CLEAN AS NEW

POWERED BY TECH SONIC®

CASE STUDY

OFFLINE ULTRASONIC CLEANING – RESTORING AS BUILT PERFORMANCE DURING TURNAROUNDS

Gwen van de Bilt, Field Supervisor, Waste and Cleaning, Shell Moerdijk

INTRODUCTION

In April 2013, the Shell Moerdijk Chemicals plant conducted the biggest – ever TA event in the history of the site. One of the successes we had involved employing off-line ultrasonic cleaning. We made use of two ultrasonic tanks, each with different chemistry, for cleaning some 60 heat exchanger bundles and ~ 700 other pieces of equipment.

We originally piloted this technique in 2012 and the promising results led us to employ the technology at a much larger scale for this turnaround event.

Our cleaning objectives in the MLO were to restore "as–built" equipment performance, potentially allowing us to change from a four-year TA interval to a six-year interval on many pieces of equipment.

In addition, we wanted to assure equipment integrity (no damaged equipment from cleaning – which has happened before!), minimize the production of waste effluent, restore full heat transfer capability, including completely cleaning the hard-to-reach middle area of the shell side of the tube bundles, which we believe have never been cleaned properly by traditional methods in the past.

There are several cleaning techniques that can be used to restore the thermal and hydraulic performance of a heat exchanger by removing the accumulated fouling.

The traditional method used is High Pressure Water Jetting (HPWJ). This technique, however, can be time consuming and is not always effective. HPWJ only cleans the zone of direct water impact. The equipment can also be eroded by the extreme force exerted by the HPWJ.

The shell side of heat exchangers – between the tubes – cannot be cleaned very well and the metal surface is "partly scraped" by the HPWJ, so instead of removing 100% of the deposits, the result on the inner tubes of the bundle is a lot of fouling remaining and an uneven and rough surface.

It is precisely the first few microns of fouling that are the most important to remove: i.e. 0.5 mm of fouling can cause heat transfer losses of 40-99,7%!

The impact of the fouling above the 0.5 mm is often relatively insignificant (fig. 1), so a partial removal of the fouling without cleaning to bare metal is often not effective at restoring performance.

This is why eliminating 100% of the fouling is an important goal when cleaning heat exchangers.

