Baseline Inspections

A CASE STUDY

It is well documented that fired heaters are a critical component of any oil refinery. Mechanical failure of process tubing contained within fired heaters can have catastrophic safety, environmental and financial effects. Historically, failure risk has been minimized by implementing various NDT management systems, however in more recent years, small bore smartpigging techniques have transformed the way in which this risk is managed. Smartpigging inspections during scheduled turnaround periods can allow any general or localized tube anomalies to be accurately located and quantified, allowing further fitness for service assessments to be carried out. Furthermore, by combining a 'baseline' smartpigging inspection prior to the heater entering commercial operation and regular smartpigging inspections at the end of each operating period, an accurate corrosion rate can be calculated. Determination of accurate corrosion rates will allow for more precise remaining life assessments of the process tubes.

Background

Cokeusters USA were contracted by a client to carry out a **Merlin™ in-line inspection** on the radiant section of an Atmospheric crude heater as part of their scheduled maintenance turnaround in 2018. The coils that were to be inspected were newly commissioned, and had not yet entered commercial operation. Upon manufacture, seamless tubes are susceptible to various manufacturing tolerances, which can result in deviations from the specified nominal tube dimensions. To obtain a complete evaluation of tube geometry, a complete inspection of all process tubes using the **Merlin smartpig** was requested by the client.

Merlin 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 scanner unit employs a series of custom built piezo-composite transducers, each constantly firing and receiving a complexity of rapid-fire ultrasonic pulses.

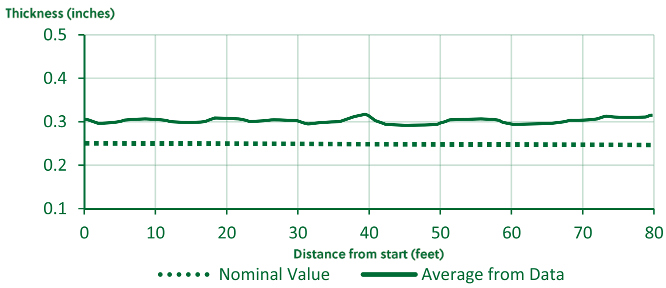
SMART PIG SPECIFICATION

Tube Diameter Range (Internal)	**2.6"-12"**
Wall Thickness static accuracy	**0.012"**
ID accuracy	**±0.75% (full scale)**
Axial location accuracy	**2.4" (typical)**
Spatial Resolution	**0.3"x 0.5" (typical)**
Data sampling rate	**60Hz**
Measurements per sample	**128 (3-5")** **256 (6-12")**
Transducer center frequency	**5MHz**
Battery life before charge	**8 hours**
Running speed	**1.0-3.0fps**

Inspection Results

Multiple inspection runs were carried out using the **Merlin™ smartpig** in order to confirm and validate data. Over two hundred and thirty thousand individual wall thickness measurements were recorded in each tube. From the as-obtained data it was clear that the average wall thickness for each tube was significantly higher than the specified nominal values for the replacement tubes. The specification sheet for these tubes gave dimensions of 4.5"O.D x 0.25"M.W. Inspection data showed that the average wall thickness across all of the tubes was 0.305". This represents an increase of 18%.

AVERAGE WALL THICKNESS OF RADIANT TUBE 1



Effects on assessing deterioration rates

The graphs (right) demonstrate the effect that carrying out a baseline inspection can have when it comes to assessing the condition of the furnace coils within the heater. **Graph 1** shows the average wall thickness for the coil from three separate smartpig inspections carried out over ten years. **Graph 2** demonstrates the same results, except the average wall thickness value obtained from the baseline inspection has been replaced with the specified nominal thickness for the coil.

As the 'best fit' lines show, this can have a dramatic effect on corrosion rates. **Graph 2** shows a corrosion rate of 0.004" per year. In **Graph 1**, with the benefit of the baseline inspection, a corrosion rate of 0.011' per year has been calculated.

Graph 3 demonstrates the effect this can have on corrosion rates forecasted over 20 years.

WHAT DO THESE RESULTS TELL US?

