The CONTACTOR™

Published Monthly by Optimized Gas Treating, Inc.
Volume 12, Issue 7, July, 2018

Temperature Measurement Discrepancies in the Claus Thermal Reactor †

In monitoring the temperature of Claus thermal reactor refractory, it is common practice to employ both thermocouples and infrared pyrometers on the same furnace. This practice is advisable because it provides redundancy and eliminates common-cause failures. However, sometimes there is a discrepancy between the temperatures reported by the thermocouple versus the temperature reported by the pyrometer, particularly when the devices are mounted in the same area of the furnace. In these cases, four possible causes are:

1. Each instrument is reporting correctly, but the temperatures are different..
2. The thermocouple is wrong.
3. The pyrometer is wrong.
4. Both instruments are wrong.

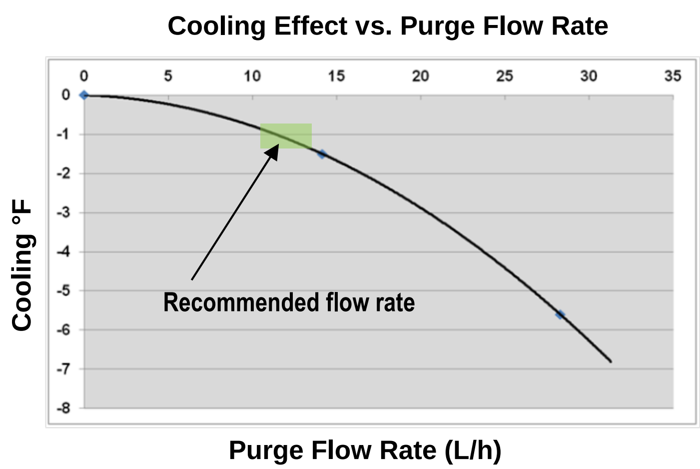

Figure 1 - Cooling Effect of Thermocouple Purge

Thermocouple Errors

Thermocouples generally do not read high. If the thermocouple is reporting a higher than expected temperature, strong consideration must be given to the possibility that expectations, rather than the thermocouple, are the issue. One reason for a high temperature reading is direct flame impingement on or near the thermowell. In this case, the thermocouple is not in error, but is reporting the high temperature to which it is exposed.

Thermocouples reading lower than expected, or lower than the actual temperature, may be caused by corrosion or contamination of the thermocouple junction(s). This is usually from failure to maintain the proper purge flow and pressure over the long term or because of mechanical breakage of the ceramic thermowell.

Thermocouples used in Claus service must be continuously purged to provide long term reliability and accuracy. But, the thermocouple can read low if this purge is significantly higher than the recommended purge rate of approximately 11 liters/hour (L/hr) as shown in Figure 1. This flow rate cools the thermocouple by only a few degrees, but cooling increases rapidly as the purge rate is increased. Excess purge cooling can easily be tested by temporarily turning off the purge flow and observing a rise in the indicated temperature. (Briefly turning off the purge will not harm the thermocouple.)

Pyrometer Errors

Sight Path Blockage

Pyrometers work by measuring the intensity of infrared light that is radiated from a hot surface. The most common problem with pyrometers has to do with material coming between the furnace and the sensor and blocking the infrared energy. Usually, errors are detected as the pyrometer slowly decreases its signal strength relative to that of the thermocouple(s). The typical cause is from a layer of sulfur accumulating on the lens or viewport glass. As this becomes more and more opaque, the IR energy reaching the sensor is attenuated, causing a lower and lower reading over time.

Another possible cause is buildup of sulfur compounds in the base of the nozzle or in the bore through the refractory, again blocking the transmission path for the IR energy. This problem is minimized and often prevented by keeping the nozzle and viewport at a temperature above the freezing point of sulfur.

† This issue of *The Contactor* was written by Ted Keys, Senior Engineer, Delta Controls Corporation, Shreveport, Louisiana, +1 (318) 424-8471. References to SulphurPro™ were added by OGT.

Use of a heated lens assembly, a pre-heated low flow lens purge and insulation on the nozzle, block valve and lens assembly can prevent buildup of these sulfur deposits. Note however, that high flow purging of the nozzle cools the nozzle and can actually encourage the deposition of sulfur in the nozzle. It can also cool the carbon steel enough for corrosion to occur in the vicinity of the purge nozzle – vessel shell joint. Therefore, contrary to historic norms, high flow nozzle purging is not recommended.

