

Caustic Gouging

Background

Cokebusters Ltd was contracted by a client to carry out a Merlin™ in-line inspection of a ten-line Heat Recovery Steam Generator as part of their scheduled maintenance turnaround in 2015. The inspection was carried out using the patented Merlin™ Intelligent Pigging system for accurate geometric assessment of both the evaporator and economizer coils in ten separate lines, containing two different nominal tube sizes: 3 and 4-inch. The single bodied, neutrally buoyant design allowed the smart pig to travel easily from inlet to outlet and back again, effectively carrying out two inspection runs in one operating procedure. This superior manoeuvrability is a distinct advantage of the Merlin design over other smart pigging systems. Furthermore, the furnace contained a number of short radius bends which the pig was able to navigate successfully.

Merlin Inspection System

The **Merlin™ Mark IV Smartpig** is a polycarbonate, 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 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 to a computer. The data is then automatically interpreted and analysed by the Merlin™ software, which can then output various graphical images and C-scans of the process tubes.

The smart pig itself is constructed from a neutrally buoyant polycarbonate, the interior of which contains the electronic circuitry, and lithium-ion battery pack. 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 HDPE framework for protection and propulsion through the tubes during inspection. 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/descaling.



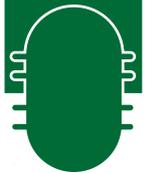
Figure 1: Merlin Mark IV Smartpig

Bend Coverage

During a meeting with the client in August 2015, it was requested that an attempt be made to improve measurement accuracy and return bend data coverage. To achieve an increase in measurement accuracy, a complete calibration process review was carried out, resulting in significant improvements in wall thickness and internal radius measurement accuracy. Moreover, a new prototype alignment brush was designed and developed in an attempt to improve bend data coverage. Having used this new design concept during this inspection, bend coverage was increased to >70% in the 4-inch return bends.

Inspection Results

Six areas of possible localized internal wall loss were observed in the Evaporator 2&3 tubes in lines 3, 6, 7, 9 and 10. The possible wall loss was identified by an increase in internal radius measurement from the surrounding mean values. Unfortunately, it was not possible to obtain wall thickness measurements at these points. This is likely to be due to an irregular interior surface topology resulting in ultrasonic scatter or deflection at the areas of internal loss/corrosion. The increase in internal diameter was clearly visible in the graphical plots (**Figure 2**) and 3D C-scans which accompany our report (**Figure 3**).



CASE STUDY CAUSTIC GOUGING

EVAPORATOR 2&3 TUBE 10

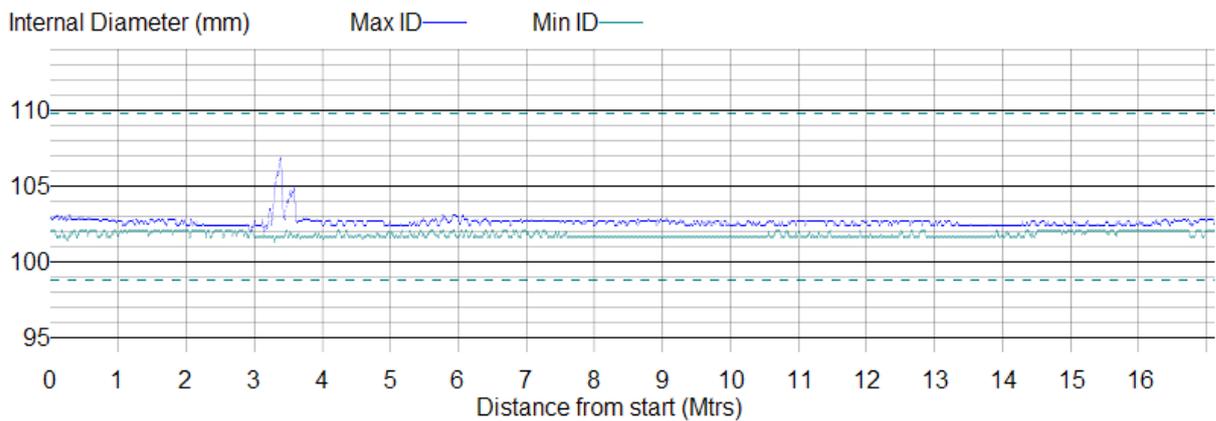


Figure 2: Graphical plot showing internal diameter increase in Evaporator 2/3 Tube 10

