Cokebusters

Case Study: Baseline Inspection

Background

It is well documented that fired heaters are a critical component in refining. Mechanical failure of process tubing contained within fired heaters can have catastrophic safety, environmental and financial effects.

Historically, failure risk has been minimized by deploying various NDT techniques. However, in more recent years, small bore Smart Pigs have transformed the way in which this risk is managed.

Smart pigging during scheduled turnaround periods can allow general or localised tube anomalies to be accurately located and quantified, allowing for further integrity assessments to be carried out.

By combining a 'baseline' Smart Pig inspection of the process tubes prior to the heater entering commercial operation with further periodic inspections, an accurate corrosion rate can be calculated. Determination of such rates will allow for more precise remaining life assessments.

Challenge

Cokebusters were engaged to carry out inspection on the radiant section of an atmospheric crude heater, in Texas, as part of a refinery scheduled maintenance turnaround in 2018.

The coils that were to be inspected were newly commissioned and had not yet entered operation. Seamless tubes are known to be 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 Cokebusters' Smart Pig was requested.

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.

Figure 1 – Example Cokebusters' Smart Pigs

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.

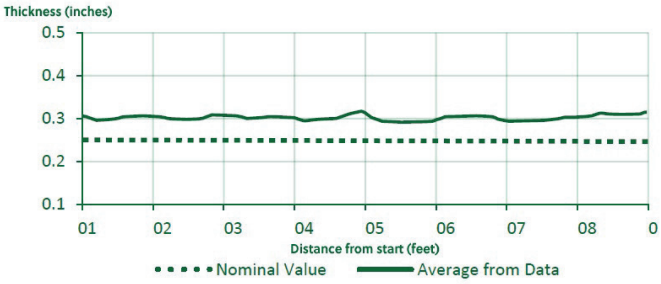
Reporting formats include tabulated data, graphical plots and a customizable 3D reader version of the entire heater coil (C-scan).

Inspection Results

Multiple inspection runs were carried out using the Smart Pig in order to confirm and validate data. Over 230,000 individual wall thickness measurements were recorded in each tube.

From the data it was clear that the average wall thickness for each tube was in fact significantly higher than the specified nominal values for the replacement tubes.

Graph 1 – Average Wall Thickness of Radiant Tube 1



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 represented an increase of some 18%.

Effects on assessment deterioration rates

The graphical plots 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 2 shows the average wall thickness for the coil from three separate Smart Pig inspections carried out over ten years.

Graph 3 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 at T=0. As the 'best fit' lines show, this can have a dramatic effect on corrosion rates. Graph 3 shows a corrosion rate of 0.004" per year. In Graph 2, with the benefit of the baseline inspection, a corrosion rate of 0.011" per year has been calculated.

Graph 4 demonstrates the effect this can have on corrosion rates forecasted over 20 years.

What do these results tell us?

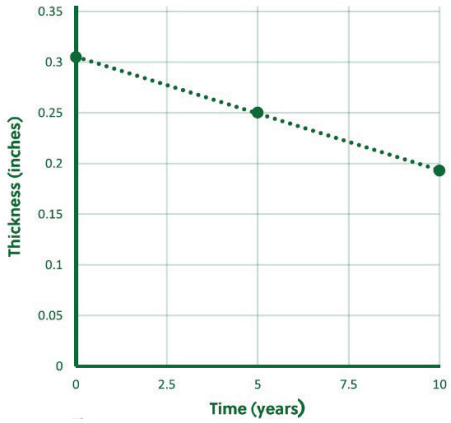
In Graph 3, where the first Smart Pig inspection was carried out after 5 years of the new coil being in service, the assumption could be made that the coil had not deteriorated from its original condition.

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%.

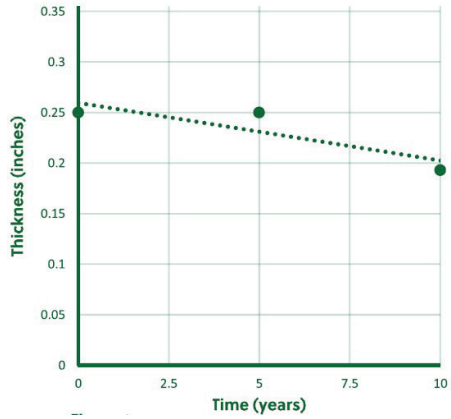
Equipped with only the data from the 5 year inspection, it is plausible that the decision could have been taken to not carry out another Smart Pig inspection after ten years, and instead plan to perform one after fifteen, or even twenty, years.

As Graph 4 illustrates, had the coil continued to deteriorate at the rate it had over the first five years of it being in service, by Year 20, wall thickness would have been as low as 0.08". Consequently, the decision to delay further Smart Pig inspections could have had catastrophic results.

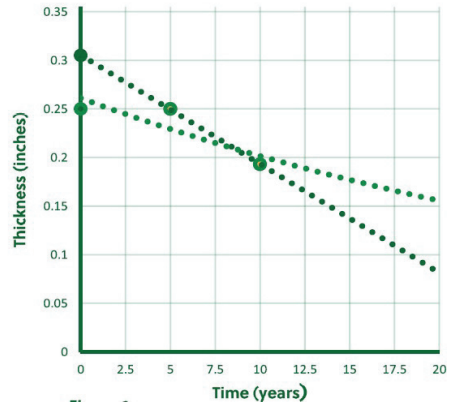
Graph 2



Graph 3



Graph 4



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 Smart Pig inspection will remove the uncertainty caused by mill tolerances during the manufacturing process and so equip engineers with the data required to confidently make decisions on maintenance, repair and inspection activities.

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