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ULTRASONIC CLEANING OF BADLY FOULED COMPABLOC EXCHANGERS

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ABSTRACT

This paper describes the use of ultrasonic technologies to clean badly fouled Alfa Laval Compabloc® 106 heat exchangers—which could not be effectively cleaned by conventional methods. The fouling of these units has been a major concern to our client (the "Refinery") for many years. A network of 8 of these heat exchangers is used in the FCCU, as they provide very efficient heat transfer and large surface area in a small footprint. When they were first installed in 2002, the pressure drop across them was very low (3.5 psig). Over the next 8 years and through periodic, unsuccessful cleaning attempts, these units had become a severe limiting factor to the efficient operation of the FCCU.

By spring 2010, the pressure drop across them had been hovering above (9 psig) with many days reaching 12. It thus became apparent that waiting until the scheduled April 2011 shutdown of the plant to clean these units would not be prudent. These Compabloc exchangers would need to be cleaned and finding a new cleaning protocol was absolutely necessary.

The Refinery decided to test clean a single unit using the new process proposed by Tech Sonic. Based on the overwhelming and rapid success with the first unit, the refinery subsequently opted to clean all four critical Compabloc units in the top bank of the FCCU. This new process is described below.

With the clean Compabloc units back in operation, the refinery client captured the throughput and heat transfer data rates to reveal an annual (bpd) recovery of US$4.27M.

INTRODUCTION

Ultrasonic technology has been used by Tech Sonic for the cleaning of refinery components for over 10 years. In a companion paper (Kieser et al., 2011) we describe the mechanisms of this technology and its application to shell and tube type heat exchangers. Many of the heat exchangers we have treated throughout our trials, had never been successfully cleaned by any other methods. This paper describes our work in cleaning Compabloc exchangers units in a refinery FCCU. There are eight Compabloc units comprising the heat exchanger network (HEN) - four (running in parallel) in the top bank, and four in the bottom bank, serving as the overhead condensers coming off the top of the Fractionator in the FCCU. The plates in the exchangers are welded together, so cleaning them is difficult. The foulants typically observed in the FCCU are a mixture of thermally degraded hydrocarbons. However, due to a previous upset, polymers mixed with bumped catalyst have hardened within the exchangers making them foul quickly and extremely difficult to clean. When the HEN was first installed, the pressure drop (DP) across them was 3.5 psig at 70% capacity. Within a year of operation, this value had risen to 4.2 psig, indicating that the network was fouling to some degree. Figure 1 shows the relationship between DP and flow capacity as it has changed over 7 years of operation. In 2006, an extensive chemical cleaning of the entire HEN was undertaken, which resulted in an improvement (drop) in DP, but not to "like new" performance levels.

Figure 2 shows the historical DP data for the HEN. The dip in 2007 is the result of a lengthy and expensive chemical cleaning in the 2006 turnaround. The data raised three

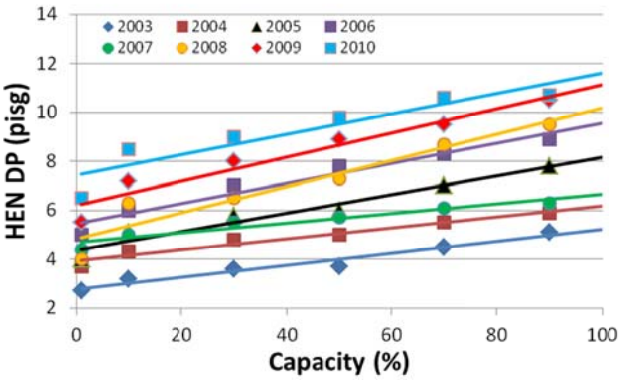

Figure 1. Differential Pressure (DP) vs. Flow Capacity (%) for the 8 unit Compabloc exchanger network by year

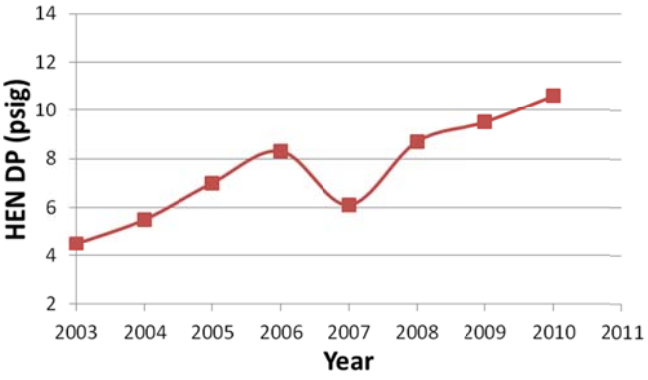

Figure 2. Compabloc exchanger network DP at 70% Capacity by Year

concerns: First, with a rate limiting DP around 9 psig, these exchangers would not perform adequately through the fall season and service could not wait until the scheduled spring 2011 shutdown. Test runs done in early 2010 indicated that the maximum achievable production rate was only 85% of full bpd capacity. In the summer and fall months, when full capacity rates would be required, this 15% loss in production due to these exchangers would be significant.

