Risk reduction in industrial cooling water systems

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Glen Bowen of **Solenis** introduces a series of chemistries to mitigate risk

In heavy industry manufacturing plants, many unplanned outages are related to water chemistry and cooling water issues. Whilst considerably less than 1% of a plant's operating budget is spent on water treatment, the impact on business results is far-reaching. Unfortunately, growing concerns over water scarcity and rapidly changing plant water quality already make delivering results especially challenging.

Cooling water is used in chemical processing plants to remove heat generated by manufacturing processes efficiently. Maintaining efficiency in a cooling water system requires treatment programmes that mitigate corrosion, deposition and microbiological fouling. These three interconnected challenges are important to any industrial operation, but they pose significant risk to chemical manufacturing plants (Figure 1).

Improper treatment of cooling water results in increased risk to chemical processing plants. These risks can be associated with:

- Heat exchanger and process equipment failure, leading to lost production and unbudgeted capital expenditures
- Poor performance of equipment, resulting in lower production efficiency and reduced product quality
- Unnecessarily high water usage and chemical treatment costs

These risks can be compounded for chemical processing plants that are actively changing their operations to increase efficiency. For example, the use of lower quality or recycled make-up water and/or increasing cycles of concentration in the cooling tower can create stress on the heat exchangers, leading to unplanned downtime and lost production.

However, what if chemical manufacturers could measure water variability with extreme precision and bring new levels of uptime and reliability? Innovations, both in water treatment chemistry and on-line performance monitoring, are now available to help address these challenges.

Cooling water chemistries

A critical first step in mitigating risk in cooling water systems involves selection of appropriate treatment chemistry. Solenis's Performax* MX series of chemistries employs three differentiated components to deliver improved performance: the stress-reducing inhibitor (SRI), high-tolerance dispersant (HTD) and zero-phosphate inhibitor (ZPI) technologies.

These components allow customers to operate neutral pH programmes with increased tolerance for upsets (pH, blowdown, cycles, chemistry) and also allow customers to use an alkaline pH programme confidently (less acid, fewer pH excursions and reduced corrosivity), with reduced risk of deposition.

The patented SRI chemistry Solenis has developed for challenging cooling water applications can, as part of the Performax MX cooling water programme, can be used as an inorganic phosphate replacement for mild steel corrosion inhibition. Acting as a combination of anodic and cathodic corrosion inhibitors under both neutral and alkaline pH conditions, SRI chemistry provides mild steel corrosion inhibition without increasing the calcium phosphate saturation to the same degree that inorganic phosphates do.

In fact, when used with the HTD and ZPI technologies, SRI reduces calcium phosphate saturation 7.5 times compared to a typical alkaline pH cooling water programme. Cooling water systems get the same corrosion protection, but with a much lower risk of deposition from phosphate materials. This is ideal for high-stress applications in chemical processing and refining industries where systems are prone to deposition.

The HTD technology is designed to improve control of zinc phosphate, calcium phosphate and suspended solids, while being resistant to typical polymer 'poisons', such as aluminum, silica, silicate and iron, which can degrade performance. This makes the HTD polymer ideal for high-temperature, low-flow and high-stress systems, as well as those that experience upsets or variation in water quality and control.

HTD is a significant improvement over traditional copolymer and terpolymer dispersants and even outperforms quadrapolymer products. For reuse water and grey water applications, it was tested at 82°C skin temperature, >50 ppm orthophosphate and >500 ppm calcium. Even at these highly stressed conditions, it successfully inhibited calcium phosphate with only a 2-3 ppm polymer dose. HTD allows customers to increase their cycles of concentration, thus reducing make-up water, effluent water, and chemical costs.

The ZPI technology is the newest calcium carbonate scale inhibitor available on the market. It is a dedicated homopolymer designed for calcium carbonate control in alkaline cooling water systems.

