Case Study: CH-1924

ADVANCED TREATMENT TECHNOLOGY REDUCES BIO-FOULING AND IMPROVES HEAT TRANSFER IN A LARGE ONCE-THROUGH SEAWATER COOLING SYSTEM AT A MIDDLE EAST REFINERY

INTRODUCTION

A major refinery complex in the Middle East had a history of chronic leaks on the seawater heat exchangers of their once-through seawater cooling system. The operating company's vision for the future is to be the world's leading integrated energy and chemicals company by 2020, focusing on maximizing value creation across the hydrocarbon chain, but the challenging cooling system was compromising their goal of minimizing the operating costs in their refinery operation.

BACKGROUND

Management on site was very focused on reducing the number of heat exchanger failures and improving the heat exchanger performance across the refinery. The leaks had been identified by the inspection department as being caused by under-deposit corrosion associated

Customer Impact	eROI	Economic Results
Heat transfer rate improved by 70%; 85.72 MBTU/h. Natural gas savings equal to 700,000 MBTU/year.	ENERGY	Natural gas savings of $4 million/Year
Above energy savings equates to 20 million Nm^3 of natural gas, avoiding 37,000 tons of CO_2	AIR	
Reduced the cost of maintenance and increased the reliability of the heat exchangers in the plant	ASSETS	Savings worth $ 0.5 Million/year

eROI is our exponential value: the combined outcomes of improved performance, operational efficiency and sustainable impact delivered through our services and programs.

with bio-fouling. Biological growth was visible at the seawater inlet settling basin and the seawater outfall. The once-through seawater cooling system has a flow rate of around 20,000 m^3/hr and serves all the various process applications across the refinery. Because of the bio-fouling, cooling water flow rates were reduced in some of the critical heat exchangers and performance was impaired.

Historically, chlorine gas had been used to chlorinate the seawater, followed by a period using sodium hypochlorite. A chlorine dioxide programme had been tried previously but management had not been satisfied with the monitoring and control system in place, as well as the safety aspects surrounding the storage of the chemicals and the operation of the generating equipment. The refinery had reverted back to using sodium hypochlorite with very unsatisfactory results.

The customer asked Nalco Champion to provide alternative chlorine dioxide technology to maximize the productivity of the refinery through improved cooling water efficiency and plant reliability, as well as reduce the total cost of operation associated with the fouling and localized corrosion.

SOLUTION

Nalco Champion assed the current situation from a Mechanical, Operational and Chemical perspective and proposed an improved biocide programme designed to prevent bio-fouling and improve the refinery's reliability and efficiency. Nalco Champion proposed the Purate Technology platform, involving the on-site generation of chlorine dioxide, with improved safety, monitoring, and control as a priority. This patented technology produces ClO_2 on site from chlorate and is therefore the most cost effective programme for these large once-through seawater systems.

Purate Technology

Purate is the Nalco Champion patented technology to produce ClO_2 from sodium chlorate ($NaClO_3$) with 100% theoretical efficiency. This is a chlorine free method to produce ClO_2, which is prerequisite for an AOX free operation.

$$NaClO_3 + {}^1/_2\,H_2O_2 + {}^1/_2\,H_2SO_4 \rightarrow ClO_2 + {}^1/_2\,O_2 + {}^1/_2\,Na_2SO_4 + H_2O$$

Purate generators are manufactured to the highest safety standards specifically for the Purate process. Purate and sulfuric acid are fed to a reactor inside the generator using chemical metering pumps, where they react to produce chlorine dioxide. The reaction products are absorbed into a water stream via the venturi eductor. Interlocks governing water flow and reactor pressure ensure the safe operation of the ClO_2 generator. The concentration of chlorine dioxide in the effluent water from the generator is typically in the range of 500-3000 mg/l. A process flow diagram of a typical generator is shown below.

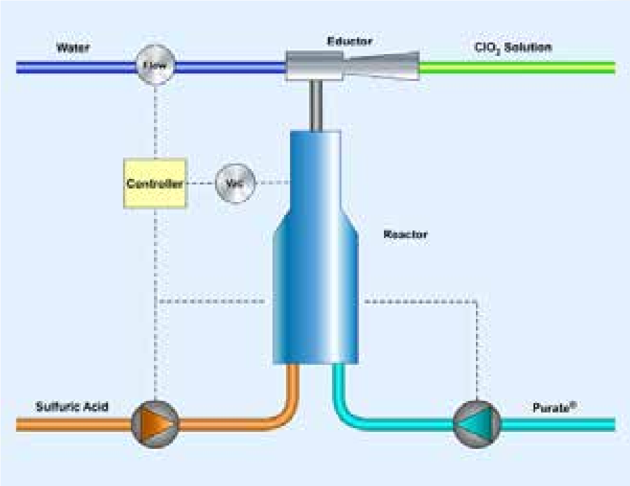

Figure 1: Process flow diagram of a typical generator

Key benefits of ClO_2

- Chlorine free process – no AOX and THM formation
- Preferred oxidizer for removing biofilm and preventing biofilm formation
- Practically pH independent (pH 4-9)
- Very effective for controlling bacteria, algae, mussels, and barnacles

A 6 month trial period was agreed and Nalco champion brought in a complete Purate dosing and control package delivered in a specially designed container. The generator comes with 4 independently controlled dosing points.

