KEY TO THE FUTURE

Wally Schaefer, Jorvic Vital and Melissa Callejo, Nalco Water, USA, explain the importance of heat exchanger monitoring data in enabling the ammonia plants of the future.

For almost 100 years, the nitrogen processing industry has utilised data to help optimise production. Data continues to drive investments and process efficiency as decision makers work with engineers to troubleshoot problems and maximise production. What differentiates the past from today is how fast plants can leverage data to drive positive outcomes.

'Plant of the future' solutions include a comprehensive view on how operations are utilising real-time, online tools to predict the performance of critical heat exchangers, prevent unscheduled downtime and prolong asset life and production runtime, ultimately delivering a step-change in reliability and profitably in the new digital world.

Situation

Under design conditions, heat exchangers should provide reliable duty and a long service life with little or no maintenance. However, plants commonly run over operating design and cooling systems come with numerous mechanical, operational and chemical challenges depending on the water source, configuration of the system and type of heat exchanger.

Corrosion, whether velocity-induced or under-deposit pitting, shortens asset life or, in the worst case, can result in unexpected loss of production. Biofouling creates an insulating layer, resulting in a loss of heat transfer efficiency. The loss of heat transfer efficiency means that somewhere else in the system, additional energy is required to make up for the shortfall.

Solution

There are many root causes of heat exchanger problems and most are preventable if detected early, so corrective action may be taken. Providing a holistic, data-driven, performance management program for critical heat exchangers can quickly activate a response required to optimise reliability, asset protection, and total operating costs.

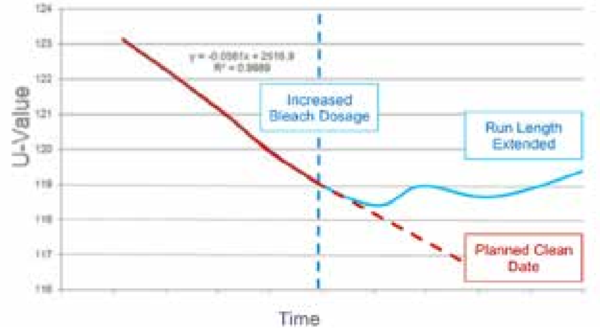

Figure 1. U-Value optimised with proactive monitoring of microbiological activity and chemical feed strategy.

Figure 2. Overlaying heat transfer efficiency and flowrate to decide on cleaning needs.

OMNI™ Total Heat Exchanger Performance combines in-depth system audits, 24/7 monitoring, unique diagnostic tools, and consultative service that optimises heat transfer and guarantees reliability. OMNI provides new insight into process performance and can help deliver reliability and profitability.

Results

The following case studies illustrate how OMNI proactively utilises data and provides bottom-line savings by early detection and proactive response to declining heat transfer performance.

Case study 1

A real-time heat exchanger key performance indicator (KPI) showed a steady decline in U-Value, a loss in heat transfer efficiency. A quick investigation started with examining factors contributing to this event.

Water chemistry data was quickly correlated and showed very low chlorine residuals in the cooling water return and a rise in microbiological counts. This signalled that the amount of bleach being added was not meeting system demand. After consulting with plant operators, it was agreed to slowly increase the bleach dosage by increasing the oxidation reduction potential (ORP) set point to improve microbiological control and eliminate the biofilm layer in the heat exchanger.

Biofilms are much more heat insulating than typical mineral scales. In fact, biofilms can be four times more heat insulating than a calcium carbonate scale of similar thickness. The reason biofilms reduce heat transfer so much is microorganisms and the extracellular products they secrete are largely made up of water, which has a very high heat capacity.

As shown in Figure 1, the impact of an effective and quick correlation of performance data with microbiological treatment indicators was clearly demonstrated as U-Values quickly improved. By restoring and maintaining U-Value performance, the plant avoided a projected cleaning date and will be able to extend its production run until the scheduled maintenance turnaround.

