NEW POSSIBILITIES

Tim Haugen, Quest Integrity, USA, outlines the benefits of ultrasonic-based smart pigging inspections and cleaning on steam reformer convection coils in the ammonia, methanol and hydrogen industries.

Ultrasonic-based smart pig inspections have become a mainstay for maintaining fired heater and furnace tube integrity. However, many steam reformer owner-operators across the ammonia, methanol and hydrogen industries are unfamiliar with the technology or are not aware it can be utilised for the inspection of convection sections including coil configurations connected to common headers (manifolds).

Although it is a widely accepted practice to inspect the radiant tubes in steam reformers, inspection plans or any other means to help determine the condition of convection coils are almost non-existent. As such, little to no inspection data has been collected on these coils. This is due to the lack of an entry point into the convection box, accessibility to the inside of tubes connected to common headers, space restrictions, and the challenges associated with conducting external inspections on tubes with raised surfaces (e.g., fins and studs). When considering all these accessibility issues, internal and external inspection technologies such as smart pigs, external crawlers and handheld UT solutions, cannot be utilised without major modifications to the furnace or sacrifices in the amount and quality of inspection data readings. As a result, many convection sections are not inspected and are instead maintained using conservative lifecycle predictions based on tube age, operating conditions, tube metallurgy and feedstock quality. Although steam reformer convection sections typically operate in less harsh environments (e.g., lower temperatures, and less corrosive feedstocks) as compared to some other fired furnaces and heaters, tube failures do occur from wall loss and creep growth.

To mitigate possible future tube failures and obtain much needed integrity data, a methanol plant located in the Middle East performed an automated in-line 'smart pigging' inspection and fitness-for-service screening assessment on 100 natural gas preheater coils (Figures 1 and 2). The coils had never been cleaned before and some internal fouling was suspected given the number of years in operation. As such, the solution provider selected to perform the inspection and assessment was also asked to clean the coils using an advanced mechanical cleaning and pumping technology in addition to pumping the smart pigging inspection tool through the coils.

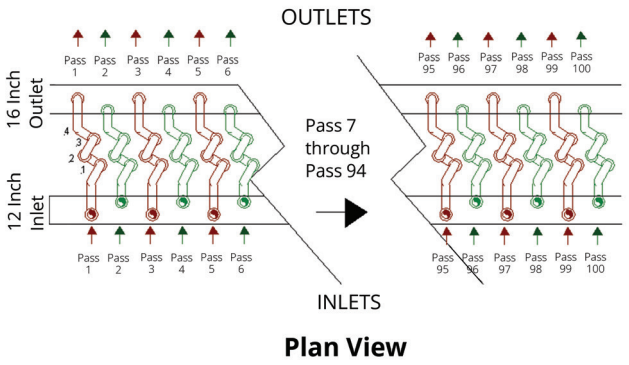

Figure 1. Natural gas preheater section.

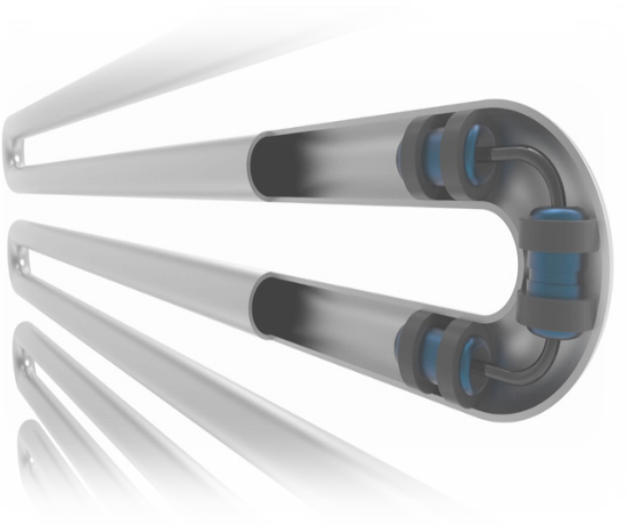

Figure 2. Smart pigging inspection tool.

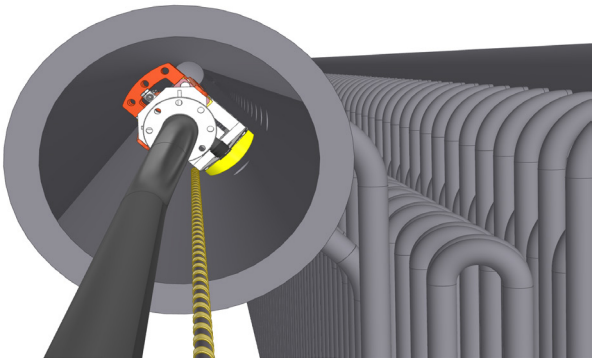

Figure 3. HDS inside a common header.

Project services and execution

Quest Integrity was chosen as the solution provider to carry out all three of the services for this project.

The cleaning service selected used pumping trucks and mechanical cleaning pigs to effectively remove internal fouling from tube walls, restoring proper heat transfer and thermal efficiencies. For the inspection, a high-resolution ultrasonic in-line inspection technology was utilised. This detects and measures damage such as internal and external corrosion, erosion, pitting and fretting as well as deformations such as bulging, swelling, denting and ovality in numerous coil configurations. The technique provides owner-operators with a comprehensive and quantitative mapping of a coil's wall thickness and geometry. The inspection data from this service can then be used along with heater design and operating parameters to conduct a fitness-for-service screening assessment following the API 579-1 Standard. The assessment provides owner-operators with the confidence that a furnace can be returned to service and safely and reliably operated until the next planned shutdown.