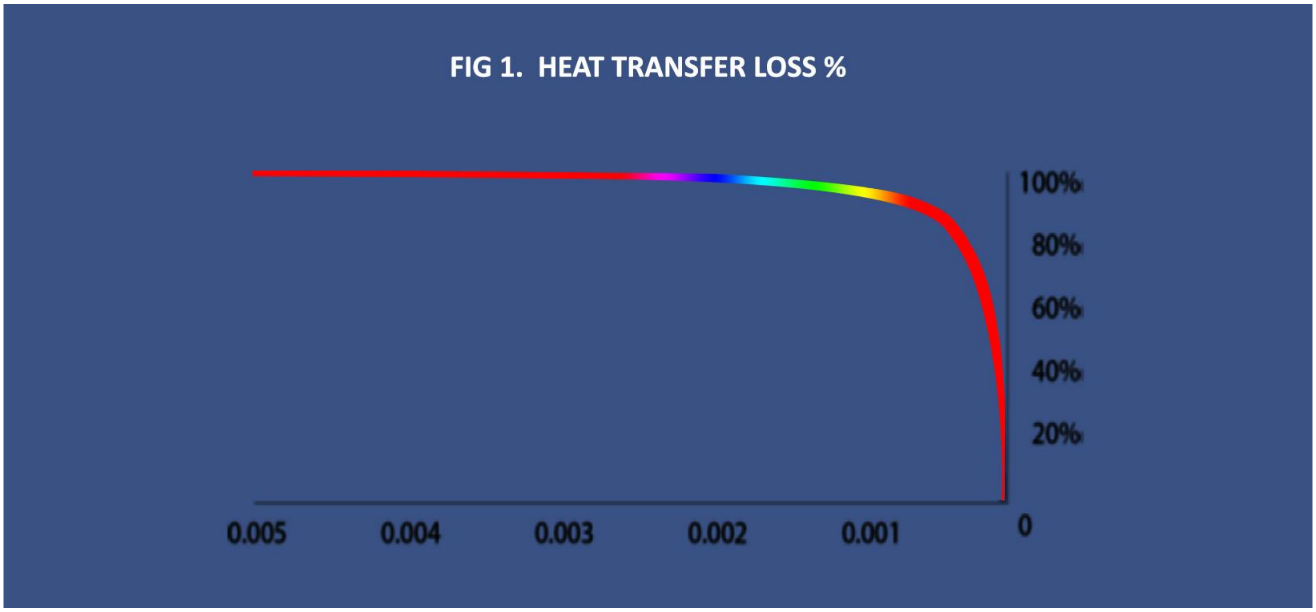


Fig. 1 Heat transfer loss of a Stainless Steel tube (10 mm diam., 1 mm thick) in relation to the thickness (mm) of a ceramic type of fouling (k = 1)

Our objective in the 2013 Turnaround was to try to achieve better cleaning results and reduce the fouling on heat exchangers such that they would exhibit “like new” performance when restored to service.

In search of a cleaning technique able to restore the as-built performance in a limited amount of time, a pilot test was performed in 2012 with ultrasonic cleaning.

The results were very promising, and the decision was made based on those pilot tests, to apply this new method during the TA 2013 of Moerdijk Lower Olefins Unit (MLO); the biggest TA ever on this site.

ULTRASONIC CLEANING

Ultrasonic cleaning involves the use of high–frequency sound waves (25 kHz; above the upper range of human hearing of about 18 kHz) to remove a variety of contaminants from parts immersed in aqueous media.

The contaminants can be dirt, oil, grease, buffing/polishing compounds, and mold release agents, just to name a few. Materials that can be cleaned include metals, glass, ceramics, and so on. Ultrasonic cleaning is powerful enough to remove tough contaminants, yet gentle enough not to damage the substrate.

It provides excellent penetration and cleaning in the smallest crevices and between tightly spaced parts of the equipment.

FIG. 2 A CAVITATION BUBBLE AT THE MOMENT OF COLLAPSE

The microjet can be seen forming directed towards the substrate.

In a process named cavitation, micron–size bubbles form and grow due to alternating positive and negative pressure waves in a solution. During rarefaction, the liquid “tears” open, forming a void (or cavitation bubble). At the next compression wave, the cavitation bubble may implode, collapsing and folding in on itself, creating an inrush of liquid directed towards the substrate or particle on which the bubble formed.

Just prior to the bubble collapse (Fig. 2), there is a tremendous amount of energy stored inside the bubble itself. The kinetic energy of the “microjet” is very high, with kinetic temperatures of several thousand K, and pressures of up to 500 atm.

The implosion event, when it occurs near a hard surface, changes the bubble into a jet about one–tenth the bubble size, which travels at speeds up to 400 km/hr toward the hard surface.

With the combination of pressure, temperature, and velocity, the jet frees contaminants from their bonds with the substrate. Because of the inherently small size of the jet and the relatively large energy, ultrasonic cleaning has the ability to reach into small crevices and remove entrapped deposits very effectively.

An excellent demonstration of this phenomenon is to take two flat glass microscope slides, put lipstick on a side of one, place the other slide over top, and wrap the slides with a rubber band.

When the slides are placed into an ultrasonic bath with nothing more than a mild detergent and hot water, within a few minutes the process of cavitation will work the lipstick out from between the slide assembly.

It is the powerful scrubbing action and the extremely small size of the jet action that enable this to happen.

The solution used in ultrasonic cleaning is a very important consideration and should be suitable for the fouling to be removed and the material of the equipment. The solution temperature also has a profound effect on ultrasonic cleaning effectiveness. In general, higher temperatures will result in higher cavitation intensity and better cleaning.