As a non-phosphate and non-phosphonate molecule, ZPI will not precipitate with calcium, as traditional phosphonates do, and can

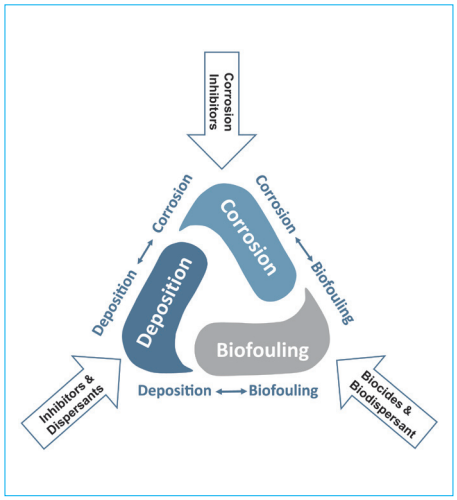

Figure 1 – The cooling water triangle

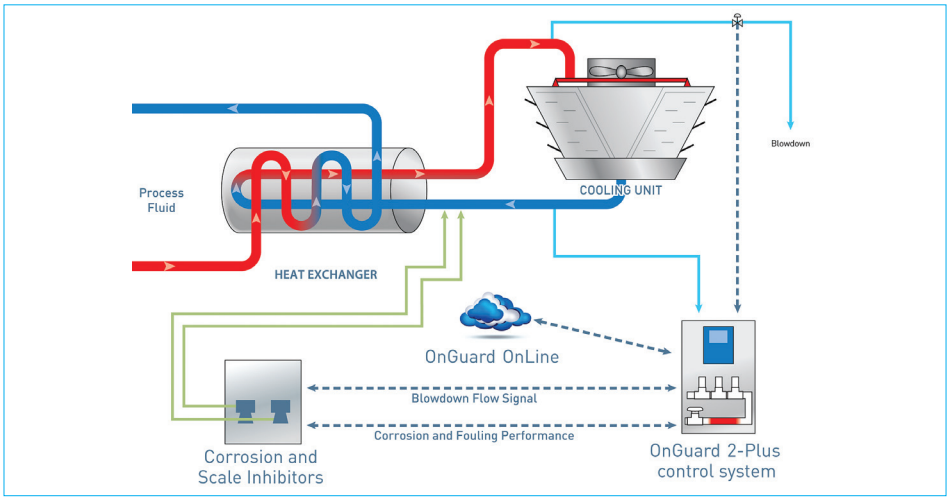

Figure 2 – OnGuard 2-plus control system & OnGuard 3H working principles

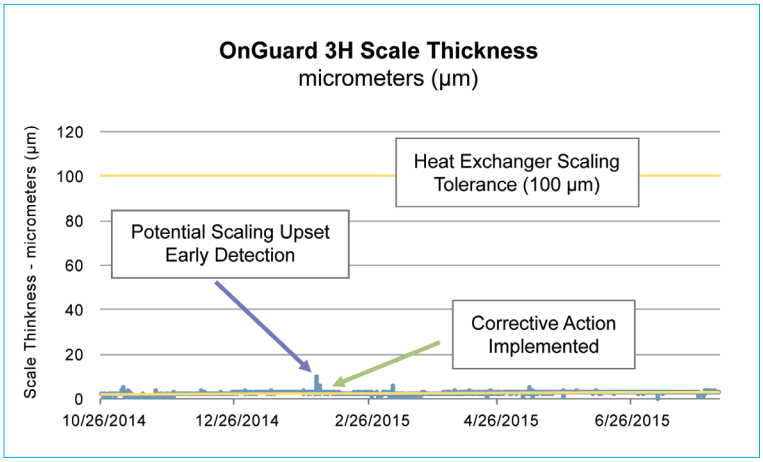

Figure 3 – OnGuard 3H analyser performance monitoring

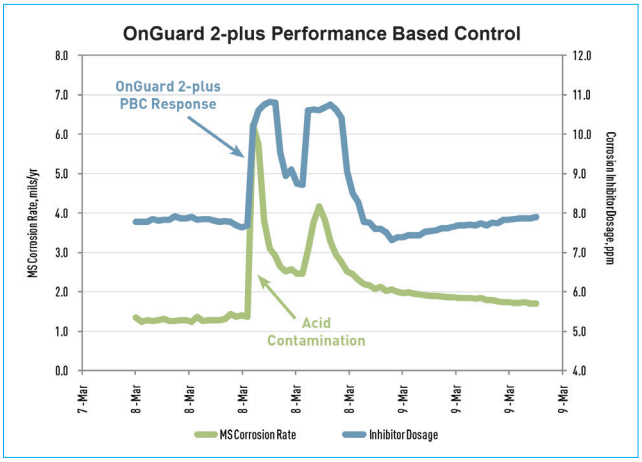

Figure 4 – Monitoring KPIs with OnGuard 2-plus control system

provide calcium carbonate inhibition at higher saturation levels than traditional phosphonate chemistries. ZPI allows chemical processing, refining and high-stress cooling systems to operate with less corrosive alkaline cooling water programmes, with a reduced risk of deposition.

