Solving the biofilm threat in industrial cooling water systems

Solenis' Christina Moering discusses biofilm challenges and a treatment programme that proactively protects industrial cooling towers from biofilm

Industrial cooling water systems provide perfect conditions for the growth of microorganisms, because the cooling water temperature is ideal, and the water contains nutrients from natural debris and contaminants introduced from process leaks.

Biofilm forms when planktonic (i.e., free-floating) microorganisms begin to adhere on surfaces, such as pipe walls, heat exchangers and cooling tower fill, and begin secreting extracellular polymeric substances. The resulting slimy extracellular matrix protects the community of microorganisms that has adhered to the surface from environmental stresses and increases their potential to survive and reproduce in the cooling water environment.

Biofilm formation in cooling water systems tends to start in areas not accessible to microbiological control treatments, such as dead ends or low-flow areas. Therefore, it is not easy to detect.

Biofilm in industrial cooling water systems is undesirable both for human health reasons, as it can provide a habitat for pathogenic organisms, such as *Pseudomonas* and *Legionella*, and also for operational reasons. Because biofilm is composed mostly of water, it is more insulating than typical mineral scales (Figure 1).

The insulating effect of biofilm negatively reduces the cooling capacity of heat exchangers: a biofilm layer that is only 20 µm thick can increase heat transfer resistance by 7%. Microbiologically induced corrosion represents another often-neglected threat that can lead to downtime for costly maintenance and repair.

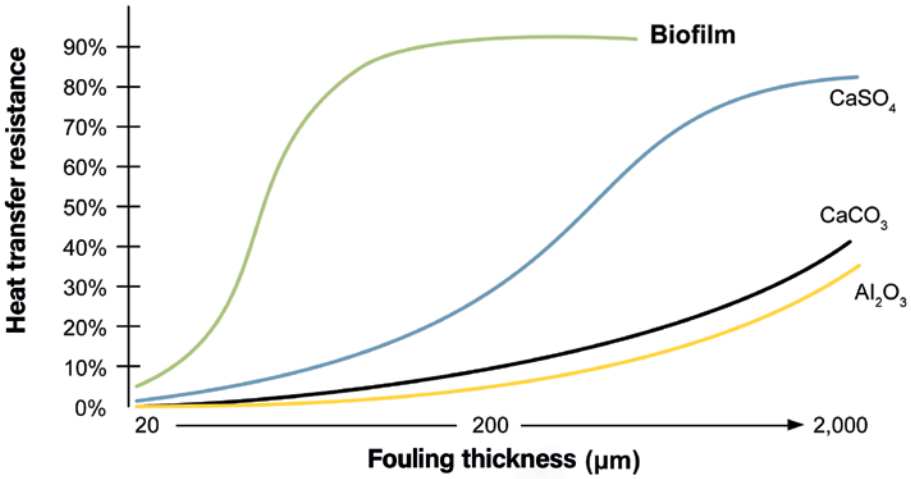

Figure 1 - Thermal effect of biofilm and typical mineral scales

It is estimated that 20–50% of all corrosion originates from microorganisms. The fact is that biofilm causes many more problems in industrial cooling water systems than individual microorganisms (Figure 2).

For companies operating a cooling water system, early detection and effective protection against biofilm are imperative to ensure maximum operating efficacy and reliability. Solenis' ClearPoint biofilm detection and control programme brings together a novel biofilm analyser and a proprietary chlorine stabiliser chemistry to address biofilm growth in industrial cooling water systems.

Real-time biofilm measurement

Often, biofilm is detected only when operational problems occur or when a slimy matrix is tangible or visible on easily accessible surfaces in cooling towers. Common analytical methods, such as the determination of total bacteria counts (laboratory analysis, dip slides), have limited our ability to predict possible biofilm growth on surfaces because these methods cover only planktonic and not sessile microorganisms.

An additional disadvantage is that it takes several days to deliver results. Sessile coupons can predict biofilm growth on a surface, but coupons take even longer to deliver results, prolonging the time until corrective actions can be taken. None of these techniques clearly quantify the amount of biofilm.

