Applying chemical cleaning solutions

The use of specially formulated cleaning chemistry applied to distillation columns, heat exchangers, pumps and other key processing equipment can improve operating margins

Bruce R Jansen
Refined Technologies

Many refineries are using chemical cleaning as a strategic means to add profitability. Some are using it to increase throughput, others to reduce operating expense, but the bottom line is to increase net income.

It is difficult to argue against the benefits of keeping equipment maintained on a timely basis. As an analogy, most of us perform routine maintenance on our cars to optimise performance, increase safety and fuel efficiency, and prevent breakdown at inopportune times. Processing equipment must be maintained in the same way. Chemical cleaning removes contamination that impedes product flow, decreases heat transfer, masks other problems and harbours sites of local corrosion. In addition, chemical cleaning can be used as a strategic means to improve operating efficiency. In its proprietary program of Strategic Chemistry, Refined Technologies uses its proprietary chemistry and patented Vaporganic process to improve a refiner's operating margins.

Amine regenerator

The amine absorption process removes H_2S or CO_2 from a gaseous sour feed. The amine is allowed to flow down through an absorber tower, where it is contacted by the sour feed gas to be purified, which is moving up the tower. The amine, which becomes contaminated with H_2S or CO_2, is discharged from the bottom of the tower to a steam regenerator. The rich amine flows in the steam regenerator countercurrent to the steam that strips the H_2S or CO_2 from it. The now lean amine is then returned from the bottom of the regenerator tower to the top of the absorption tower for reuse. This particular refinery uses the secondary amine, diethanolamine.

Among other controls, the refinery monitors a pressure differential across the tray section in the regenerator. As the pressure differential increases, the ability of the regenerator to reproduce lean amine is diminished. To compensate for the regenerator's diminished capacity, the rich amine feed must be reduced, eventually leading to a reduction in sour gas feed to the absorber, which may put a limit on the refinery's production rate.

An upset in the process can allow hydrocarbon carryover into the amine. The hydrocarbon may react with the amine, causing by-products, which are split out in the regenerator and left on the trays. As the trays collect these by-products, the differential pressure is increased. In this case, the refinery elected to use chemical cleaning after the pressure differential in the regenerator increased from 1.5psig to over 3psig.

By working closely with the refinery, Refined Technologies developed a cleaning plan where the regenerator was isolated, de-inventoried and cleaned using QuikTurn and the Vaporganic process. The cleaning process was completed in less than ten hours. After cleaning, the unit was put back on-line and a chart was produced to evaluate the effects of the cleaning process.

The charts generated by the chemical cleaning program demonstrated that the differential pressure immediately dropped by approximately 50%, while the rich amine feed rate increased by the same amount. The refinery process engineer responsible for the unit said that: "It appears that the chemical cleaning lowered the pressure differential on the tower and reduced the tray plugging, which was probably causing the stacking issues that we were seeing." QuikTurn dissolved the amine by-products that were plugging the trays and essentially regenerated the regenerator.

Centrifugal pump vibration problems

A team of vibration analysis professionals at one large refining facility is assigned to monitor the vibration levels of rotating equipment across the refinery in an effort to predict equipment failure and avoid unexpected unit outages. As a rule, when vibration levels exceed predetermined thresholds, the maintenance department is advised to purchase the parts needed to overhaul the equipment. The subject pump is a wash oil circulation pump on a delayed coking unit. Recently, peak vibration levels exceeded the action threshold, rising to a point that was nearly twice the measurement obtained when the pump was returned to service following the last rebuild.

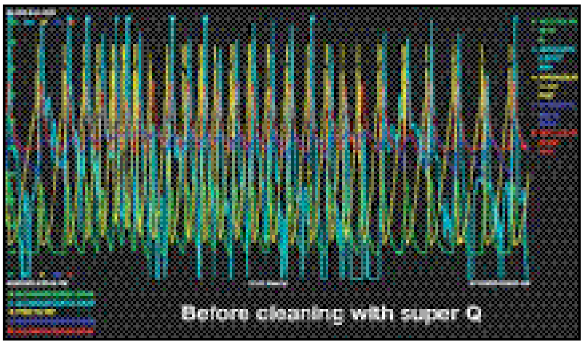
However, this time, rather than rebuilding the pump at a cost of more than $10 000, the pump was cleaned using a patented cleaning process to remove an imbalance caused by impeller fouling. Vaporganic returned the pump to its full operating capacity.

