Filming Corrosion Inhibitor Reduces Corrosion in Combined Cycle Plant with Air-Cooled Condenser

NALCO Water
An Ecolab Company

CASE STUDY - POWER
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SITUATION

Cyclical operation places mechanical and operational stress on power plants. According to the National Renewable Energy Laboratory, "[C]ycling a plant may be required for numerous business reasons and is not necessarily a bad practice; however it does increase maintenance costs and forced outages."[1]

EPRI agrees. "During cycling operation, cycle chemistry and corrosion are difficult to control." [2]

To address these stresses, power plants have looked to new technologies to help them protect their units during cyclical operation or to minimize the amount of corrosion product generated during short-term outages. The most commonly adopted chemical additives have been filming corrosion inhibitors.

FILMING CORROSION INHIBITORS

Filming corrosion inhibitors have been in common use since the 1940s. Early work by the U.S. Bureau of Mines demonstrated the efficacy of filming amine chemistry for oxygen corrosion inhibition. Their use fell out of favor in the power industry over the years, mostly because of concerns about sticky deposits resulting from overfeed (gunk balls), movement of corrosion products into low-flow areas of the system, their impact on cation conductivity and their propensity to film probes and sensors needed for system control and monitoring.

New amine-free technologies, built upon foundational work performed by Nalco Water in the 1940s, has shown promise in reducing corrosion product transport in cyclically operating boilers, both in coal and natural gas-fired plants, without the drawbacks associated with filming amines.

PROGRAM

Building on that early formulation, product development work started on a new filming corrosion inhibitor, one that does not contain filming amine chemistry or require formulation with an organic amine like cyclohexylamine.[3]

[1] *N. Kumar, P. Besuner, S. Lefton, D. Agan and D. Hilleman, Power Plant Cycling Costs, April 2012, Intertek APTECH, Sunnyvale, California, National Renewable Energy Laboratory*

[2] *State-of-the-Art Boiler Design for High Reliability Under Cycling Operation, EPRI Technical Report 1009914 (December 2004), pp 1-5.*

[3] *U.S. Patent Office, Patent Number 2,469,450, "Process for Inhibiting Foaming in Steam Boilers"*

- It is a homogenous product that requires no in-situ mixing
- It is stable across a wide temperature range for at least 12 months
- It is fully freeze/thaw recoverable and requires no agitation to recover
- There is no viscosity change with temperature
- It does not require formulation with neutralizing amines
- It contains no US EPA priority pollutants
- LD_{50} >89,500 mg
- It is volatile
- There is no cation conductivity increase at typical use dose
- NFPA rating of 0/0/0
- Is manufactured and cleared by the US EPA in accordance with the Toxic Substances Control Act (TSCA) and The Frank R. Lautenberg Chemical Safety for the 21st Century Act.
- Is detectable at use concentrations by an accurate analytical method.

The new program was evaluated over a several-year period in a 600 MW, 2x1 combined cycle plant with an air-cooled condenser. Like many power plants, this plant cycles more today than historically.

Excessive iron concentrations in the final feedwater indicated active corrosion in the air-cooled condenser. A film-forming, amine-based product (not supplied by Nalco Water) was initially applied to address the issue. Iron corrosion product concentrations dropped, demonstrating the efficacy of the treatment.

RESULTS

About two years later, the plant took the opportunity to improve on those early results. The new filming corrosion inhibitor developed by Nalco Water, POWERFILM™ 10000, contains no filming amine or neutralizing amine solvents, eliminating the potential negatives associated with those two product components. Its use promised to deliver better results at a lower use cost than the earlier treatment.

Trial work was conducted in accordance with a field trial protocol developed with the engineering staff at the plant. Data was collected using a Corrosion Product Sampler manufactured by NWT. These instruments allow a controlled stream of water to pass through a 0.45µ filter pad of known cross sectional area. Filters were collected on a regular basis and sent to Detora Analytical for analysis.

In addition to the filter analysis, MW generation data was collected from the plant historian. Coupling this data with the corrosion product data and annotated with operational details provided context and a clear view of the impact of the corrosion inhibitor on the plant's operation. The results are shown in Figures 1 and 2.

The plant ran in an almost base-loaded condition from the start of the incumbent treatment in March through the end of September. Then an operational problem put the plant into an unscheduled outage, followed by limited production in a 1x1 configuration. During this time, the new treatment was fed intermittently. In mid-January the following year, the plant returned to a more normal production schedule. After collection and review of a statistically valid dataset, the head-to-head comparison of the relative performance of the two treatments was complete and the data was clear. The new treatment outperformed the incumbent inhibitor, reducing corrosion product generation by 40% at the same dosage rate.