The second major concern with the data was that, in 2006, when all 8 exchangers were chemically cleaned, the DP only dropped by about 2.2psig. This cleaning took a significant amount of time (much longer than originally expected), and in the end result was unsatisfactory. Finally, in 2009 a single exchanger unit CC-106A was sent offsite for cleaning. Unfortunately, this method of chemical cleaning and shot peening was also unsuccessful, expensive and time consuming (the unit was shipped off-site for a month), and showed no significant improvement in the HEN performance. To make matters worse, by the end of April 2010, there were many days when the observed DP was above 12 psig. It is quite possible that, with the rate of fouling, the unit rates would have been forced below 80% of full bpd capacity by the summer months. It was decided that at least some of these exchangers had to be cleaned in the spring of 2010, as the unit needed to be running at full rates. It was also determined that a new cleaning method had to be found. The timing of the cleaning was selected to coincide with the #1 Crude unit outage, and a cleaning plan was put in place.

Based on the success demonstrated with traditional tube and shell exchangers, we proposed to test our proprietary ultrasonic technology with the Compabloc exchangers at the Refinery. As all previous methods were deemed unsatisfactory, and with the very expensive proposition of replacement looming, an experimental plan to deploy the technology on the Refinery site was developed. Since we had not encountered this type of heat exchanger in the past, success was not guaranteed, and the Refinery approval was given to try to clean a single exchanger, with the option to clean others if the first one proved successful .

METHOD

Tech Sonic utilizes a proprietary combination of ultrasonic technology and aqueous cleaning fluid within specially engineered vessels to remove both hydrocarbon and inorganic contaminants from the surface of a work piece in a rapid, safe and environmentally friendly alternative to traditional cleaning methods. A more complete description of the method may be found in (Kieser et al., 2011)

Owing to unit upsets, a significant amount of catalyst had hardened within the exchangers, forming an epoxy like substance in addition to the normal hydrocarbon fouling. A specific protocol consisting of time in the ultrasonic bath and interval rinsing with light-pressure water was developed. We anticipated that while the ultrasonic bath would sufficiently loosen foulant on the exchanger surfaces, interval water rinsing would be necessary to remove these loosened layers. This would allow the ultrasonic energy to work inward on the numerous layers of foulant in the complicated structure of the exchanger and facilitate physical displacement of the foulant. At the same time the rinsing (done externally) would reduce the loading on the cleaning fluid, which was anticipated to be heavy.

The first exchanger came very clean after a total of 16 hours in the ultrasonic bath and 3 hours of rinse time. When cleaning began for the second exchanger, the Refinery re-evaluated the decision to only clean two exchangers. Since the trial was considered completely successful, it was decided that all four exchangers in the top bank would be cleaned, but that all the work would have to be completed in a 2-week timeframe. Due to the time required to remove the exchangers from the unit, to disassemble and reassemble them, the timeline was very tight, and insufficient time was available to clean each exchanger as completely as the first. Less than 16 hours would be available for each unit, in order to meet the required schedule.

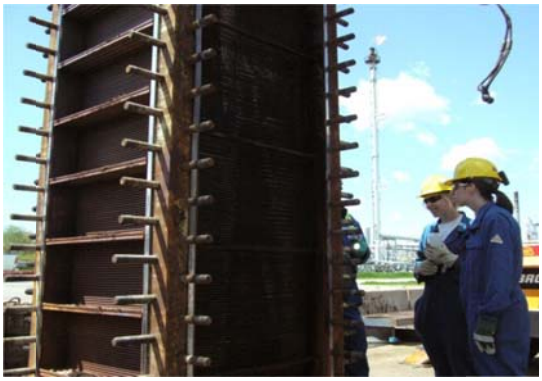

Figure 3 Alfa-Laval Compabloc Heat exchanger: CC 106A. Inspection prior to the cleaning

Figure 4. Covered Test Vessel

Figure 5. CC 106A being removed after 6 hours in the vessel

Figure 6. Close up: CC-106A --BEFORE

Figure 7. Close up: CC-106A --AFTER

RESULTS

One exchanger was cleaned to a state where detailed borescope inspection revealed no fouling and the operational DP was indistinguishable from a new exchanger. Two units, which spent less time in the cleaning vessel and had less intermediate rinsing, were visually inspected and deemed to be “close to new” condition by the Refinery. A fourth exchanger was given a quick half day treatment in the vessel and significant improvement was seen, but not enough time was available to address this unit fully. Under ideal circumstances, all four (or all 8) exchangers would be processed with the complete treatment. Figure 8 shows a

comparison between the differential pressure across the capacity range for the HEN prior to and after cleaning. Figure 9 shows how this brief cleaning activity affected the HEN performance from a historical perspective.

Worth noting in Figure 9 is that the drop in DP observed as a result of the partial cleaning of the HEN was significantly greater than the drop in DP observed from an intensive, time consuming and expensive complete HEN chemical cleaning done in 2006.