After the pump had been blocked in and de-inventoried, it was cleaned using a minimal amount of cleaning chemical. The cleaning took only 30 minutes, which allowed the pump to be placed back into service and rechecked for vibration in very short order. At a frequency of 21 450min^{-1}, a vibration level that was measured at 0.076in/sec before cleaning was reduced to just 0.014in/sec after cleaning. This represents an 81.6% reduction in vibration resulting solely from the cleaning process.

Hydrocracker feed filters

Due to heavier charge, a US Gulf Coast refinery hydrocracker was having difficulty managing pressure differential across its feed filters. The heavier charge created a problem for the filters, as it lay down a thick gummy film that caused a high pressure drop and necessitated more frequent backwashing.

These fully automatic filters are arranged in five banks of ten filters per bank. As the differential pressure across the five banks reaches 25psi, the filters automatically enter a backwash cycle, one bank and one filter at a time. Each filter is auto-aligned to the slop system and backwashed with feedstock for



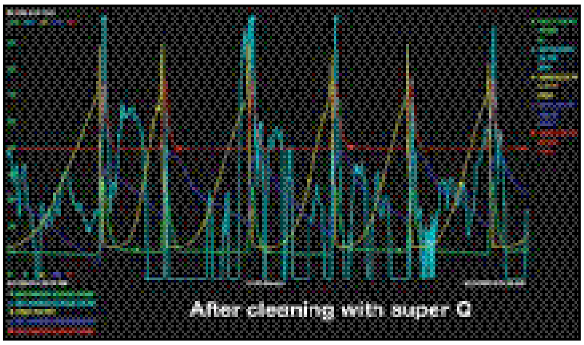


Figure 1a *(top) Before cleaning with Super Q, with each peak of the yellow line representing a backwash cycle*

Figure 1b *(bottom) shows backwash frequency reduced to 12 times a day after cleaning with Super Q*

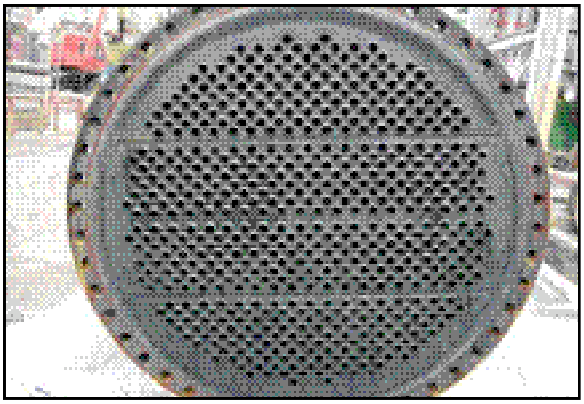


Figure 2 *Slurry/feed pre-heat exchanger tube bank*

several seconds. The resulting slop oil must then be reprocessed as crude charge. Under normal operating conditions, the filters backwash approximately 12 times per day and consume nearly 500bpd of feedstock.

Recently, the backwashing frequency had increased from 12 times per day to more than 50 times per day, requiring diversion of some 5000bpd of feedstock to backwash needs. The Figure 1a graph represents a 12-hour period and each peak of the yellow line represents a backwash cycle of all 50 filters.

Generally, when the consumption of feed oil for backwash needs becomes too great, or when filter efficiency becomes too diminished, the filters are taken out of service one bank at the time, disassembled and mechanically cleaned. Each bank remains out of service for approximately three days and the cleaning and mechanical costs average $25 000.

The refinery began looking for an in-line cleaning solution and chose to utilise the Vaporganic process. All five banks were cleaned in place and returned to service in eight hours. The cleaner was injected using a 3/4in bleeder into hard-piped steam that was lined up to each bank of filters. The "post-clean" results are illustrated in Figure 1b. As can be seen from the graph, the backwashing frequency was reduced to 12 times a day, requiring only 500bpd of backwash oil.

Implementing the proprietary Strategic Chemistry approach to improving the performance of these filters has saved this refinery thousands of dollars in backwash oil, lowered reprocessing rates, increased feed charge and reduced mechanical cleaning costs.

