Cokebusters

CASE STUDY

External high temperature oxidation

in a vacuum distillation furnace

Merlin INSPECTION TECHNOLOGY

BACKGROUND

Cokebusters Ltd was contracted by a client to carry out a Merlin™ in-line inspection of an 8-Pass Vacuum Distillation Furnace as part of their scheduled maintenance turnaround in 2014. The inspection was carried out using the patented Merlin™ Intelligent Pigging system for accurate geometric assessment of both convection and radiant coils in eight separate passes, each containing 4 different nominal tube sizes: 4, 6 and 8-inch. The single bodied, neutrally buoyant design allowed the intelligent pig to travel easily up to and from concentric reducers within each path, effectively carrying out two inspection runs in one operating procedure. This superior maneuverability is a distinct advantage of the Merlin design over other intelligent pigging systems.

MERLIN MARK IV INSPECTION SYSTEM

The **Merlin Mark IV Smartpig** is a carbon fibre, single bodied un-tethered device, which employs a series of ultrasonic transducers to measure tube wall thickness and internal radius at equally spaced circumferential locations along the full length of the heater coil, effectively scanning the process tubes for geometric abnormalities or defects. The smartpig records and stores the received data to its on-board memory, which is later uploaded via USB to a computer. The data is then automatically interpreted and analyzed by the Merlin™ software, which can then output various graphical images and C-scans of the process tubes.

The Smartpig itself is constructed from a neutrally buoyant, moulded carbon fibre body, the interior of which contains the electronic circuitry, and lithium-ion battery back. The microprocessor manages the operation of the whole device, including data acquisition, sorting and storage. The battery pack is capable of achieving a run time of up to 8-hours before a recharge is necessary.

The scanner unit employs a series of custom built piezo-composite transducers, each constantly firing and receiving a complexity of rapid-fire ultrasonic pulses. The moulded body is encased in a separate Carbon Fibre/HDPE/Kevlar framework for protection and propulsion through the furnace tubes. This complete unit is able to be driven bi-directionally through tight radius tube coils under water pressure supplied by the same pumping unit as used for mechanical decoking.

Figure 1: Merlin Mark IV SmartPig

INSPECTION RESULTS

A similar pattern of wall loss was observed in all 8 of the radiant 4-inch sections of tubing, with Pass G containing the most severe damage. This wall loss was particularly pronounced within the tubes located at the middle areas of each coil (Tubes 11 to 21, Figure 2). Correlation with the internal radius measurements obtained from the intelligent pig confirmed that the wall loss was predominantly external. After consultation with the Cokebusters mechanical decoking Technicians, it was verified that these particular radiant areas also showed the highest level of internal coke contamination. Figure 3 shows a cross-sectional tube image taken from one of the affected areas. The data table below the image clearly identifies the extent and orientation of the wall loss at this particular axial location. Figure 4 displays the 3D wall thickness C-scan obtained from Pass G.

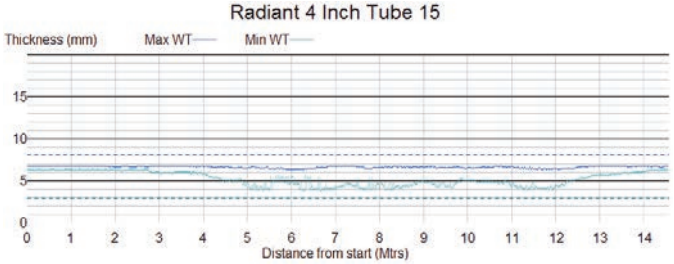


Figure 2: Graphical plots showing the correlation of internal diameter and wall thickness within a heat-affected tube.

DAMAGE MECHANISM

Following consultation with Refinery Engineers, it was hypothesized that the damage mechanism was due to localized flame impingement, which was ultimately caused by burner misalignment. The elevated skin temperatures within these areas accelerated internal coke build-up at the heat-affected zones, which was confirmed by the Cokebusters mechanical decoking Technicians. The insulating coke layers further increased the skin temperatures, which ultimately led to severe external oxidation.