These three chemistries work as part of the Performax MX series with the aim of enabling chemical producers to accomplish new levels of production efficiency with highly variable, stressed and/or reused water systems.

Performance monitoring

Selecting the most appropriate chemistry is only half of the equation when it comes to addressing risk in cooling water systems. Advanced monitoring and control technology must also be implemented to maximise efficiency and reduce risks in cooling systems. Until recently, monitoring and control of cooling water treatment programmes relied on the direct measurement of inhibitor components and/or the use of dye-traced programmes.

Recent inventions in fouling monitoring have led to highly accurate simulation equipment, which can be programmed to simulate specific cooling water heat exchangers. The most accurate of these devices will detect heat exchanger fouling on a 'micro' level long before the 'macro' instruments around the heat exchanger (temperatures, flows and U coefficients) will detect the fouling.

The OnGuard* 2-plus control system (Figure 2) provides cooling water performance monitoring of heat exchanger fouling with duplication of the heat flux, shear stress and surface temperatures. Advanced algorithms allow for heat exchanger simulation, in compliance with the NACE* International fouling monitoring protocols. Accurate performance monitoring for fouling with the OnGuard 2-plus provides quantitative heat exchanger fouling factor measurements and can account for inorganic, organic and biofouling in cooling water systems.

Solenis also offers the OnGuard 3H analyser, its latest development in heat exchanger performance monitoring that combines the fouling factor duplication of the OnGuard 2-plus with direct measurement of scale thickness using unique and patented ultrasonic technology.

Scale thickness measurement with the 3H analyser has proven to be accurate to levels as low as 5 µm. This gives users access to highly accurate and reliable methods of fouling detection, both with indirect measurements (heat exchanger fouling factor) and direct measurements (scale thickness). Chemical processors can thus safely increase their risk tolerance with challenging water and increased cycles, ensuring uninterrupted productivity.

Case studies

A European integrated paper mill suffered from severe scaling in the cooling water system associated with a critical process condensate heat exchanger. The OnGuard 3H analyser was installed to monitor the performance of the exchanger at microscopic levels. It allowed the mill to make performance-based adjustments to the chemical feed rates.

The mill was also able to make changes to chemical addition points of the Performax MX series of blended inhibitors. The combined use of the OnGuard 3H analyser and the Performax chemistry eliminated scaling in the exchanger, improving reliability and production efficiency for the mill (Figure 3).

Solenis has pioneered and patented the use of performance-based control (PBC) in cooling water systems, which facilitates online, real-time monitoring of heat exchanger performance when used with OnGuard control systems. PBC systems involve using key performance indicators (KPIs) as inputs to create an output that moves the measured system values closer to the desired results.

For example, if the measured corrosion rate or fouling factor for a system is above the KPI target, the custom-configured PBC algorithms in the OnGuard control system can provide a rapid response, increasing the addition rate of the deposit control agents and/or the cooling water corrosion inhibitor. This further reduces the risk of poor performance and failures in the high-stressed water conditions seen in the chemical processing industry.

In another case study, a North American speciality chemical plant's cooling tower acid tank developed a leak that was contained in the chemical basin. In an effort at disposal, the acid was pumped into the cooling tower sump, which depressed the system's pH to below 4.0.

Continuous, online corrosion analysers built into the OnGuard 2-plus control system immediately detected elevated corrosion rates. When the spike in corrosion was detected, the system used the PBC trim algorithm to increase the feed rate of corrosion inhibitor automatically until corrosion rates returned to target. The use of PBC eliminated the risk of heat exchanger failures and costly production downtime (Figure 4).

Conclusion

Increasingly varying water quality and the use of recycled water, coupled with unique manufacturing challenges to achieve new levels of production efficiency, increase the stresses on water for maintaining peak cooling efficiencies. Solenis's portfolio of SRI, HTD and ZPI water treatment can help heavy industry manufacturing plants overcome these challenges. Coupled with advanced monitoring and control techniques available in the OnGuard monitoring and control systems, they can enable chemical producers to minimise risk and attain new levels of productivity.

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