Coker fin fans

Another refinery recently had a need for four bays of overhead condensers to be cleaned due to a gradual change in pressure differential that increased the pressure in its main coker fractionator. Higher pressure drops through these overhead condensers caused a higher pressure inside the fractionator, preventing the coke drums from operating at optimum production levels.

By cleaning the condensers with Refined Technologies' chemistry in the vapour phase, this refinery was able to lower its pressure differential by 6psi, facilitating a 1000bpd throughput increase. In addition, each clean was complete in only one-and-a-half hours from feed-out to feed-in due to the efficiencies and effectiveness of the process. Previous hydroblasting cleaning methods normally required five days to complete. Due to the cleaning process, no cleaning effluent was released to the waste-treatment unit, nor was there a need for storage in fractionation tanks for future processing.

Coker spray header

In the weeks preceding this project, the refinery had experienced an increasing back pressure and a decreasing flow rate through the upper HGO pump around to the return spray header of its coker main fractionator. The reduced flow rate significantly diminished its ability to operate the coker efficiently. Refinery engineers concluded that the problem was due to plugging caused by coke fines and oily sludge build-up in the spray nozzles. Refined Technologies was contacted when pressure to the spray header climbed above 200psig.

To develop a solution, Refined Technologies' engineers met with the process engineers and unit operators. Together, they studied the fractionation system and developed a cleaning procedure that included injection of cleaning chemistry into an LCO wash line that tied into the HGO upper spray header at the tower. To execute the procedure, both the LCO and HGO lines were blocked and de-inventoried, and steam was applied to each line. With the fractionator in service, cleaning chemistry was injected into the LCO line. Injection took approximately one hour and was followed by an additional hour of continued steaming. Throughout the injection process, pressure was closely monitored inside the fractionator. No pressure or downstream problems were encountered.

Immediately after injecting the chemical cleaner and returning product to the header, back pressure dropped to 100psig. Pressure in the header continued to drop, and two days later pressure in the header was only 50psig. For this refinery, timely use of chemical cleaning prevented an ultimate shutdown of the coker.

FCCU slurry exchangers

A refinery located in a major ultra-low-sulphur gasoline-centric market was in pursuit of a means to improve FCCU operating margins and the performance of its slurry/feed pre-heat exchangers. Due to the nature of the service, one of six banks of slurry/feed pre-heat exchangers is removed from service every six to eight weeks for mechanical cleaning. This mechanical hydroblasting of each bank typically requires 10–14 days out of service.

As an alternative to hydroblasting, the refinery chose to implement chemical cleaning using the Vaporganic process. To ensure positive confirmation of the post-cleaning results, the exchangers were pulled for inspection (Figure 2). The success of this application has led to additional cleanings that have yielded a return of 8°C of pre-heat. Understanding that each FCCU slurry circuit

