel savings, reduced emissions, increased net power generation, and improved dispatch capability. The combination of a flexible and capable toolset, application expertise, and the power of continuous improvement is now providing continuous and significant performance benefits to the station.

To learn more about AVEVA's solutions, please visit: aveva.com/en/industries/power-utilities