In **Graph 2**, where the first smart pig inspection was carried out after 5 years of the new coil being in service, the assumption could be made that the coil had not deteriorated from its original condition. It is only by having the benefit of a baseline inspection it can be seen that, during those five years, the condition of the coil had deteriorated from an average thickness of 0.305", to 0.25". This represents a wall loss of 0.055", or 18%.

Equipped with only the data from the 5 year inspection, it is plausible that the decision could have been taken to not carry out another smartpig inspection after ten years, and instead plan to perform one after fifteen, or even twenty, years. As **Graph 3** illustrates, had the coil continued to deteriorate at the rate it had over the first five years of it being in service, by year twenty, wall thickness would have been as low as 0.08". Consequently, the decision to delay further smart pigging inspections could have had catastrophic results.

Conclusions

It is clear that there are many benefits to carrying out a baseline inspection prior to coils being entered into commercial service. In addition to identifying any issues before coils are put into service, an initial smartpig inspection will remove the uncertainty caused by mill tolerances during the manufacturing process, and equip engineers with the data required to confidently make decisions on maintenance, repair and inspection activities.

GRAPH 1

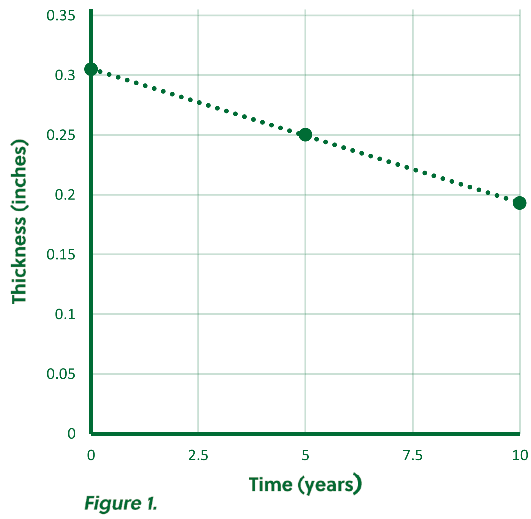


Figure 1.

GRAPH 2

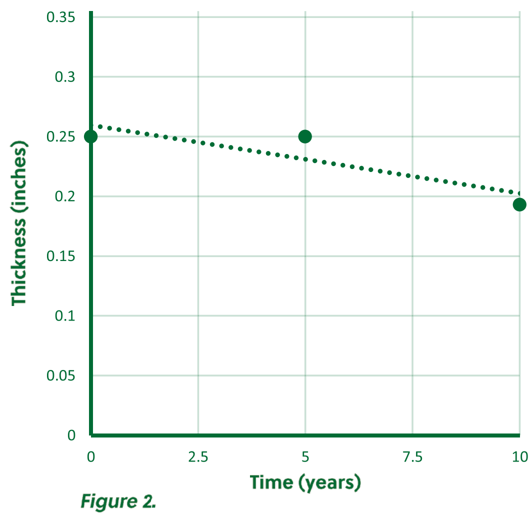


Figure 2.

GRAPH 3

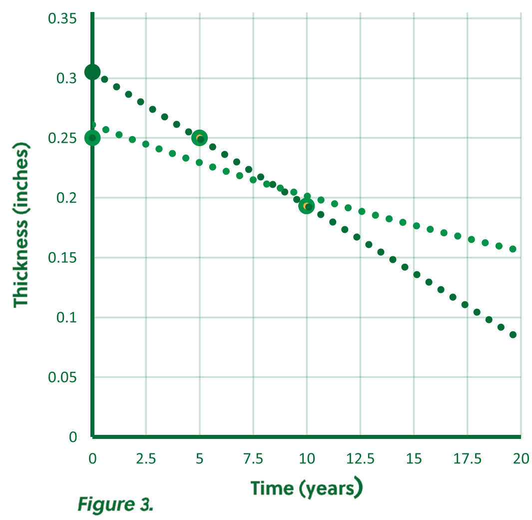


Figure 3.

Cokebusters

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Merlin INSPECTION TECHNOLOGY