However, if the temperature approaches the boiling point of the solution too closely, the liquid will boil in the negative pressure areas of the sound waves, reducing or eliminating cavitation altogether.

Water cavitates most effectively between about 65-75ºC (149-167ºF); a caustic/water solution, on the other hand, cleans most effectively at about 82ºC (180ºF) because of the increased effectiveness of the chemicals at the higher temperature.

Because of the size and volume of the open top baths used for cleaning large industrial equipment, pure solvents are generally not used for safety reasons.

2013 TURNAROUND RESULTS

For the 2013 Moerdijk MLO TA we contracted to have 2 ultrasonic baths provided for use at our washpad. One bath was 9.75m x 2m, with an aqueous degreasing solution for oily, hydrocarbon fouled parts, and the other was 6m x 1.4m filled with an organic acid chemistry to be used for limescale and other scale/corrosion fouling.

The washpad layout was typical for a TA, with noticeably less HPWJ Equipment required because of the Ultrasonic Baths. One HPWJ pump was used to feed a 3-5 Rigid Lance ID cleaner, a semi-automated rinse arm, and a Shell Side OD Blaster. A 350 bar (5000 p.s.i.) pressure washer was also employed for rinsing parts cleaned in the ultrasonic bath.

FIG. 3 WASHPAD LAYOUT FOR THE 2013 SHELL MOERDIJK MLO TURNAROUND INCLUDING TWO LARGE ULTRASONIC BATHS

One thing which we learned during the exercise is that totally blocked tubes have to be unblocked before going into the vessel. Exchangers were placed in the bath first to remove O.D. fouling and soften I.D. fouling.

As an exchanger is raised from the bath it is easy to see if there are blocked tubes and in this case the exchangers were then moved to the washpad for lancing to open the tubes.

Typically, once the ultrasonic soak was completed, the ID of the tubes were simply rinsed using the multi-lance system to flush the tubes at high volume.

Exchangers that were fouled on the I.D. with scale, if they were not able to fit in the acid bath, were lanced to ensure complete scale removal on the inside, if a visual inspection of the I.D. after the ultrasonic soak indicated that this would be beneficial.

Oily heat exchangers (or those fouled with organic material) were typically soaked for 2-3 hours and took about 3 hours per rinse, so 3-4 heat exchangers can be cleaned in 24 hours per ultrasonic vessel.

The cleaning process in the ultrasonic bath continues with or without people and the use of HPWJ is significantly reduced because the need to lance the tubes (other than for
The cleaning window for the TA was a total of 16 days.

During the course of the TA, we cleaned a total of 51 heat exchangers and approximately 700 other pieces of equipment including spools, filters, pump parts, valves and many more.

Compared to similar events, where only HPWJ was used for cleaning, **we estimate the reduction of HPJW effort was >75% and the reduction in water consumption and wastewater generation was approximately 86%.**

Included in this is the disposal of approximately 12,000 litres of the acid chemistry, which was spent by the end of the TA.

In contrast, the aqueous degreaser solution was still viable, and approximately 90% of the chemistry was recovered and pumped into totes for storage and reuse, with the balance of approximately 8,000 litres of liquid waste from the bottom of the bath disposed of.

EXAMPLES

There were many different parts cleaned during the event besides heat exchangers. The results in cleaning heat exchangers was a marked improvement visually in the cleanliness of the O.D. of the tubes. Because of the ability of the ultrasonic to reach into all areas of the bundle, rinsing was effective at removal of all the fouling on the inner tubes of the bundles.

