Mechanical Decoking of Furnaces the Right Way

Arjo van Toor, Global Business Director at Quest Integrity

Quest Integrity received an urgent call from a European refinery for an immediate mobilization to perform an Advanced Decoking and Cleanliness Verification (ADCV™) on a 4-pass vacuum furnace. The furnace tripped in less than 24 hours, and tube wall temperatures quickly exceeded the design specifications due to excessive coke formation. The asset-owner had no other option but to take the furnace offline for an unexpected cleaning. It goes without saying that this unplanned outage was going to be very costly due to the loss of production. As such, the asset-owner needed to have the furnace up and running as soon as possible to minimize lost production time.

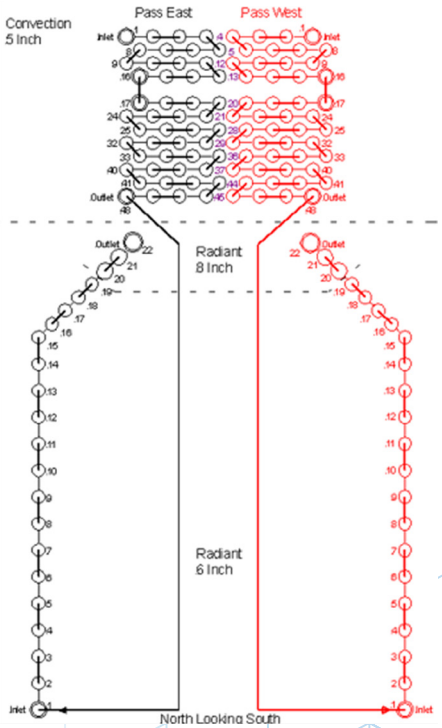

Figure 1. 4-Pass Vacuum Heater

This furnace had presented numerous operational challenges over the years for the unit operators, making it exceedingly difficult to achieve a high level of efficiency for reasons unknown to the refinery.

The ADCV™ service was selected for this project due to its progressive and technology driven approach to locating and removing areas of internal fouling, reducing cleaning times, avoiding unnecessary wear to tube walls from over cleaning and identifying operational issues. To optimise cleaning operations and improve heater efficiency, ultrasonic (UT) technology was utilised as part of the cleaning service to detect and quantify internal fouling (coke).

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Figure 2. Internal Fouling

Over a 14-hour period, Quest Integrity performed an advanced mechanical cleaning of the furnace coils along with a cleanliness verification. An area of internal fouling “coke” had proved to be especially difficult to remove during cleaning operations, and the decision was made to cut out the tube (see coke at 9 o’clock position in Figure 2.) Plant personnel were primarily concerned with understanding why the fouling in this specific area couldn’t be removed during cleaning, which would have eliminated additional downtime and costs. Did the ADCV™ service underdeliver on its promise?

However, there was more to this story that provided a completely different perspective on the cleaning result.

If a conventional mechanical cleaning service had been employed for the most recent project, where the cleaning result can only be verified by the cleanliness of the pigging water, the leftover fouling in this particular tube would have gone unnoticed. As a consequence, the furnace would have continued to experience operational inefficiencies, as before, and at the risk of another unplanned outage from elevated tube temperatures and a possible tube rupture.

Taking a deeper look at the tube and the coke formation, it became clear that the coke was comprised of two different layers. After the previous conventional mechanical cleaning, the furnace went back online and quickly coked up at the same location over and over again producing the second layer of coke as seen in the tube image.

The leftover coke from insufficient cleaning practices acted as an accelerate for the rapid formation of new coke. Since coke acts as an insulator, elevated temperatures occurred in the previously fouled area. This in turn caused new and more rapidly developing formations to occur on top of the existing layer of coke, making the older layer harder over time.

The older layer of coke became so hard over time that even a metal studded decoking pig could not remove it. To further complicate matters, prolonged overheating from the internal fouling deformed the tube, making it difficult for the cleaning pig to conform to the shape of the tube to properly clean it.