As with many steam reformers, common headers were attached to the inlet and outlet of each coil. This added to the complexity of the project, since the cleaning pigs and inspection tools would need to travel through the header first for entry into the coils. Cutting 200 tubes welded to the inlet and outlet headers (or even a portion of the total tubes) and installing temporary flanges and launcher barrels was not an option given the time and cost associated with such modifications.

To overcome these hurdles, a header delivery system was installed inside the inlet and outlet common headers and attached to each coil. The delivery system effectively connected the coils via hoses to the water pumps installed on the cleaning truck (Figures 3 and 4). This created a closed loop system, allowing water to enter

the coils while keeping the headers dry. The water inside the coils provided a couplant for the ultrasonic inspection, while also propelling cleaning pigs and the inspection tool through the coil via the cleaning truck pumps.

Significant internal fouling was encountered during the cleaning process, which was not expected, with some coils completely blocked. The solution provider managed to clean all of the unblocked coils and assist the plant in unblocking a portion of the remaining coils. Removing the fouling greatly improved thermal efficiency and heat transfer and allowed for the highest quality ultrasonic inspection. The inspection was performed successfully, and a comprehensive high-resolution ultrasonic data set was collected. All of the on-site work was completed within the expected timeframe and without disrupting or delaying the turnaround schedule.

Figure 4. Set up for coil cleaning and inspection (typical process heater).

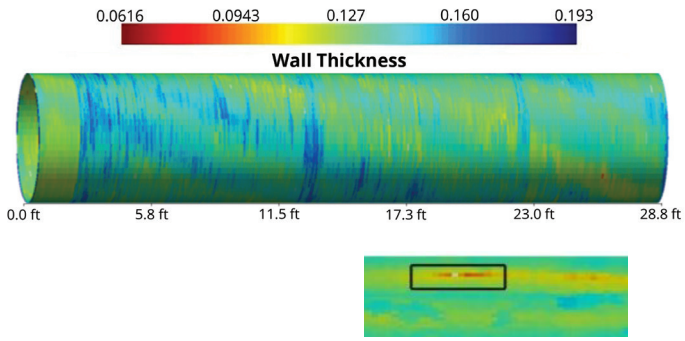

Figure 5. Tube thickness plot showing localised wall loss.

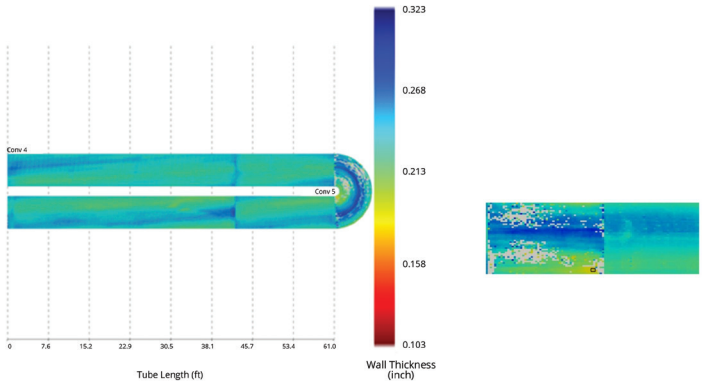

Figure 6. 2D thickness plot showing localised wall loss in return bend.

Inspection and assessment results

The high-resolution inspection revealed internal and external localised wall loss upwards of 40% in numerous pipes (Figure 5). General internal wall loss up to 26% was also present in the 180° return bends. The result of the engineering screening assessment showed that the coils were fit for service for the next four-year operating period. A remaining life assessment was also performed on each coil as part of the screening assessment, showing an estimated remaining life of 15 years with a recommendation to re-inspect in four years to monitor corrosion rates and detect any other localised damage that may affect coil integrity.

Fertilizer plants

The same techniques discussed in the case study have been successfully applied on steam reformer coils located in fertilizer plants. For one plant, smart pigging inspections on flue gas cooler coils are conducted on an almost annual basis to monitor and troubleshoot localised areas of internal wall loss experiencing high rates of corrosion. This is in response to a tube failure several years ago. The root cause of the corrosion damage from metallurgical testing was departure from nucleate boiling caused by intermittent loss or reduced water flow. Periodic inspection monitoring will most likely occur for the foreseeable future in order to validate or confirm the effectiveness of the corrective actions.

In another instance, unexpected internal wall loss was found on the inside radius of 1D return bends in a feed gas coil (Figure 6). Although the straight pipes were in good condition with minimal wall loss, moderate thinning upwards of 32% wall loss was found in the return bends. This discovery prompted an investigation and root cause analysis.

Conclusion

Periodic in-line inspection and mechanical cleaning are a sensible strategy for managing the long-term reliability and performance of steam reformer convection sections. The benefits realised by performing an advanced mechanical cleaning and smart pigging inspection are numerous. Utilising custom engineered header delivery systems on assets that were previously deemed as un-inspectable with smart pigging technology opens up the opportunity for a cleaning and a comprehensive assessment of the coils' conditions.

As seen in the first case study, the advanced mechanical cleaning of the natural gas preheater coils revealed significant fouling and flow restrictions that were previously unknown. As a result of the cleaning, the heat transfer efficiency increased over 60% and the product rate increased significantly as well, enabling the plant to produce an additional US$1 million of methanol a year.

The smart pigging inspection technology provided valuable insights on the actual condition of the coils, and the fitness-for-service screening assessment provided assurances that the coils could be safely operated for the next operating period.

The three services, combined with a purpose-built header delivery system, provides plants with a highly effective approach to optimising the performance and reliability of its steam reformer, minimising downtime and maximising production and profitability. WF