THE RATIONALE FOR FILMING INHIBITORS

As this new filming inhibitor was developed, we have had many opportunities to speak with power plant operators, corporate chemists and others involved in the decision to apply filming inhibitors. Their reasons to look at these new treatments differ and go well beyond the quantifiable benefits in terms of corrosion product generation. (Less corrosion product is better than more corrosion product.) The following are some of the reasons users have given us to employ a filming corrosion inhibitor.

I don't want my people getting comfortable with out-of-spec chemistry.

Some users have found their plant chemists, knowing their chemistry will likely be out-of-spec during cyclical operation, become less concerned about it. When the root cause of the out-of-spec condition does not obtain from cycling, it remains unaddressed for longer than necessary, impacting results.

There's more to worry about than the main condenser.

The main condenser is always the paramount concern, but plant and corporate chemists have pointed out that other components — reheaters, feedwater system components, etc. — can take the plant offline just as easily as a condenser leak. Particularly with older plants, operators are very concerned about expensive or untimely failures in these auxiliary systems.

Additionally, downtime during periods of peak demand can mean a failure to generate at just the time when the potential for profit is highest, something most power plants can ill afford.

Chemical cleanings aren't free or without risk.

Even moderate corrosion product generation results in waterside deposition that can be removed only through chemical cleanings. These costly evolutions, performed frequently enough, increase a plant's operating costs unnecessarily.

Plants are operating well beyond their intended life spans.

Longevity is a key business imperative, particularly with older, coal-fired units. A relatively modest expenditure on a filming corrosion inhibitor reduces wear-and-tear on older components, potentially keeping them in service longer and minimizing routine maintenance costs.

CONCLUSION

Changes in the power generation market necessitated changes in chemical treatments. Users have evaluated these new treatment programs and found they can deliver higher availability, longevity and lower maintenance costs for units running under highly cyclical conditions. Results measured at one combined cycle plant demonstrated that, although the earlier film forming, amine-based chemistry reduced corrosion product generation, the newer treatment, which contains neither a film forming nor a neutralizing amine, delivered even better results, at a lower use cost.

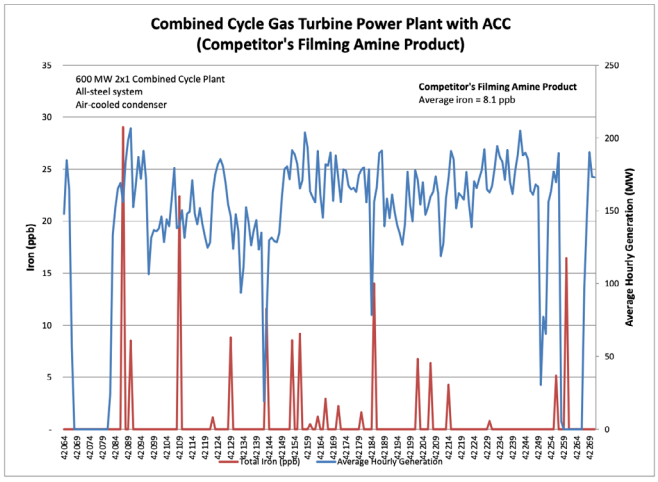

Figure 1: Operational graph showing corrosion product generation under competitor's filming amine product.

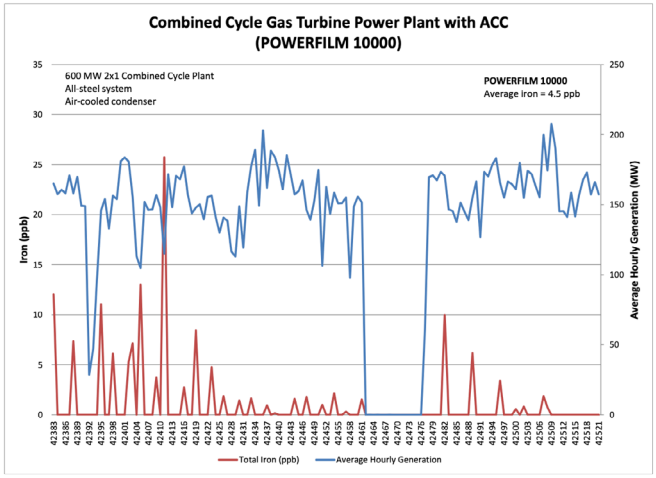

Figure 2: Operational graph showing corrosion product reduction using Nalco Water POWERFILM™ 10000

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