The OnGuard 3B analyser provides the earliest detection and most accurate measurement of biofilm growth possible in industrial cooling water systems, enabling detection and monitoring of biofilm in real time. The Karlsruhe Institute of Technology and the Center for Biofilm Engineering at Montana State University have both independently validated its biofilm early detection capability and measurement accuracy.

The analyser uses a patented ultrasonic sensor that detects

Cooling system issues	Biofilm	Iron-oxidising bacteria	Sulfate-reducing bacteria	Acid-producing bacteria	Pathogenic bacteria		Algae	Fungi
					Pseudomonas	*Legionella*		
Heat transfer resistance	•	•			•		•	•
Reduced cooling efficiency	•				•		•	•
Equipment fouling	•	•	•		•		•	•
Increased corrosion	•	•	•	•				
Tower structure decay	•	•	•	•				•
Health risks	•				•	•		

Figure 2 - Problems caused by biofilm and common microorganisms

biofilm with measurement accuracy of approximately 10 µm and at a resolution of +/- 5 µm. A side stream of cooling tower water is taken and run through the analyser. Ultrasonic pulses are fired at a heated target assembly and then reflected back to the ultrasonic sensor (Figure 3). A reduction in travel time indicates the presence of biofilm.

Heating the target assembly and duplicating the shear stress of the heat exchanger by controlling the water flow allows the analyser not only to measure biofilm thickness, but also to calculate the insulating effect of the biofilm and the actual loss of heat transfer efficiency expected in the modelled heat exchanger.

The analyser differentiates between soft deposits (organic and (scaling), and it automatically corrects for variations in temperature, conductivity and pressure to ensure accurate biofilm measurement.

Biofilm control & removal

Only a few microbiological control treatments can effectively penetrate and remove biofilms. Without them, biofilm removal often requires expensive and extensive manual cleaning.

Strong oxidising biocides, such as sodium hypochlorite and chlorine, have been used for decades to control microbiological activity in industrial cooling water systems; however, although they effectively control planktonic microorganisms, they are unable to penetrate and control established biofilms caused by sessile microorganisms.

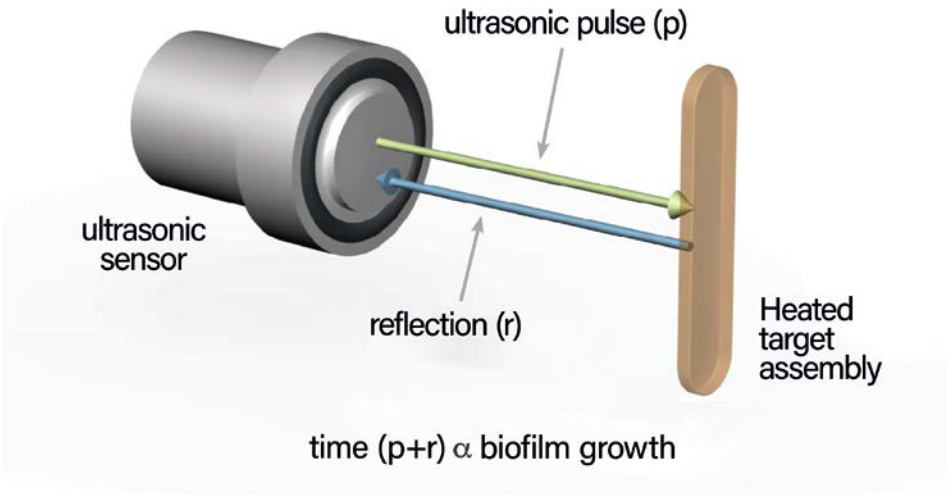

Figure 3 - Working principle of the ultrasonic sensor

The proprietary Biosperse chlorine stabiliser chemistry is used in combination with sodium hypochlorite to produce a patented, *in situ*-stabilised active chlorine system. The resulting solution effectively controls a broad spectrum of microorganisms, including bacteria, mould, yeast, algae and molluscs.

