Application

ABB Navigator 600 silica analyzer
Combined cycle power plant boilers

Online silica analyzer at PPL power plant pays for itself in three days

Earlier warm start-ups for a combined cycle, gas-fired power plant lead to short payoff time

Silica analyzers in modern power plants keep operators aware of harmful silica concentrations in the water-steam turbine cycle. In the boiler silica forms silicate deposits that interfere with heat transfer and are very difficult to remove. In the turbine, silica deposits on the blades and causes drastic decreases in efficiency. Power plants with high pressure boilers closely monitor silica concentrations to avoid these problems.

Plants monitor silica with online analyzers, grab-sample testing, or some combination of the two. Both options are expensive. Online analyzers tend to have high capital and maintenance costs. Just the cost of the reagents can exceed $2000 per year per analyzer.

Analyzing grab samples can take 1/2 hour or more of valuable operator time just to test one batch of samples. Taking grab samples for analysis prior to start-up often results in start-up delays of 15 to 30 minutes. Even this short delay for a 550-megawatt plant can deny revenue of $5,000 to $10,000 a day. With more than 100 warm start-ups a year, these dollar savings quickly add into the millions per year.

Real-time silica analysis

To curtail these maintenance costs and capture savings from timely start-ups, engineers at PPL Generation's newest energy center in Lower Mount Bethel, PA decided to try a silica analyzer: the ABB Navigator 600. This compact analyzer can monitor up to six streams simultaneously. It drastically cuts reagent consumption, and virtually eliminates maintenance.

A cost justification prepared for the plant estimated that the Navigator 600 analyzer would save nearly

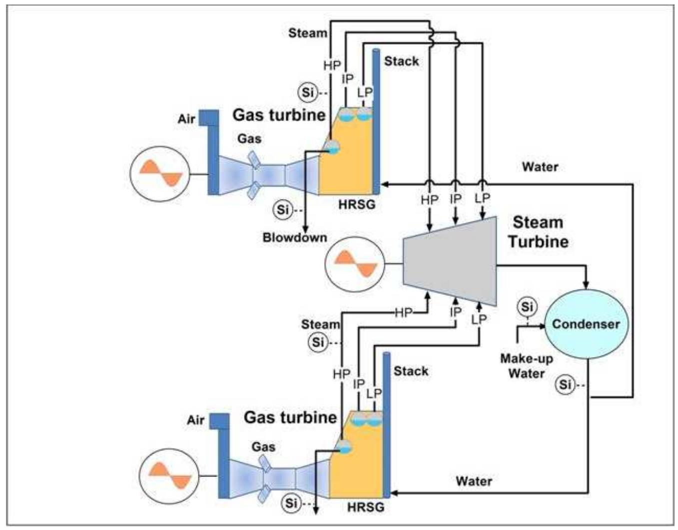

Figure 1.Exhaust gases from the gas-fired turbines heat three drum boilers in each HRSG for the steam turbine.

$28,000 annually by replacing three existing silica analyzers and eliminating grab sample testing. At this rate, the payback time for the new analyzer would be eight months. But the savings from faster startups provided payback in just three days.

Combined cycle generation

The Lower Mount Bethel plant, completed in 2004, is a 600 MW nominal natural-gas-fired combined cycle mid-merit peaking facility. It sits on the west bank of the Delaware River about 80 miles north of Philadelphia. Two gas-fired combustion turbine generators, two heat-recovery steam generators (HRSGs) with duct burners and one steam turbine generator in a combined-cycle configuration provide efficiencies ranging up to 60 percent.

Heat from the two gas turbines' exhaust gas is used to generate steam in each of the HRSGs. The boilers

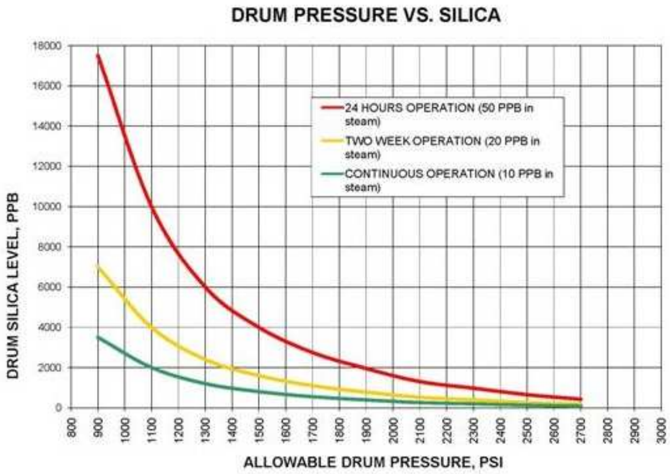

Figure 2. Silica carryover from the drum to the steam increases with increasing drum pressure.

operate at three different pressures: 2235, 415, and 75 psi (high pressure, intermediate pressure and low pressure).