The trial performance was tracked by monitoring a variety of parameters:

- Safety
- Visual inspection - Seawater strainers & fouling plates
- Microbiological testing
- Chlorine dioxide residuals and ORP readings
- Seawater heat exchanger performance

The Purate programme was started initially as a clean-up phase due to the considerable amount of marine life in the basin as well as the seawater system itself. The injection points were located upstream of the seawater intake screens and a number of fouling plates were inserted in different locations to measure the effectiveness of the chlorine dioxide. At the chlorine dioxide start-up, the dosage was carefully monitored and slowly increased over the first few weeks. Gradual clean-up was essential as dislodging the excessive growth rapidly could lead to clogging in the system. After the careful clean-up phase, the dosing strategy was optimized towards enhanced heat exchanger performance.

RESULTS

The careful clean-up of the badly fouled system started with a slow increase of the dose rate until residual chlorine was detected at the outfall, indicating a cleaner system, and the dose rate could be reduced stepwise to its normal operational level. This took 3 months, during which constant improvements were achieved without disrupting operation. Figure 2 shows how the Colony Forming Units (CFU) dropped during the trial period. Most importantly, a log 2 reduction in sulphate reducing bacteria (SRB), responsible for the localized pitting corrosion beneath bio-films, was found.

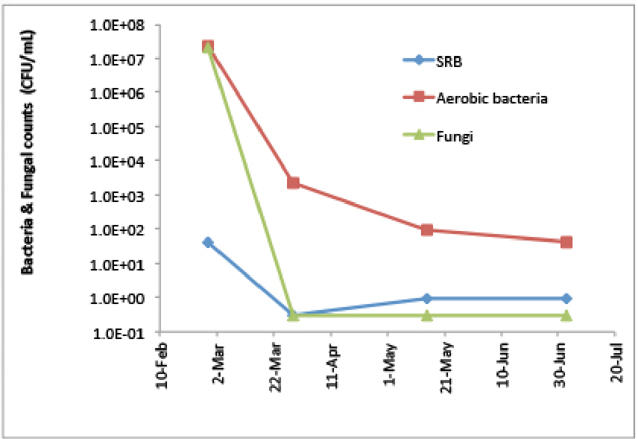

Figure 2: Microbial and fungal counts in seawater system

Interestingly, immediate improvement in heat transfer was observed upon treatment. Figure 3 shows the overall heat transfer coefficient of the condenser in one of the 4 MED desalination systems. The heat transfer efficiency increased by a factor of four, significantly improving the desalination throughput. Figure 4 below summarizes the results of the trial.

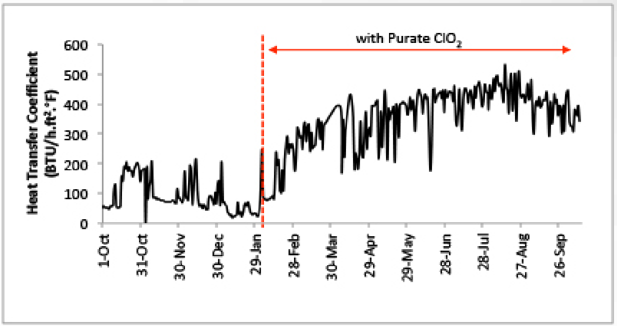

Figure 3: MED train C heat transfer coefficient improvement

CONCLUSION

The Nalco Champion Purate technology has delivered significant improvement to the sea water circuit. The customer decided to use the Purate Technology as the best long term solution to bio-fouling. The improved safety standard met the agreed upon key personal and environmental safety criteria. Visual inspection point showed the Purate system is extremely efficient in cleaning the sea water intake basin as well as the heat exchanger surfaces.

The result of better bio-fouling control is improved heat transfer performance resulting in annual savings of $4 million. By maintaining a cleaner seawater system, maintenance cost could be reduced by $0.5 million annually.

ASPECT	IMPROVEMENT
Safety	A safer system for employees and environment
Monitoring and Control	Rigorous testing, additional ORP monitoring recommended
Analysis & Visual	Log 2 to Log 7 reduction in TVC, Cleaner Surfaces
P15-VDU strainer backwash frequency reduction	80%
P15-VDU HX Heat Transfer Coefficient	22%
MED-Heat Transfer Coefficient	70%

Figure 4: Impact of Purate technology on customer operation

BEFORE PURATE TREATMENT

AFTER PURATE TREATMENT

NALCO CHAMPION Locations

Headquarters
7705 Hwy 90A
Sugar Land, TX 77478 USA

Asia Pacific:
2 International Business Park
#02-20 The Strategy Tower 2
Singapore 609930

Europe:
Ir.G.Tjalmaweg 1
2342 BV Oegstgeest
The Netherlands

Latin America:
Av. das Nações Unidas 17.891
6º Andar 04795-100
São Paulo SP Brazil

NALCO Champion
An Ecolab Company

nalcochampion.com