Figure 4: 3D Wall Thickness C-Scan

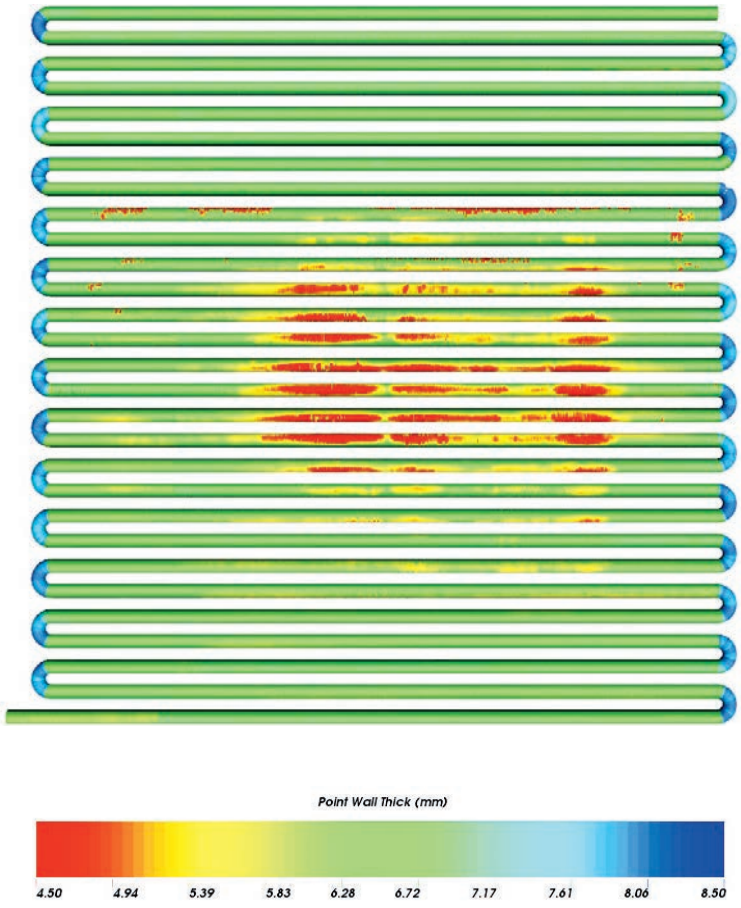
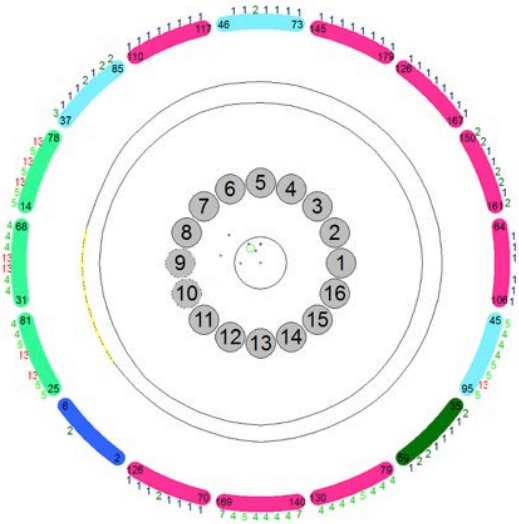


Figure 3: Cross-sectional tube image obtained from an area of external wall thinning



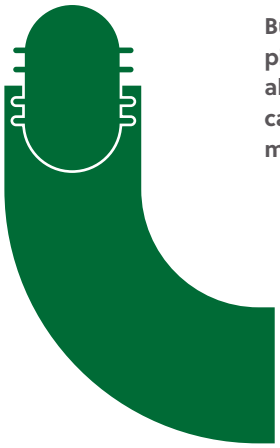
Radiant 4 Inch Tube 14
Length 14.54 Dia 102.3 (+5.7 -2.0) Wall 6.0 (+2.0 -1.5) Pos 8.56 mtrs

Tx	IR	WT	Good	Tx	IR	WT	Good	ID
1	50.7	6.2	8,8,8,8	9	50.6	3.3	8,5,8,0	101.3
2	50.5	6.4	8,8,8,8	10	50.3	3.4	8,5,8,0	100.8
3	50.3	6.5	8,8,8,8	11	51.0	4.6	8,1,8,1	101.3
4	50.4	6.4	8,8,8,8	12	50.6	5.0	8,8,8,8	101.0
5	50.5	6.6	8,8,8,8	13	50.9	5.3	8,6,8,6	101.3
6	51.0	6.5	8,8,8,8	14	50.4	5.5	8,8,8,8	101.3
7	50.7	6.0	8,8,8,8	15	50.6	5.8	8,8,8,8	101.3
8	50.5	4.8	8,4,8,4	16	50.5	6.1	8,7,8,7	101.0
				Av		5.5		101.2

CONCLUSIONS

Following the Inspection, the tubes that were identified as damaged and below the calculated corrosion allowance were removed upon Cokebusters advice. All defect quantification and location was confirmed by the client using manual UT methods.

Burner alignment was reviewed and adjusted accordingly. Regular mechanical decoking and intelligent pigging operations were also recommended to eliminate the potential for similar future damage. It was also suggested by the client that no other commercially available intelligent pigging system has the capability of navigating plugged headers with similar geometry to those found within these radiant coils, making the Merlin inspection system a unique intelligent pigging service.



Cokebusters

Cokebusters
The Armoury Building,
Hawarden Aviation Park,
Flint Road, Chester CH4 0GZ

01244 531 765
info@cokebusters.com
cokebusters.com

Merlin
INSPECTION TECHNOLOGY