The greater the pressure, the greater the chance of silica carryover from the boiler water into the steam. As the curve in Figure 2 indicates, at 1800 psi a silica content of 1000 ppb in the boiler water will produce carryover of 20 ppb in the generated steam. Silica carryover is not an issue in the low and intermediate pressure boilers. But carryover increases sharply with higher pressures. At 2000 psi, about 5% of the silica in the boiler water carries over into the steam. So operators at the Lower Mount Bethel plant aim keep the silica content in the high pressure boiler water below 200 ppb, preferably below 100 ppb. This assures that the steam silica concentration will be less than 10 ppb, a safe level for the turbine.

Operators deal with high silica content in various ways, depending on conditions. The best way is to not put the silica into the boiler in the first place. For this reason only ultrapure water is fed to the boiler. To reduce levels of impurities that do get into the boiler operators periodically discharge (blow down) boiler water to waste. As a last resort operators can reduce the boiler pressure until the silica level is reduced by blowdown.

Silica carryover from the boiler drums can occur in a number of other ways. High water levels and frothing within a boiler can release silica into the steam. Leakage of raw water from the condenser introduces silica into the cycle. Resins in the demineralizer eventually become exhausted, raising silica content in the makeup water. Lastly, microscopic undissolved silica particles may pass through filters and the demineralizer and get in the boiler. These particles dissolve in the high pressure boilers, producing a sudden jump in measured silica concentration.

Monitoring silica content

Monitoring silica at the plant originally consisted of three analyzers--one on each HP steam line and one on the condenser discharge. In addition, grab sampling of boiler water blowdown from the two HP drums and the makeup water amounted to 32 manual silica tests per day. Figure 1 indicates the position of the six monitored points in the cycle.

Over a four-month period the new Navigator 600, temporarily mounted, proved itself for accuracy, low reagent consumption and maintenance, living up to the cost justification mentioned earlier. Estimated annual reagent cost per analyzer will be half that of existing analyzers at the plant.

Figure 3. Chuck Feichtel, Senior Chemical Lab Professional, adjusts ABB Navigator 600 silica analyzer readout.

Maintenance labor for changing reagents and recalibrating (typically a 1-2 hour process) significantly decreased. The new unit periodically cleans and calibrates itself, requiring virtually no maintenance except replacement of the reagents every three months. Reduced handling of reagents lessens the chances of contamination and contact with hazardous chemicals.

Many plants consider silica analyzers to be maintenance intensive, requiring the monthly replacement of tubing, o-rings, and fittings. The Navigator 600 is expected to require only five to 10 minutes of annual maintenance for servicing its peristaltic pump.

In the permanent installation, the one analyzer's six streams monitors high pressure steam and boiler water from each of the two HRSGs, boiler water from each of the two HRSGs, and condensate from the condenser and makeup water from the condensate storage tank. This eliminates the need for additional analyzers and for grab samples. The output signals run to the plant's data historian computer.

Results

ABB’s Navigator 600 Silica analyzer now provides real-time readings of steam silica content during warm start-ups. The operators can configure the six-stream ABB analyzer to selectively sequence only critical sample points during start-up. PPL estimates savings of up to thousands of dollars per day. Once the plant is online, operators return the unit to sequencing the six sample points normally monitored. Sample points for normal operation measure silica in high pressure steam and boiler water from each of two HRSGs, plus the condensate and makeup water.

The plant has also added a second Navigator 600 silica analyzer for the demineralizer that produces the makeup water. The demineralizer for water treatment sits in a portable trailer. It consists of three tanks: cation resin, anion resin, and a final “polisher,” a mixed-bed of both resin types. The demineralizer processes filtered water from the river to provide the makeup water. Acid and caustic regenerates the resin beads as necessary.

The plant’s silica specification for the demineralized ultrapure water is 10 ppb. The new two-stream Navigator 600 analyzer monitors silica in the anion and mixed-bed tanks. They provide a timely indication that the resins are becoming exhausted and must be replaced. At that time the plant orders a new demineralizer trailer containing fresh resins.

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