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OMNI Heat Exchanger Reliability Provides Unique Insight into Cooling Water Treatment and Heat Exchanger Performance

NALCO Water
An Ecolab Company

CASE STUDY – CHEMICAL INDUSTRY

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SITUATION

Under design conditions, heat exchangers should provide reliable duty and a long service life with little or no maintenance. However, plants rarely run at design conditions and cooling systems come with numerous MOC challenges. There are many root causes of heat exchanger problems and most are preventable, particularly corrosion and fouling.

Corrosion, whether velocity-induced or under-deposit pitting, puts asset integrity at risk. Fouling creates an insulating layer, resulting in a loss of heat transfer efficiency (reduced duty) or decreasing available flow area (reduced throughput). The loss of heat transfer efficiency usually means that somewhere else in the system, additional energy is required to make up for the short fall. The increased pressure drop through a heat exchanger represents an increase in the pumping energy required to maintain the same flow rate.

The costs associated with poor heat exchanger reliability can go beyond issues of decreased efficiency. A shutdown resulting from a fouled or leaking exchanger causes lost production in addition to the costs of cleaning and repair. Taking a large, integrated production facility off-line can easily cost millions of dollars.

Often, many of these issues go unnoticed until there's a major upset. OMNI Heat Exchanger Reliability introduces a better way to monitor the effectiveness cooling water performance to assure asset protection and performance.

BACKGROUND ON MONITORING METHODS

Traditionally, coupons are used to assess corrosion and scale in cooling water systems. Coupons are considered standard monitoring protocol by the Association of Water Technologies (AWT) and the National Association of Corrosion Engineers (NACE). Coupons matching system metallurgy are exposed for a given time in the flowing water. At selected time intervals, the coupons are removed, cleaned, and reweighed to determine the metal loss, reported in mils per year (mpy). Coupons only reveal what happened to a particular metal over a specific time in the system, and hence are better used for trend analysis.

On-line corrosion meters are also used to provide continuous on-line monitoring of corrosion rates. The two most common methods are liner polarization resistance (LPR) and electrical resistance. The corrosion rate trend generated by these devices is valuable for troubleshooting sudden changes in system conditions; such as acid spills, chlorine levels, and inhibitor treatment levels.

Both monitoring methods should be used and can complement each other in a well-designed monitoring program. Corrosion monitoring results must always be examined in context with analysis of water chemistry, operational conditions, and mechanical parameters.

A NEW PARADIGM

It's well understood that water velocity, heat exchanger metallurgy, and heat flux are major factors that govern scaling and corrosion. The shortcoming of coupons and on-line meters is they monitor scale and corrosion on the bulk water and not under the dynamics of actual process conditions.

> *"The Test Heat Exchanger has introduced a quantum shift in testing technology... it's like being right inside your heat exchanger"*

Test heat exchangers have been used to simulate actual skin temperature and velocity to better determine scale and corrosion mechanisms in the cooling water. However, previous methods of simulating heat exchanger performance resulted in poor, unrealistic results. This was due to the utilization of electric heating elements which do not provide a uniform contact with the metal surfaces resulting in hot spots and unreliable heat transfer conditions.

The patented Sentinel™ Test Heat Exchanger, part of the OMNI Heat Exchanger Reliability program, eliminates this inherent design weakness by using a liquid-to-liquid interface that provides uniform heat transfer to the tube surfaces and, therefore, much more realistic results.

FIELD EVALUATION

Sentinel™ was installed in an ammonia production facility to monitor performance of the cooling water system and compare results to traditional monitoring methods.

Sentinel™ has two annular exchangers consisting of a ½' OD metal tube inserted in a 1" clear polycarbonate shell. The tubes are designed to match existing metallurgy. The ½" exchanger tubes are pre-weighed before exposure to the cooling water. Cooling water flows through the exchanger on the shell side (outside the ½' tube) and process water flows inside the ½" tube. Sentinel™ can model skin temperatures from 80 to 190 °F, and velocities from 1 to 8 fps. In this evaluation, cooling water velocities were set and maintained throughout the exposure period in both exchangers at 4.0-4.5 fps. Two different skin temperatures were modeled. Exchanger #1 was set at the design skin temperature of the process exchanger bundle at 115 °F, and Exchanger #2 was set at 125 °F.

New corrosion coupons and LPR probes were installed at the beginning of the exposure period. Coupons were removed and analyzed as were the ½" annular exchanger tubes in the Sentinel™.

EVALUATION RESULTS

The insight afforded by Sentinel™ is best described by the Ammonia Superintendent, "The Test Heat Exchanger has introduced a quantum shift in testing technology... it's like being right inside your heat exchanger". What was discovered by Sentinel™ was not observed on corrosion coupons or the LPR continuous monitors during the 46-day exposure period.

Corrosion coupon results on the cooling water supply and exchanger outlet were 1.32 mpy and 1.9 mpy, respectively, and LPR readings were less than 2.0 mpy. The corrosion rate for the Sentinel™ exchanger tubes was 1.93 mpy for Exchanger #1 and 3.88 mpy for Exchanger #2.[1] By themselves, these data points are expected; corrosion rates are more aggressive under stressed conditions found in the exchanger. However, further examination of the exchanger tubes revealed localized corrosion with pit depths > 20 mils.

Photomicroscopy and deposit analysis conducted on both exchangers showed a buildup of mineral scale (Figure 1), primarily composed of iron phosphate, which resulted in under-deposit corrosion (Figure 2).[3]

Exchanger 1: Velocity: 4.0-4.5 fps; Skin Temperature: 115 °F

figure 1

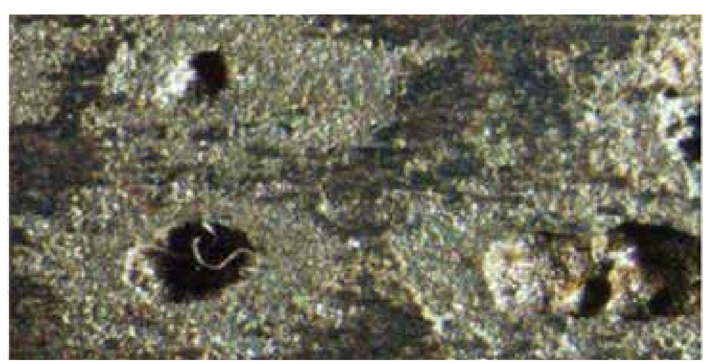

figure 2

A thicker layer of iron phosphate scale (Figure 3) was found on Exchanger 2 that operated 10 °F higher skin temperature. The scale surface is interrupted by iron tubercles which, once removed, revealed deep pits (Figure 4).

Exchanger 2: Velocity: 4.0-4.5 fps; Skin Temperature: 125 °F

In contrast, the coupon results from 46-day exposure period contained few localized corrosion results and no reported pitting to the extent observed on the exchanger tubes.

figure 3

figure 4

CONCLUSION

Sentinel™ provided a new understanding of the nature of the scale and performance under actual heat flux conditions. Correspondingly, the cooling water treatment program was adjusted, which included an overlay of pyrophosphate to sequester iron and minimize deposition. These changes were evaluated over the next exposure period, and Sentinel™ monitoring documented that iron phosphate scale had been eliminated and corrosion was also significantly reduced. Now considered as a best practice by the plant, they plan to continue to use Sentinel™ as a tool to optimize cooling water treatment and heat exchanger performance.

1,2,3,4 - L.J. Aspinall, Knew Value, LLC and Brian Bloxam, CF Industries, "Cooling Water Scale and Corrosion Monitoring", CTI Journal, Vol. 37, No. 2

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