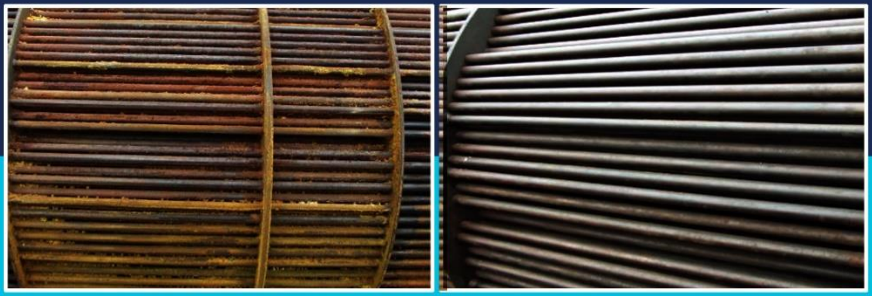
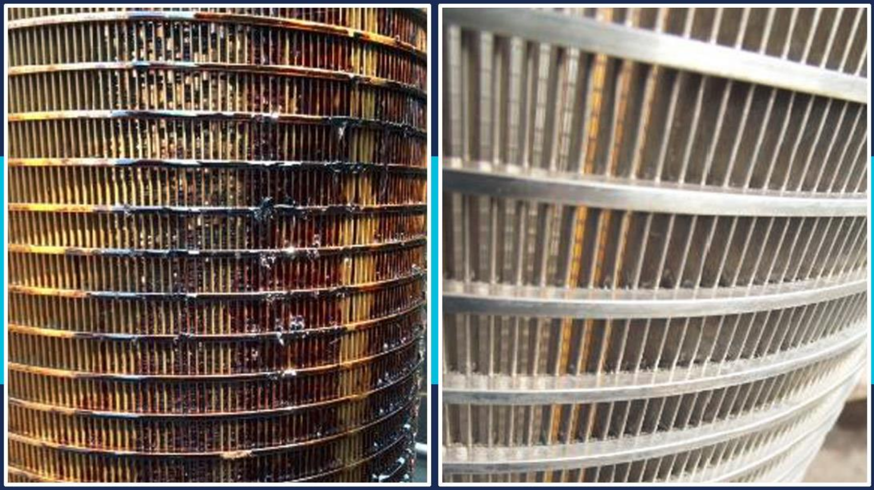


FIG. 4 A BADLY FOULED KRAKGAS BUNDLE, WITH THE O.D. CLEANED THOROUGHLY USING ULTRASONICS AND RINSING.

Many different types of filters were cleaned, including wedge wire filters which typically require a lot of effort to clean using HPWJ and can result in damage to the filter. The ultrasonic method was fast and allowed multiple parts to be cleaned simultaneously, with 100% clean results using only a low-pressure rinse following immersion.

FIG. 5 TYPICAL WEDGE WIRE FILTER FOR CLEANING, MULTIPLE FILTERS CAN BE CLEANED AT THE SAME TIME WITH ONLY A LOW-PRESSURE RINSE



A total of approximately 700 pieces of equipment besides heat exchangers was cleaned in the course of the event. Too many to be included in this review. Parts cleaned included valves, spools, filters (of all types), unstructured packings, spools, baskets, oil coolers, pump parts, scaffolding, and many more.

Figure 6 shows a stark example of the cleaning effectiveness of the method on an oily fouled scaffold gate and a fouled.

FIG. 6 A GATE FROM THE PROCESS UNIT, BADLY FOULED WITH AN OILY PRODUCT, AFTER 10 MINUTES, HALF SUBMERGED IN THE ULTRASONIC BATH

Fig. 6 A gate from the process unit, badly fouled with an oily product, after 10 minutes, half submerged in the ultrasonic bath. On the left you can see a dirty filter and on the right one that was cleaned inside and out in the bath.

CONCLUSION

We found that in all cases, the ultrasonic process, when combined with low-pressure rinsing and HPWJ produced significantly faster and better results than the traditional HPWJ methods alone.

The reduction in wastewater generation alone more than compensated for any additional cost of including the ultrasonic cleaning, and in fact made the overall cost of the TA with respect to cleaning activities less than half of a typical, similarly sized event using HPWJ only.

CLEAN AS NEW
POWERED BY TECH SONIC®

Clean As New - Offsite Cleaning Facilities

1303 Thompson Park Drive
Baytown, Texas 77521 USA
T: +1.832.271.2666
E: info@cleanasnew.com
U: https://cleanasnew.com