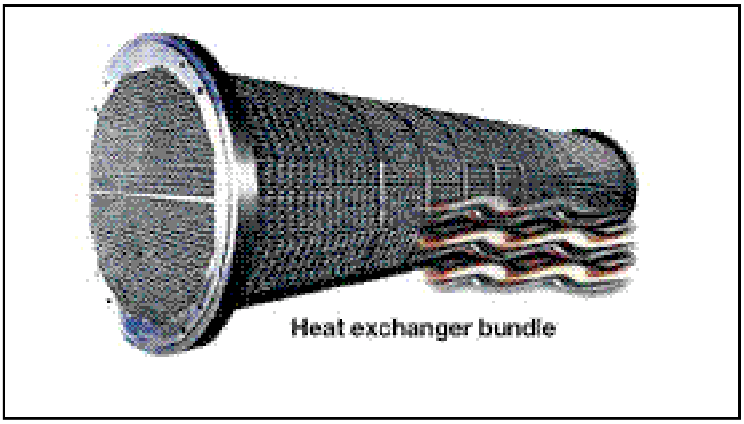


***Figure 3** Twisted-Tube heat exchanger*

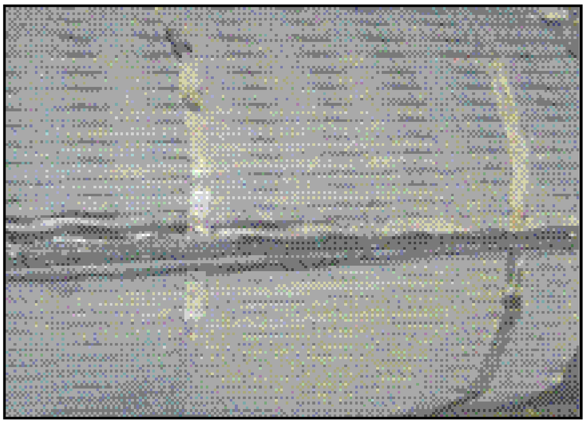


***Figure 4** Twisted-Tube bundle after chemical cleaning*

configuration is unique, routine cleaning of slurry exchangers and slurry boilers can improve profitability. Maintaining them, in place, the patented chemical cleaning processes discussed so far can:
— Increase feed pre-heat temperatures
— Improve light ends reboiling
— Reduce demand for combustion air
— Improve the ability to cool slurry
— Increase steam generation.

The technology is applicable to a wide range of equipment configurations and:
— Is applied using the patented Vaporganic process
— Restores duty and increases throughput
— Can be applied through 3/4in bleeders
— Can be vented to slop oil or pump-out system
— Can be applied in six hours or less
— Cleans without water rinsing
— Requires minimal labour to apply.

Cleaning of specially designed heat exchanger tubing

Since 1995, hundreds of proprietary Twisted-Tube exchangers have been operating under a wide variety of field conditions. Over the years, Twisted-Tube technology (Figure 3) has proven to be an efficient, effective and attractive alternative to solving heat-transfer issues in the plant with minimal changes to equipment.

Twisted-Tube heat exchangers can provide a higher heat-transfer coefficient and better overall operating performance than any other tubular heat exchanger for the following reasons:
— Complex swirl flow on the shell-side induces the maximum turbulence to improve heat transfer
— Powerful tube-side turbulence is achieved even at high viscosities and/or low velocities. Velocity remains constant and uniform
— Uniform flow distribution gives more effective length and surface area than other shell and tube exchangers
— Baffle-free design directs shell-side fluid to true longitudinal flow
— Each Twisted-Tube is extensively supported at multiple contact points along its entire length
— Tube fretting and failure due to vibration is eliminated
— Longitudinal swirl flow reduces the high pressure drop associated with segmental baffles.

Chemically cleaning these bundles in place is becoming an effective and preferred alternative to pulling and blasting. Shown in Figure 4 is a Twisted-Tube bundle that was chemically cleaned in place using Refined Technologies' patented chemical cleaning technology. A shroud surrounding the bundle when it was cleaned was removed to reveal the extent to which the outer heat-transfer surfaces of the tubes came clean.

When integrated into a regular preventive maintenance programme, chemical cleaning is an effective way to significantly reduce energy costs and/or increase throughput. Timely chemical cleaning is an effective way to return heat transfer without the issues normally associated with mechanically pulling, cleaning and reinstalling twisted tube bundles.

Crude vacuum tower

A large refinery pipestill with a 240 000bcd capacity elected to use the cleaning patented process previously discussed to clean its large vacuum tower due to the effectiveness of the process. By using the cleaning solvent in the vapour phase, it knew that all surfaces of the vessel internals would be contacted and cleaned. Considering the large surface area of the tower, it would have been impossible to effectively clean it with traditional liquid circulation methods.

The chemical cleaning process not only thoroughly degreased the entire vessel; it also degassed the internal atmosphere to allow for immediate permitted entry. Contractors were able to enter the vessel and begin maintenance work immediately after the rinsing phase of the Vaporganic process, as shown in Figure 5.

***Figure 5** Clean trays in a large vacuum tower after chemical cleaning*

Since the cleaning chemistry and the effluent generated are all natural and completely biodegradable, there were no upsets at the WPU during the turnaround. As a matter of fact, the refinery was able to achieve the highest environmental rating possible from the WPU throughout the down period. The results from cleaning the vacuum tower with QuikTurn were noted by the feedback from refinery personnel involved in the turnaround:
— "The effectiveness of the cleaning application exceeded expectations. We were able to save at least three days on cleaning time alone." - M.B.
— "We will absolutely use this cleaning application again for upcoming turnarounds." - D.F.
— "This was the first time we had ever gone into the tower after cleaning and could physically see the bubble caps on the trays." -G.W.