The avoided cost of an unexpected five-day outage to clean this critical heat exchanger is US$2.4 million (US$1.5 million in energy and US$0.9 million in gross margin production opportunity).

Case study 2

OMNI data was used to make a business decision regarding whether to open a critical heat exchanger during a planned maintenance outage or earlier. Historical U-Value trends indicated the heat exchanger was maintaining its operation without any scaling or biofouling issues. However, the cooling water flowrate showed a constant, slow decline (see Figure 2). Based on these metrics, and after confirming that the cooling water network operation did not change, it was highly likely that the water inlet tube sheet was being plugged by debris and restricting the flow of water.

Having the ability to translate these variations to critical information, such as velocity of the water on the tubes, led to the conclusion to open and clean this exchanger during the turnaround and not three months earlier where the market conditions were more favourable for the customer. The plugged tubes were confirmed during turnaround as shown in Figure 3.

The plant observed that the decision for cleaning a heat exchanger is based on business drivers. Having the data from OMNI is key for making decisions about scheduling a cleaning procedure.

Case study 3

A key component of the OMNI program is a test heat exchanger that replicates cooling water performance at the skin temperature and velocity of the most critical exchangers in the plant. The simulator in this particular case study with CF Industries' Courtright Nitrogen Complex used KnewValue's Sentinel, which provided several methods of monitoring and assessing fouling, scale and corrosion. The clear polyacrylic shell allows for visual observation of the annular exchangers at any time. The annular exchanger tubes can also be pulled for laboratory analysis. Pre-weighing of the heat transfer tube allows for determination of scale accumulation, as well as actual metal loss due to corrosion at the end of the exposure period. Metallographic and deposit analysis further defines the type of mineral scale, as well as whether corrosion is velocity-induced or a result of under-deposit pitting.

In this case, a rapid build-up of scale and corrosion was observed on the test exchanger tubes during a 46-day exposure period. Standard corrosion coupon results on the cooling water supply and exchanger outlet were 1.32 mpy and 1.9 mpy, respectively. The corrosion rates for the test exchanger tubes were 1.93 mpy for Exchanger 1 and 3.88 mpy for Exchanger 2. The data points were not unusual since corrosion rates are more aggressive under heat exchanger conditions. Corrosion rates typically double with every 18°F increase in metal temperature. However, further examination of the exchanger tubes revealed localised corrosion with pit depths greater than

Figure 3. Debris in the inlet of the critical heat exchanger.

Figure 4. Photomicroscopy and deposit analysis results drive the decision to change cooling water treatment programme.

20 mils. Photomicroscope (Figure 4) and deposit analysis showed a build-up of mineral scale, primarily composed of iron phosphate, which resulted in under deposit corrosion.

Based on this new understanding of the nature of the scale and performance under actual heat flux conditions, the cooling water treatment program was adjusted, which included an overlay of pyrophosphate to sequester iron and minimise deposition. After these program changes, only slight corrosion was observed, and pit depths were 0.1 mpy, a 99% improvement and a quantum change in asset protection. Ensuring the designed asset life of a tube bundle can save an average of US$50 000 – US$75 000 per year for each exchanger (based on bundle replacement cost of US$450 000 and 20-year lifecycle).

"The test heat exchanger technology [Sentinel] is a paradigm shift – a new way of thinking about how we monitor corrosion in a cooling system," explained Brian Bloxam, Ammonia Plant Superintendent, CF Industries – Courtright Nitrogen Complex. "We continue to evaluate the simulator's results as they correlate data about our critical asset performance to help drive action to maintain our plant's uptime and reliability."

Conclusion

In conclusion, enabling the ammonia plant of the future requires a comprehensive solution that includes the ability to quickly correlate KPIs on the water chemistry, operation and mechanical factor to accelerate decisions to deliver step-change on reliability and profitability. Gathering information that impacts critical heat exchanger assets will continue to support the nitrogen processing industry to scale up production for years to come. WF

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