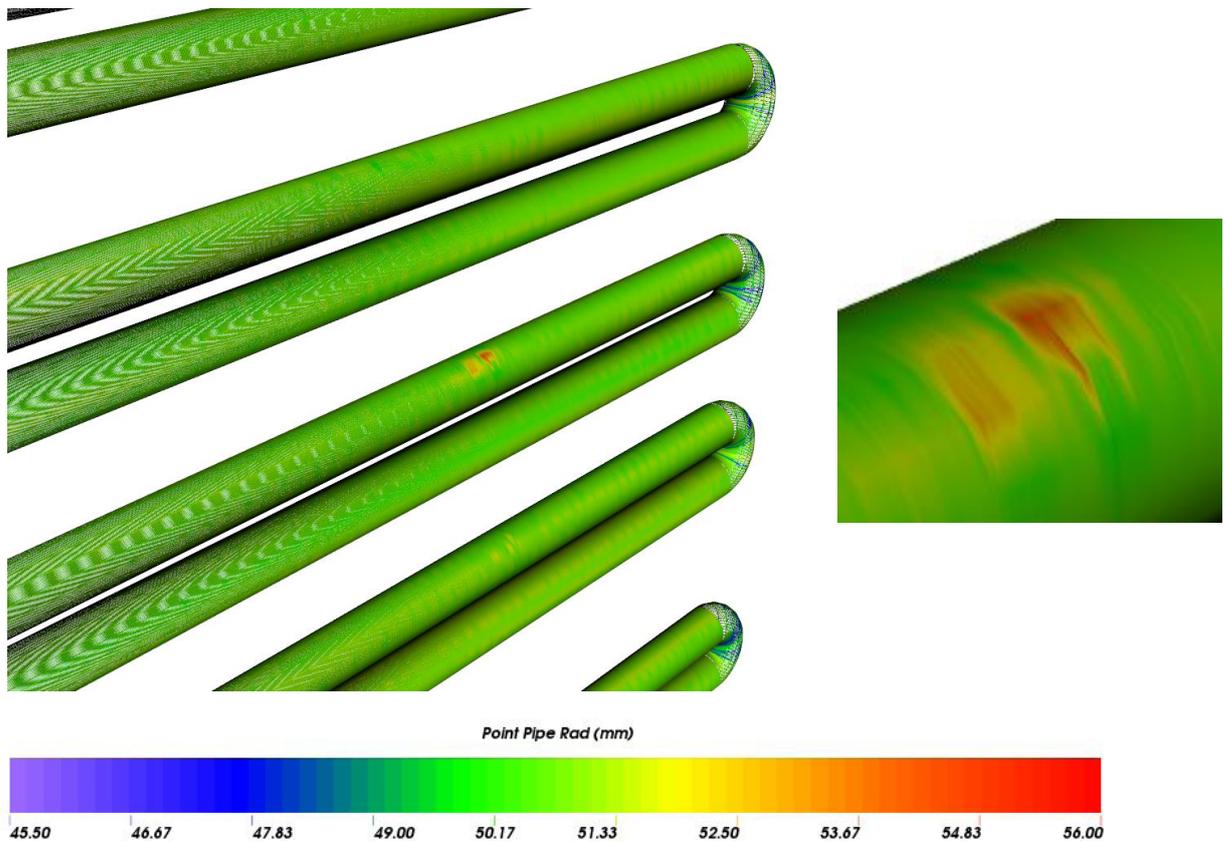


Figure 3: Internal diameter 3D C-Scan

Conclusion

Following the Inspection, the tubes that were identified as damaged were removed upon Cokebusters advice. It was recommended by Cokebusters that a metallurgic tube sample was obtained from the affected areas to carry out a full EDX/XRD analysis. The presence of metallic copper, iron hydroxide, magnetite and metal oxide scale would confirm that caustic attack is the mechanism responsible. All defect quantification and location were confirmed by the client using manual UT methods.

Caustic attack is a major concern for HRSG processes, but is avoidable if preventative measures are taken. It's essential corrosion deposition is minimized by applying a suitable chemical treatment and monitoring arrangement within the feedwater supply system. The prevention of excessive sodium hydroxide concentrations within the feedwater system can be carried out using adequate boiler water treatment and accurate monitoring of the water supply. Regular descaling and smartpigging operations are also recommended for total preventative maintenance.