Coker fractionator hydroblasting alternative

The coker unit at one refinery overflowed a coke drum back into the main column and relief system. As a result, the bottom suction on the tower became completely plugged with coke and heavy oil. The refinery tried for 24 hours to steam out the bottom of the tower in an unsuccessful attempt to evacuate the unit before considering the use of a chemical cleaning process. Many refinery personnel thought that the only solution to this problem would be hydroblasting.

Refined Technologies was asked to use its chemical cleaning process to not only unplug the bottom of the tower, but also to clean the entire vessel for permitted entry and inspection.

The refinery management team agreed to solve this problem in two phases. In the first phase, the chemical cleaner would be used in the bottom of the tower to evacuate all the coke and heavy oil that was causing the blockage. In the second phase, the chemical cleaner would be used once more to remove all the hydrocarbon and gas for permitted entry and inspection.

The first phase of the project was very successful. After injecting only 20 gallons of cleaning solvent over approximately four minutes, a tremendous surge of coke and heavy oil began to flow out of the main fractionator bottom drain. After the first phase was complete, the refinery estimated that $480ft^3$ of coke and heavy oil was removed from the coker main fractionator. This result was very impressive considering that the vessel had been steamed for 24 hours with no coke or heavy oil removal.

The second phase of the cleaning application involved cleaning the entire coker main fractionator in order to gain permitted entry. The second phase was completed in about eight hours, and the refinery was able to gain immediate permitted entry. When inspectors entered the main fractionator tower, they commented that the level of cleanliness was incredible.

The refinery estimates that QuikTurn and the Vaporganic process saved 11 days of manual labour needed to gain entry into the tower. The total cleaning process removed 30 tons of coke and heavy oil from the vessel. Benzene, LEL, and H_2S gas readings were all zero prior to entry. The bottom line is that the chemical cleaning approach used in this case provided the refinery with a quick and effective solution to what would have otherwise been a very costly problem.

FCCU reactor

As with the chemical cleaning process used to clean the previously mentioned coker main fractionator at one refining facility, another large refiner employed the same process to clean its FCC reactor on an emergency basis. The refinery had inadvertently filled its reactor with oil. Oil-soaked catalyst plugged the standpipes on top of the slide valves, making it impossible to drain oil and catalyst from the reactor. For 36 hours, attempts were made to clear the standpipes and drain the reactor by steam lancing through sample ports in the standpipes. With the plug and a dead leg at the slide valve, circulation cleaning solutions were impossible. A plan was developed to clear the standpipes and de-oil the reactor using the Vaporganic process. Preparation for the process began immediately.

The QuikTurn chemical was applied to seven points on the reactor system: standpipe (2), emergency carrier steam (2), fluffing steam (1) and riser (2). Within four hours from the start of injection, the standpipes were clear of oil and catalyst. Nineteen hours later, the reactor was safely blinded, manways were opened and inspectors entered the reactor. The inside of the reactor was completely oil and gas free (ie, 0 LEL, 0 benzene, 0 H_2S).

Due in part to the nature of the equipment, there was no rinse water added to the vessel to remove effluent oil, catalyst and QuikTurn chemical. Instead, Refined Technologies used a special rinse-less procedure to clear the vessel. Effluent from the process was minimised and refractory material that lines the reactor was completely unaltered by the process, except that it was rendered free of oil.

Conclusion

A great deal of additional net income is available to refineries that are able to reduce operating expense and increase throughput. Chemical cleaning is one method used by resourceful refinery professionals to add income. The effectiveness of traditional cleaning methods was limited by the amount of time required to complete the process, safety and environmental concerns or less than satisfactory results. Due to these legacy limitations, the use of chemical cleaning to improve operating performance was limited. The newly patented chemical cleaning processes discussed in this article remove traditional limitations, and open the door to new and innovative opportunities to enhance operating performance.

Bruce R Jansen *PE, MechE is vice president, engineering and technology, at Refined Technologies in The Woodlands, Texas, USA. Jansen is a registered professional engineer in the state of Texas. Email: bjansen@r-t-i.com*