The CONTACTOR™

Published Monthly by Optimized Gas Treating, Inc.
Volume 12, Issue 3, March, 2018

Introduction to Temperature Measurement of the Claus Thermal Reactor[†]

Measurement of the temperature of a Claus Thermal Reactor is considered to be one of the most challenging. It has historically been considered unreliable, expensive and often requiring costly periodic maintenance. Claus service involves extremely high temperature, thermal shock, corrosion, condensation, vibration, shifting refractory, quenching, process upsets, sulfur buildup and changes in the gas composition, all of which make this measurement an extremely difficult one.

In a Claus reactor, higher temperatures allow more efficient operation and increased capacity. Many plants utilize supplemental oxygen in order to further raise operating temperatures and to increase process capacity. Excessive temperature, however, can cause failure of the refractory materials. Therefore, it is essential that the refractory temperature be closely monitored.

Generally, there are two technologies available to make this temperature measurement, the Thermocouple and the Infrared Pyrometer. Each has its own set of advantages and vulnerabilities.

Thermocouples

Thermocouples used for measuring thermal reactor temperature are specifically designed for this service. Purged thermocouples with ceramic thermowells are the only types that have proved to have an effective service life. Due to the severe operating conditions inside the thermal reactor (high temperature, corrosive environment), thermocouples with metal thermowells are not suitable. The thermocouple must be purged to sweep away reaction gases that can slowly diffuse through ceramic thermowells and contaminate the thermocouple elements.

Due to the specialized design and material, they are subject to damage from severe upset conditions, mishandling, and improper installation.

Thermocouple Types

Type B thermocouples have a maximum temperature of 1,820°C (3,300°F), but cannot reliably read below 100°C (212 °F), limiting their usefulness in reactor start-up. Type R or Type S thermocouples have a maximum temperature of 1,768°C (3,214°F) and can read down to typical ambient temperatures making them usable for most thermal reactor operations.

Thermocouple Placement

The length of the thermowell is typically specified to position the tip of the thermocouple measuring element flush with the hot face of the refractory when the thermal reactor is at operating temperature.

Thermocouples should ideally be installed on the top centerline of the vessel to facilitate installation and minimize the risk of breakage from shifting refractory during operation. Nozzles operating below the freezing point of sulfur will tend to fill up with solidified sulfur, which could press against the ceramic thermowell and break it. Thus, short nozzles (i.e., 5 to 6-inch projection) are preferable to long nozzles to keep them hot enough to prevent sulfur from solidifying and to minimize corrosion.

Thermowells should not be installed where flame can directly impinge on them. The optimum location is best determined by CFD modeling of the reactor. Lacking that, for a typical two-zone thermal reactor, it is common to place one thermocouple two-thirds to three-fourths of the way into Zone 1 and another thermocouple two-thirds to three-fourths of the way into Zone 2.

Thermocouple Purging

Thermocouples and thermowells in Claus reactors require purging to remove reaction gas contaminants that diffuse through the ceramic thermowell and which would otherwise corrode the thermocouple wires. Nitrogen purge is preferred to air, because the oxygen in air slowly erodes the thermocouple, reducing its life. The purge supply should be clean, dry and with no entrained oil or water. Any contaminants in the purge gas tend to break down inside the thermowell, building up residue that plugs the thermocouple passages or possible ignite internally.

Figure 1 shows the preferred arrangement which places a pressure regulator upstream from the thermocouple and the purge flow controller downstream of the thermocouple

---

[†] This issue pf The Contactor was written by Steve Croom of Delta Controls Corp., Shreveport, Louisiana, +1 (318) 424-8471 x106

so as to maintain a slight positive pressure inside the thermowell. The typical purge flow rate of 11 liters per hour is sufficient to protect the thermocouple without significantly cooling it.

Because the purge gas supply may occasionally be interrupted and not re-established, periodic inspections should be conducted to verify that the purge system is functioning.

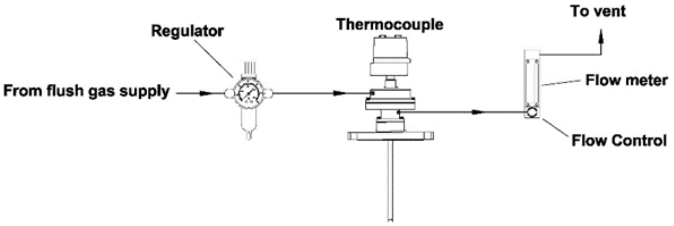

Figure 1 Thermocouple Purge Schematic

Infrared Pyrometers

Infrared pyrometers measure the infrared light radiating from the hot thermal reactor to determine the reactor temperature. They are mounted on fire-safe isolation block valves, allowing them to be serviced or replaced during normal operation. They are not easily damaged by mishandling or improper installation and will withstand severe system upsets.

Depending on the sensor technology employed, some pyrometers require frequent calibration due to sensor drift. Pyrometers are vulnerable to blockages of the sight path, usually caused by buildup of material on the window or on the nozzle wall. Single-wavelength pyrometers measure the intensity of infrared light and any blockage will result in an erroneously lower measured temperature. Dual-wavelength ratiometric pyrometers are the preferred choice which measure the "color" of the infrared light and are somewhat immune to partial sight path blockages. They can also measure the amount of blockage and trigger an alarm to alert the operator for the need for maintenance before the blockage significantly affects measurement accuracy.

Gas Temperature vs. Refractory Temperature

Some pyrometers use infrared wavelengths that pass through the reaction gases unaffected and are useful for measuring refractory surface temperature, regardless of gas conditions. Other pyrometers measure wavelengths that are emitted by the process gases and are thus sensitive to the gas temperature. While gas temperature measurement may be desirable as an early indicator of upcoming refractory temperatures or to monitor contaminant destruction, measurement accuracy can be compromised by changes in gas transparency due to changes in feed gas composition and flow rate.

Pyrometer Sight Path Protection

An unprotected sight port will become clouded with sulfur that has condensed and solidified on the interior of the window's glass surface. Some means of protection must be installed to prevent such blockage. The traditional solution has been to heavily purge the pyrometer nozzle with N_2 to prevent sulfur from entering the nozzle. While this is sometimes effective, the high flow purge will cool the base of the nozzle, promoting corrosion and buildup of sulfur. In recent years the use of specialized steam jacketed fixtures to heat the nozzle and window above the melting point of sulfur, along with a low-volume, pre-heated purge, has proven very effect at preventing any accumulation of sulfur along the sight path. Because these systems sometimes get turned off and not turned back on, routine inspections should be implemented to verify that the heating and purging systems are functioning.

* * *

To learn more about this and other aspects of gas treating and sulphur recovery, plan to attend one of our training seminars. Visit www.protreat.com/seminars for details.

ProTreat® and ***The Contactor***™ are trademarks of Optimized Gas Treating, Inc. Other trademarks are the property of their owner.