POWER Engineering

Remote Performance Monitoring Increases Efficiency

By Mathew Hurst, Performance Engineer, Emerson Process Management

As equipment performance deteriorates over time, productivity suffers and costs rise. There's a need to continually evaluate powerhouse operations to maintain efficiency, but staff time is often limited and in many cases, personnel are not trained to properly analyze existing data.

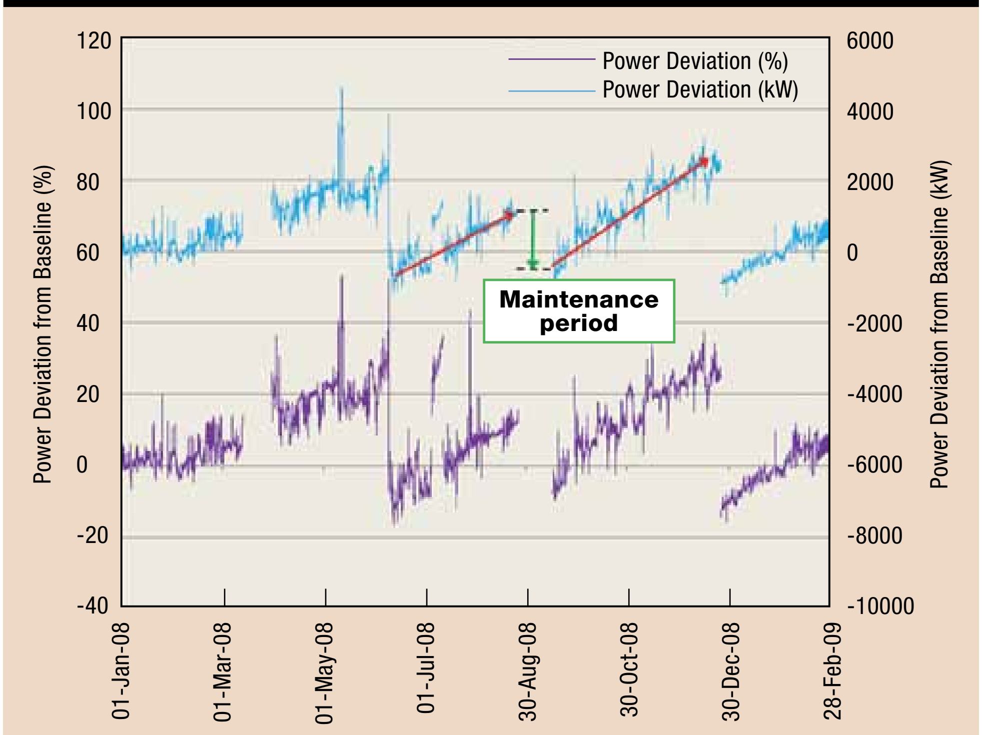
Fortunately, in this day of instant worldwide communications, expertise can be tapped remotely to periodically analyze the performance of steam boilers, turbines, heat exchangers, compressors and associated equipment. Using data recorded in your own powerhouse, knowledgeable consultants anywhere can spot something as minor as an open exterior door allowing colder than normal makeup air to enter the boiler. In fact, many energy-draining deviations from normal boiler/turbine operations can be identified remotely to maximize productivity while reducing losses.

Performance Monitoring

At one U.S. industrial power generating facility, performance monitoring discovered several opportunities that produced overall efficiency gains of more than 2.2 percent with an equivalent reduction in energy consumption. As a result, the company is saving as much as $120,000 a year.

The rising cost of coal in 2006 and a sense that energy was being wasted led this facility to initiate an internal program to monitor the performance of a coal-fired boiler and three-stage backpressure steam turbine. While operating screens displayed daily efficiencies on these units, those snapshot views barely changed from day to day and didn't distinguish efficiency change relative to loading. As a result, plant personnel did not notice the slow deterioration occurring at their aging facility, but the increasing amounts of money spent on coal were a strong indication that boiler/turbine efficiencies were not being preserved through normal maintenance during scheduled outages.

Figure 1 PERFORMANCE DEVIATION



Using equipment performance monitoring technology in which mathematical routines are embedded and performance analysis of specific pieces of equipment, lagging performance that may have gone unrecognized can be revealed.

Thermodynamic models of powerhouse equipment are developed based on original design data as well as measurements of common operating parameters. This information is available in every powerhouse, including feedwater temperatures and flows, steam header flows, pressures and temperatures, and flows and temperatures at various extraction points.

Once a model is established for a specific boiler, steam turbine or associated equipment, readings are recorded periodically and data are transmitted to a remotely located computer. Information from actual operations is compared with a theoretical performance optimum to determine thermodynamic differences. A true picture of what is actually happening emerges, often pinpointing the cause of energy-sapping deficiencies.

Specialists are often able to determine with reasonable accuracy when a piece of equipment will need maintenance to recover lost efficiency. A machine's future can be predicted based on its history, so plant operators can be informed when a given unit's performance is expected to drop below a certain financial or performance threshold, signaling when it ought to be removed from service. Performance monitoring is just one technology that contributes diagnostic information to a active predictive maintenance program.