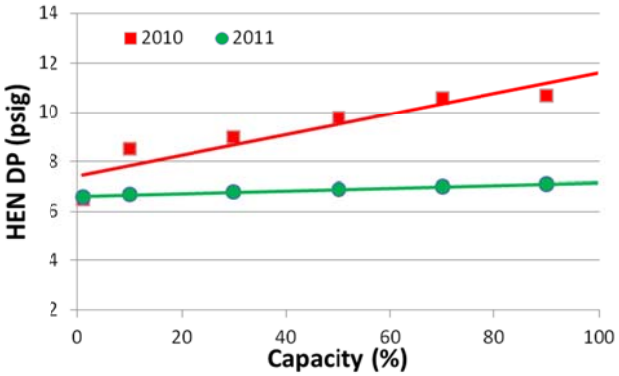

Figure 8. Differential Pressure (DP) vs. Flow Capacity (%) for the 8 unit Compabloc exchanger network, April 2010 vs Today[i]

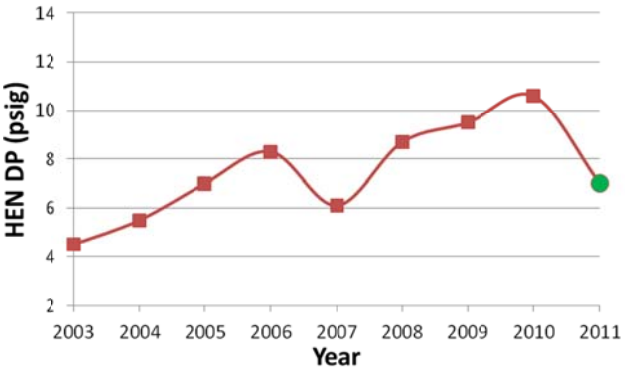

Figure 9. Compabloc (8 unit) exchanger network DP at 70% Capacity by Year (the last point is post cleaning of one exchanger and partial cleaning of three others during this study)[i]

With the units now back in service at the demanded rates by the Refinery Economics and Scheduling team, the full rates in the summer and fall months were achieved. With the Tech Sonic cleaning, the recovery in lost production revenue equates to approximately US $4.27M per year.[i] In addition, the improved DP noted in Fig.9 has also allowed for the removal of one temporary air compressor for the FCCU. For this particular HEN, the refinery's timeframe for turn-around can range from 2 to 5 years and would be determined upon DP performance. Data from one turn around to the next is necessary to truly evaluate the long term performance of the cleaning process.

While it would be desirable to demonstrate visual proof of a 'net-new clean', the nature of the Compabloc construction prohibits this from happening. As such, it is unlikely that we could achieve a 100% clean of these units. However, what has been demonstrated is a repeatable clean that exceeded anticipated results. The 20 month performance data is expected in January 2012 and will be added to follow up report.

DISCUSSION

There were a significant number of lessons learned that came out of this experimental cleaning:

1. It is important to note that the net drop in DP for the HEN was achieved by cleaning only four of the eight exchangers. It is expected that, given a few more days with the top exchangers, and cleaning the bottom four exchangers, the HEN DP would return to the original 2003 (new) level.
2. The technique is significantly safer than high pressure water blasting, presenting no significant hazards to the operators
3. Significantly faster per unit turnaround was observed: less than 24 hours per unit is possible, in contrast to conventional high pressure washing, which can take more than a week per unit.
4. Far less waste water generated (typ. <1200 l per bundle) contrasted with high pressure water blasting
5. Current samples of the fouling from these exchangers in the future will allow for better planning for chemistries and blending.
6. Specially designed rigging devices for the Compabloc's will save this refinery more than $180,000 by allowing the units to rest on the bottom of the Tech Sonic vessel, instead of being suspended by a crane.

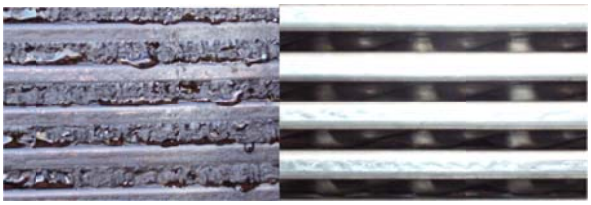

Figure10. CC 106 D Compabloc exchanger before (a) and after (b) cleaning

CONCLUSIONS

The experiment was a success in terms of finding a cleaning technology that worked on these troublesome heat exchangers, while exceeding the refinery's revenue recovery expectations.

1. The Tech Sonic method is a good fit for completing this work and addressed the intricate Compabloc exchanger cleaning thoroughly.
2. This new method will provide increased efficiency for the plant and less frequent shutdowns of the FCCU, which will result in both cost and time savings.
3. We've been invited back to clean the bottom bank of these heat exchangers (4 in total) at the next scheduled turnaround.

REFERENCES

B. Kieser, S. Smith, R. Philion, T. McCartney, *The application of industrial scale ultrasonic cleaning to heat exchangers*, Heat Exchanger Fouling Conference IX, Crete (2011)

i. All (HEN) DP (psig) performance statistics were supplied by the Refinery client, from historical performance data and post-cleaning data captured from June to Sept. 2010