Dual-wavelength pyrometers are less susceptible to sight port blockage than single-wavelength types. By measuring the color of the light from the reactor instead of just its intensity, the effects of partial blockage can be cancelled, resulting in accurate measurements even with a significantly occluded sight port. Dual-wavelength pyrometers can also measure the amount of blockage and signal a need for maintenance before the blockage becomes large enough to affect accuracy.

Sensor Drift

In recent years, sensor drift has become less of a problem than it was in the past. Older IR designs for Claus service often experience drifting of the accuracy of the sensor / electronics, requiring frequent recalibration. Modern semiconductor sensors can go for years without recalibration.

Misalignment

Although uncommon, vibration or refractory shifting as the furnace heat rises, particularly upon initial startup, can cause a misalignment of refractory to the sight path of the IR lens, partially obscuring the 'view'. Most modern pyrometers provide for visually checking of the bore sight of the instrument to detect misalignment and occlusions.

Actual Temperature Differences

No two points in the furnace are at exactly the same temperature. Reaction gases start out at near ambient temperature at the burner and rise in temperature as they react exothermically in the front part of the furnace. Later reactions are endothermic, causing a drop in temperature towards the back end of the furnace. At the same time, heat is being lost through the furnace wall. High gas velocities, turbulence, and radiant heating tend to smooth out the temperature gradients, but temperature differences of several hundred degrees at different points along the hot-face are not uncommon. These differences can change with gas flow rate and gas composition.

Effects of Reflections

A pyrometer does not necessarily indicate the temperature of the target spot. Because of the reflectivity of the refractory, about half of the light seen by a pyrometer is radiated from the target spot. The other half of the light is reflected from other surfaces within the reactor. Since those other surfaces may be at different temperatures, the pyrometer measurement can be thought of as a weighted average of the surrounding refractory temperatures. This means that if a pyrometer were pointed directly at a thermocouple (which does provide a point temperature), the two may not read exactly the same value. This is illustrated in Figure 2.

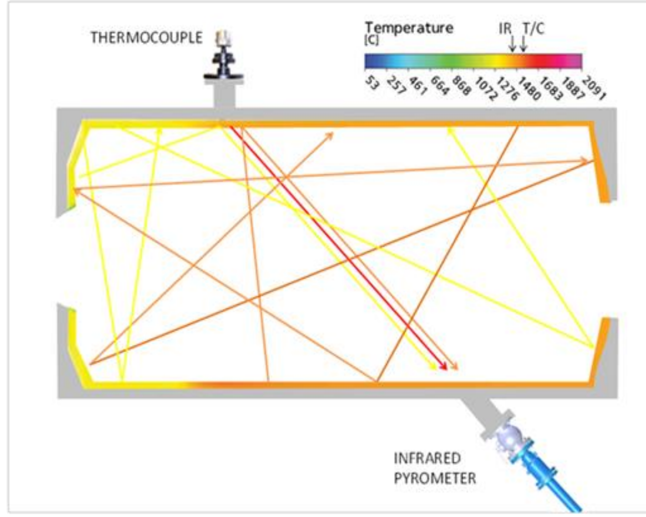

Figure 2 - Light reflection inside a furnace

When attempting to analyze temperature measurement discrepancies, comparing trend data among instruments over a few months can provide insight as to what may be the reason for the discrepancy. Diverging trend data usually indicates a worsening condition that may signify the need for maintenance or even a condition of impending failure.

The ProTreat® SulphurPro™ SRU simulator accounts for the major kinetically-limited reactions in the SRU Reaction Furnace. Some examples include BTEX and hydrocarbon destruction, COS and CS_2 formation, and ammonia destruction. Reliable predictions of furnace temperature are provided for both one and two-stage furnace configurations, and especially so for oxygen enrichment. Thermal reactor temperature is affected by each of these operating parameters in a way that is completely predictable using SulphurPro. However, model *validation* for a particular furnace depends on accurately measuring furnace temperature. This article has discussed several factors that affect the accuracy of the temperature measurement.

~·~·~·~·~·~·~·~·~·~·~·~~·~·~·~·~·~·~·~

To learn more about this and other aspects of gas treating and sulfur 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. Any other trademarks are the property of their owner.