

Background

Cokebusters was contracted by a client to carry out an in-line inspection of an 8-Pass Vacuum Distillation Furnace as part of their scheduled maintenance turnaround.

The inspection was carried out using the patented 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 manoeuvrability is a distinct advantage of the Cokebusters design over other intelligent pigging systems. Moreover, the furnace contained a series of plugged headers (mule ears) located down one side of each radiant pass, within the 4-inch tubing. The pig was able to navigate every plugged header successfully.

Cokebusters Smart Pig

The Cokebusters' Mark IV Smart Pig is a single bodied un-tethered device, which employs a series of ultrasonic transducers to measure wall thickness and internal radius, circumferentially, along the full length of the heater coil, effectively scanning the process tubes for geometric abnormalities or defects.

The Smart Pig records and stores the received data to its on-board memory, which is later uploaded, via USB, for analysis and post processing.

Reporting formats include tabulated data, graphical plots and a customizable 3D reader version of the entire heater coil (C-scan).

Figure 1 – Example Cokebusters' Smart Pigs



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.

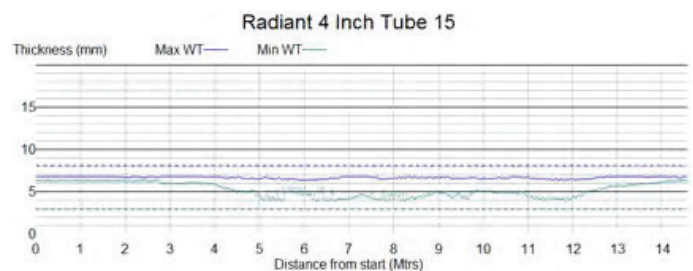
This wall loss was particularly pronounced within the tubes located at the middle areas of each coil (Tubes 11 to 21, Figure 2).

Correlation with the internal radius measurements obtained from the smart 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.

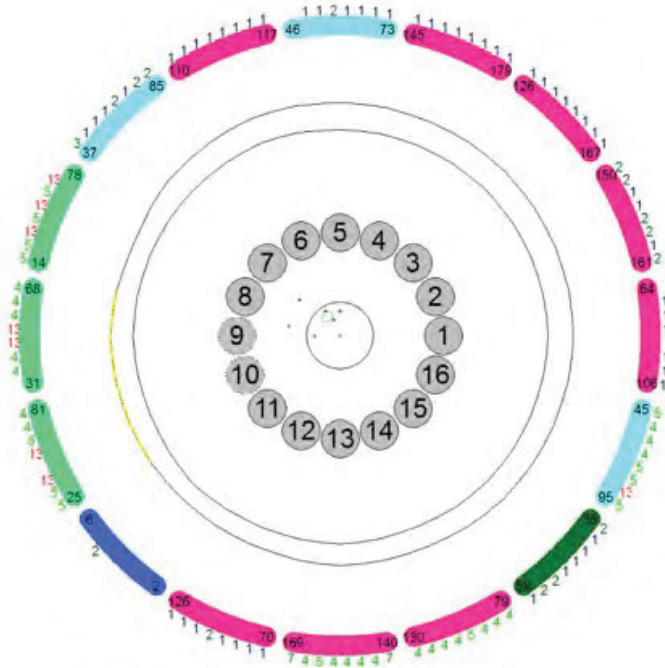


Damage Mechanism

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.

The insulating coke layers further increased the skin temperatures, which ultimately led to severe external oxidation.

Figure 3 - Pass 2 Wall Thickness C-Scan



Radiant 4 Inch Tube 14

Length: 14.54 Dia.: 102.3 (+507-2.0)

Wall: 6.0 (=2.0-1.5) Pos.: 8.56mtrs

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 smart 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 smart pigging system has the capability of navigating plugged headers with similar geometry to those found within these radiant coils, making the Cokebusters inspection system a unique inspection pigging service.

Figure 4 - Wall Thickness 3D C-Scan showing External Wall Loss in Radiant Coil 2

