Question 7: How do you monitor and protect the heater tubes from overheating in high temperature services such as catalytic reformer heaters? How is the tube wall temperature monitored?

GAYL MERCADO (Axens North America)

As a first step and low investment solution, refiners will perform a visual check on the color of tubes to check for color differences or perform a thermal scan of the tubes. These solutions are not very accurate due to iron scale formation and ceramic coating on the tubes. However, a simple visual check of tube color or thermal scan can offer refiners a baseline or trend for monitoring heater tube temps.

Tube skin thermocouples can also be installed either during design or a turnaround. On reformer heaters, tube skin thermocouples are not standard during design due to the large number of thermocouples that would be required for proper measurement. Additionally, these tube skin temperatures may not be very reliable due to the thermocouples being burned out and/or the formation of coke on the probe.

More advanced tools with everyday capabilities are becoming more prevalent in the industry and will move the safety and reliability of the fired heaters to improved levels. Using data transfer and gathering improvements, software systems are beginning to replace the historical approaches that the industry has been using for some time. Axens' Connect'InTM digital tool, which allows users to remotely monitor and analyze catalyst and unit performance, also allow engineers and operators to track key performance indicators on the heaters and detect possible issues concerning the equipment. The Connect'InTM software architecture allows users to automatically schedule data gathering, validate the data and calculate the heater yield and efficiency. Within a single tool, users can analyze data trends, calculate tube remaining life, track instrumentation problems and help diagnose issues.

Axens recommends the below maintenance approaches to minimize tubes from overheating:

- Proper maintenance of heater burners to ensure normal flame patterns will help to protect heater tubes from overheating. If overheating is suspected, some burners can be turned off or on depending on the tube-skin temperature patterns
- Reduction of the heat load on the limited heater which will then shift the required heat load on the other heaters that are not limited in heater tube temperature. However, this will result in non-flat temperature profile
- Reducing excess oxygen can help to lower and protect the heater tubes from overheating

CHRISTIAN ARNOUX (Valero)

The opinions expressed are those of the author and do not necessarily represent the views of Valero Energy Corp.

- IR scans are commonly used to monitor tube skin temperature
- Rust and scale on the tubes elevates the tube skin temperature using an IR scan
- Ceramic coating tubes during T/A may reduce the rust and scale on tubes
- Be aware of concentrated corrosion/erosion at tube weld attachments
- Either licensor can calculate the tube skin temperature from process data

STEVE PHILOON (UOP)

UOP recommends the use of a calculation to estimate the temperature of the tube metal in the heaters of a naphtha reforming unit. The method described in the API Standard 530 “Calculation of Heater-tube Thickness in Petroleum Refineries” or similar can be used.

UOP’s experience is that knife edge skin thermocouples can be useful as indicators of trends and step changes but are not reliably accurate indicators of the actual tube metal temperature. Radiant heat from the flames can cause readings that are higher than the actual tube temperatures. Shielded type skin thermocouples can provide a good indication of the tube metal temperature but the installation of the shield may create a hot spot on the tube that result in metal loss due to carburization.

Infrared pyrometers provide an indication that is higher than the actual temperature of the metal of the tube because they are reading the temperature of the scale on the outside of the tube. When the tubes are clean the indication will be accurate. This will be the case immediately after the start-up of a new unit or the restart after tube cleaning or tube replacement or if the tubes are ceramic coated. These clean-tube readings provide field verification of the temperatures estimated by the calculation method. The increasing indication from the infrared readings, over-time in an operating unit when compared to the tube metal temperature estimated using a calculation method provides direct indication of the fouling on the tubes.

RICHARD TODD (Norton Engineering)

While tube metal temperature thermocouples can provide indication of TMT trends over time their long

term reliability is always problematic. Therefore, it is imperative that owners/operators of reforming heaters obtain routine IR pyrometer readings of tube temperatures as a back-up to the installed TMT instruments. Even at the start of a run, IR scan data is necessary to establish a baseline for future

comparisons.

An IR scan of tubes in any heater does not provide highly accurate readings for a myriad of reasons, some controllable and some not. It is therefore important that the owner understand and control those variables which can be controlled. Chief among the controllable variables is the equipment being used to conduct the IR scan, the operator of that equipment and the target points for the scan. The ideal situation for collection of TMT data by IR scan would be a single individual conducting all scans with the same equipment shooting the same points on the heater tubes. While this is never totally practical, many

operators have been successful in monitoring operating reformer heaters by controlling these parameters

as closely as possible.

Several methods have been used to check the absolute accuracy of IR TMT measurements, all with varying degrees of success. The first method uses a target tube (partial tube without cooling) fitted with an internal shielded thermocouple. This method provides a similar tube surface to an operating tube and a highly accurate tube temperature measurement. The drawback is that this tube will operate at significantly higher temperatures than the operating tube, so the check temperature is typically 200 to 300°F higher than the actual operating tube temperatures. Another method is to check the tube surface temperature on the front face using a preformed hoop contact thermocouple which can be inserted into the firebox through a peep door and “hooked” around a tube to measure the front surface temperature at or very near an IR target point.

As an alternative to routine IR scanning, there are several vendors who can provide firebox cameras capable of continuous TMT monitoring capabilities. These cameras are not in widespread use, but they can provide invaluable operating trends for units which are being pushed to their limits.

Tags

Catalytic Reforming

Reliability

Start-up

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