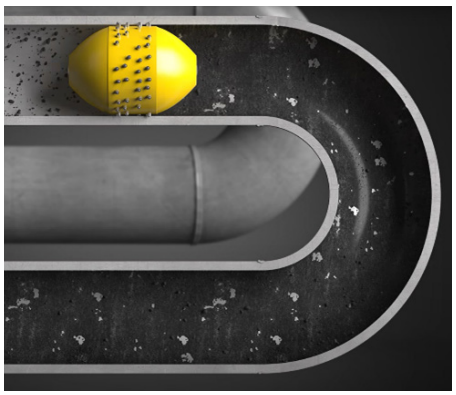

Figure 3. Advanced Mechanical Cleaning

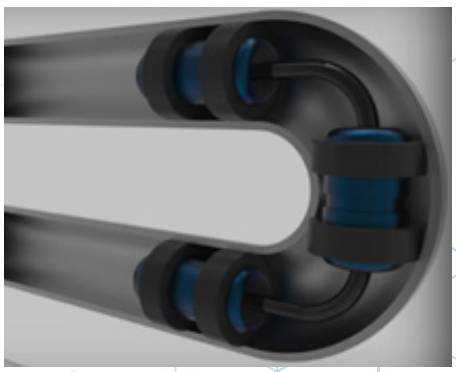

Figure 4. Cleanliness Verification

Reverting back to the most recent project, Quest Integrity utilized its cleaning verification technology to map out the location and estimated thickness of the internal fouling in each furnace coil at the start of the mechanical operations. This critical first step helped establish a strategy to optimize cleaning, save time and avoid unnecessary wear and tear on tubes by cleaning just those portions of the coils containing coke.

Full-scale cleaning operations progressed and fouling was gradually removed. Further adjustments to the cleaning plan were made based on the location and thickness of coke from additional cleanliness verification tool runs. By doing this, overcleaning of already clean tubes was avoided.

As cleaning operations neared completion, it was noted that an area of localized coke still remained in one of the tubes as shown in Figure 2. Quest Integrity executed numerous cleaning pig runs followed by a final cleanliness verification tool run, and despite best efforts, the existing coke layer remained essentially unchanged.

At this stage, Quest Integrity notified the furnace owner-operator of the situation to discuss next steps. Additional cleaning with an oversized studded decoking pig was not considered, since this would potentially damage the clean tubes. Continuing to clean with the same size decoking pig could eventually remove a small portion of the old coke layer but would have taken considerably longer. Additional cleaning time was not available since the furnace needed to be back online as quickly as possible. It's worth noting that despite the additional cleaning runs at the localized area of fouling, the total project time to carry out the ADCV™ service was 20% less than the previous conventional mechanical cleaning service.

If was finally agreed that Quest Integrity would provide a map showing the exact location of the fouling (see Figure 5) enabling refinery personnel to cut out and replace the affected tube segment. This plan ensured the furnace could be placed back online without having to address any future consequences such as tube overheating and ruptures from leftover fouling.

The ADCV™ service provided immeasurable value to the owner-operator of the vacuum furnace. Good transparency and communication along with technology-enabled cleaning solutions were the key drivers in making this project a success.

Refining and other industry owner-operators decoke and descale heaters to achieve optimal throughput, improve operating efficiency and preserve the integrity of their coils. When performing standard maintenance activities, such as furnace decoking, it is reasonable to expect services that do not diminish overall heater performance and coil integrity. By applying Advanced Decoking and Cleanliness Verification, owner-operators are able to use data-driven solutions that can reduce decoking times, reveal unexpected operational issues and validate cleaning efforts, allowing assets to return to service faster and with better operational assurances.

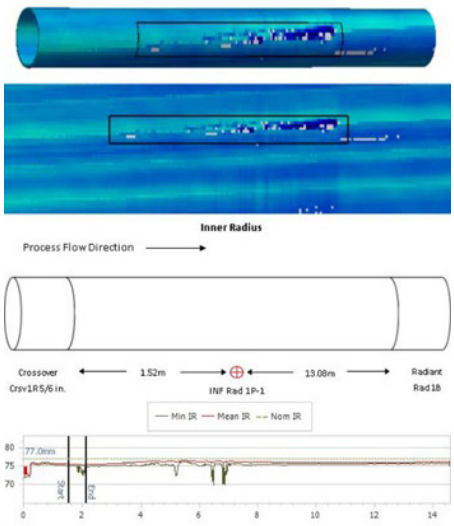

Figure 5. Map of Fouling

Table 1. Fouling Details (Figure 5.)

Category	VALUE
Internal / External	Internal
* Location	1.52m
Axial Length	0.60m
Circumferential Width	0.10m
Fouling Thickness	3.4mm
Avg. Fouling Thickness	0.6mm

* Distance from the end of the previous fitting.

Table 2. Piping Information (Figure 5.)

Name	VALUE
Material	A335-P5
Nominal Outside Diameter	168.3mm
Nominal Inside Diameter	154.1mm
Nominal Wall Thickness	7.1mm

* Distance from the end of the previous fitting.

For more information on the effects that fouling has on heater operations please review our article "Heater Tube Cleaning and Verification: The Effect of Fouling on Heater Services That Are Prone to Coking" by Fired Heater specialist Tom Gilmartin. This article can be found on the Quest Integrity website at Advanced Decoking and Cleanliness Verification.