Data Collection and Analysis

Once thermodynamic models for the powerhouse were established, an Emerson representative visited every two weeks to collect and forward some 30 measurements. Almost immediately after that first transmission, the analysts responded that the data could not be a true representation of what was actually happening at that plant. Some numbers were not even in the ballpark, probably due to faulty instrumentation. Since the power generating system could not function efficiently using output from those instruments, plant technicians started evaluating control loops and checking measurement accuracy.

A number of unreliable instruments were identified. Many transmitters were calibrated or replaced during December 2007 and July 2008 shutdowns, resulting in immediate efficiency improvements. It then became possible to focus on incremental operational changes necessary to actually achieve high performance goals.

Baseline curve characteristics were calculated from the initial set of reliable measurements and compared to the theoretical best possible performance. From this, boiler thermal efficiency deviation and steam flow production deviation were calculated, as well as overall turbine efficiency deviation and power generation deviation.

Among the key boiler performance calculations are thermal efficiency, air-to-fuel ratio and effective heat transfer coefficients of the exchangers, which decrease as fouling buildup occurs on exchanger surfaces. The turbine is examined for isentropic efficiency, power characteristics, pressure ratios, steam velocities, steam rates, power versus steam comparisons and operating losses.

A written evaluation on each new set of measurements is prepared by the analytical group and can be followed by a telephone discussion with plant operating managers. The analysts don't actually tell clients how to operate their plants, but simply point out each notable divergence between the models and actual operations, providing good ideas where to make changes for improvements. In a sense, the analysts act as watchdogs looking for suspicious indicators to help maintain a high standard of operation.

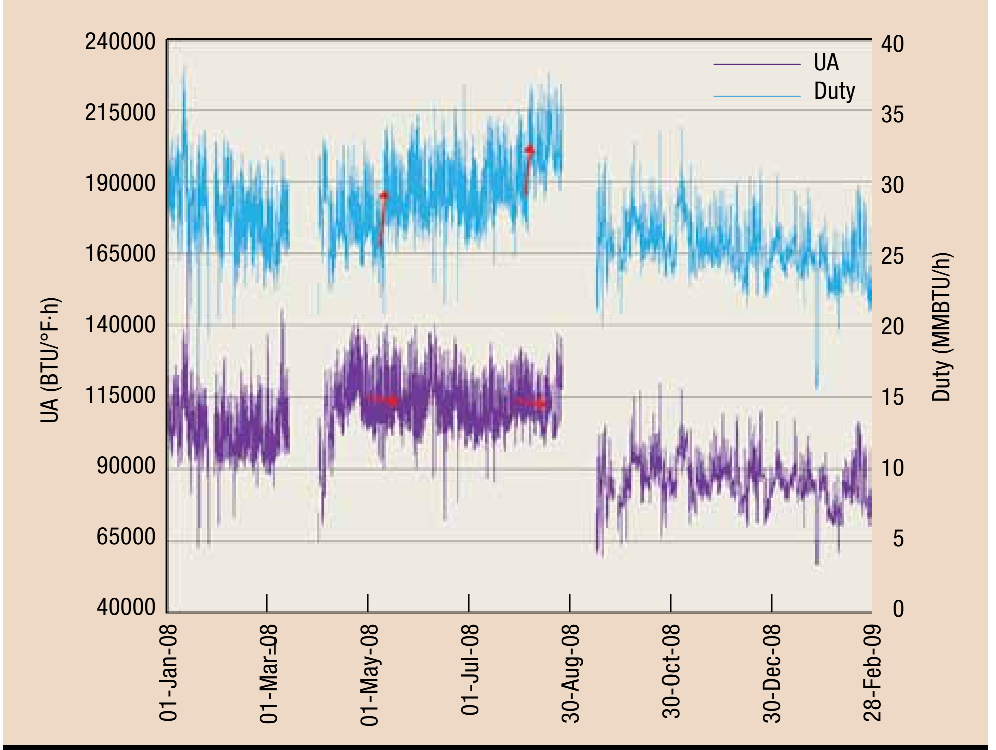
One recommendation was to use advanced control valve diagnostics to confirm that a major bypass valve was not closing completely. Subsequent analyses verified that changes had been made in response to the suggestion. When a coal pulverizer was rebuilt without their knowledge, the analysts immediately recognized something new had been added and was affecting the overall operation in a positive way.

Charting Results

A deviation chart is the preferred way of showing performance change, as opposed to raw efficiency values. This takes into account loading of the particular unit, whereas efficiency can be expected to change with changes in loading, which results in distortion.

The turbine power deviation chart (Fig. 1) shows increasing power deviation over time due to machine degradation, followed by reductions in this indicator after maintenance. This type of information was used to optimize the plant's maintenance strategy and the machine degradation rate was reduced after July 2008.

Figure 2 AIR HEATER PERFORMANCE



The boiler air heater performance chart (Fig. 2) shows degradation of the air heater exchanger after September 2007, an indication of abnormal fouling affecting boiler efficiency. Plant personnel planned a thorough cleaning of the heat exchanger surfaces at the next outage, something they would not otherwise have done at that time.

The performance monitor group regularly provided deviation cost charts, relating changes in powerhouse performance to monetary value. In one case, a decrease in fuel quality caused a steam production loss at a rate of about $15 an hour. Realizing and acting upon this loss saved the company more than $10,000 over a 30-day period. pe