Biofilms exhibit a wide variety of defence mechanisms against biocides. Therefore, compared with the control of planktonic microorganisms, effective microbiological control of biofilms may require up to 1,000-fold higher biocide concentration than typical.

The *in situ*-stabilised active chlorine solution effectively controls both planktonic and sessile microorganisms. Furthermore, it shows extraordinary biofilm penetration and dispersal: at normal use concentrations, it works 170 times faster than bleach.

Additionally, strong oxidising biocides are highly reactive with organic and inorganic materials, causing many unwanted side effects, including increased corrosion rates, increased precipitation of heavy metals, reduced equipment performance, increased maintenance costs, increased risk of chlorine off-gassing and increased levels of adsorbable organic halogens and trihalomethanes.

Because of its chemical structure, the *in situ*-stabilised active chlorine system produced with the chlorine stabiliser chemistry does not cause

any of these adverse side effects associated with using strong oxidising biocides.

Proof of performance

Solenis has applied the biofilm analyser and the chlorine stabiliser chemistry in many industrial cooling water systems across the world. Two case histories from the chemical processing industry provide examples of the application of these technologies and the improvements gained.

The cooling water system of a speciality chemicals producer was treated with hydrogen peroxide and one of three organic biocides that were alternated. The programme required large volumes of hydrogen peroxide to keep the total bacterial counts and *Legionella* under control.

During the summer, limits for bacterial counts and *Legionella* were exceeded frequently and biofilm build-up was observed throughout the cooling water system. The reduction in the cooling tower's cooling capacity limited productivity. The customer faced increased costs, due to the high consumption of chemicals, and reduced productivity, due to the unreliable treatment.

The biofilm analyser was installed to monitor biofilm build-up and the microbiological control treatment was switched to the chlorine stabiliser chemistry. Using a shock dose twice per day and with proper monitoring, the programme achieved stable and continuous performance resulting in consistently low bacteria counts and no *Legionella*.

Existing biofilm was removed during the initial cleaning phase of approximately three months, resulting in improved thermal transfer and full cooling capacity. The data from the analyser confirmed that the surfaces were biofilm-free, and the analyser provided an early warning system in case of new biofilm formation.

Use of recycled wastewater

A speciality chemicals company in southern Europe operates a recirculating cooling water system with four cooling towers, using as make-up mainly municipal water and, occasionally, wastewater from its own plant.

Heated target assembly showing the presence of biofilm

The complex cooling system provides cooling water for diverse uses, but the main volume is used for chillers. The existing microbiological control treatment programme was intensive as it used high doses of a chlorine-bromine product and an additional organic biocide on a weekly basis.

Because of contamination from the organic load in the wastewater, the microbiological control treatment was ineffective and expensive. The customer was obliged to perform off-line cleaning of the chillers every three months because of poor system performance.

The biofilm analyser and the chlorine stabiliser chemistry were employed. Real-time measurements showed that the thickness of the biofilm rapidly decreased after the new microbiological control programme was implemented.

The efficiency of the cooling system's chillers improved significantly, and downtime for manual cleaning was reduced. Real-time monitoring using the analyser, combined with better microbiological control provided by the *in situ*-stabilised active chlorine solution, allowed the operators to use higher volumes of recycled wastewater, which generated savings of about €25,000/year.

Conclusion

Solenis' ClearPoint biofilm detection and control programmeis a unique and comprehensive safeguard against microbiological activity and biofilm in industrial cooling water systems. Using the analyser to achieve the earliest detection and the most accurate biofilm measurement, combined with the proprietary chlorine stabiliser chemistry, to control both planktonic microorganisms and biofilm protects industrial cooling water systems against biofilm before cooling water systems are harmed or heat transfer efficiency is reduced. ●

Christina Moering
CORPORATE INNOVATION MANAGER
SOLENIS GERMANY GMBH & CO. KG
+49 151 52655369
cmoering@solenis.com
www.solenis.com