The CONTACTOR™

Published Monthly by Optimized Gas Treating, Inc.
Volume 15, Issue 7, July, 2021

Acid Gas Fired Reheater Control: Part 2

In the first part of this two-part article, we showed how burn strategy affects the temperature achieved by the reheater just upstream of the catalytic converter in modified-Claus based Sulphur Recovery Units (SRUs). In this the second part we look at how burn strategy affects sulphur conversion and the creation of COS, most of which ends up in the effluent from the SRU and adds to the total emitted sulphur.

Common reheat methods are (1) indirect steam heat, (2) electric heaters, (3) hot oil, (4) gas/gas exchangers, and (5) direct-fired reheaters. Direct fired reheaters can, and often do, use acid gas as the fuel for combustion. An Acid Gas Fired Reheater (AGFR) heats the main process stream by mixing the hot combustion gases from the burner into the main gas flow.

AGFRs are burners, so they require a strategy to control the flow rate of air and fuel (acid gas). The heat needed to produce the desired temperature rise in the process stream sets the total amount of H_2S combustion needed in the reheater. After setting the temperature requirement (see Part 1), there is still a degree of freedom left in the control philosophy:

- Should we feed the stoichiometrically required amount of acid gas such that it is all burned?
- Should we feed an excess amount of acid gas so that the combustion products contain a 2:1 ratio of H_2S:SO_2?

Process Description

The chemistry pertaining to AGFRs is generally similar to the chemistry in the SRU's Thermal Reactor (TR), but having different process objectives. One of the primary objectives for the TR is to generate the stoichiometric amount of SO_2 that will allow the overall conversion of H_2S to elemental sulphur to proceed as far as possible through the Claus reaction (Equation 1). This objective causes the optimal H_2S:SO_2 ratio in the TR to be close to 2:1 to match Claus reaction stoichiometry. In contrast, the primary process objective in a fired reheater is simply to liberate enough heat of combustion with a stable flame to achieve the required temperature increase in the process stream.

$$2\,H_2S + SO_2 \leftrightarrow \frac{3}{2}\,S_2 + 2\,H_2O \qquad (1)$$

As per the TR flame control strategy, to maintain reliable AGFR operation, it is imperative to have a proper air control system that maintains flame stability and lands on the required temperature control setpoint. The control scheme should be programmed to allow for independent feed flow measurement on all feed streams to the AGFR Burner; including amine acid gas, and where applicable, all fuel gas streams with steam moderation cascaded to fuel gas flow. Each feed stream will have an air demand valve that can be adjusted based on composition so as to provide the total-flow target based on the cascade temperature control setpoint. Air demand requirement for each stream is then fed to a summation block to allow for ratio air control.

Case Study

To explore the process implications of reheater operation, we ran a rate-based sulphur plant simulation in SulphurPro® with varying burn strategies from 30% to 90% of stoichiometric air-to-fuel ratio. The heat release requirement for a reheater does not change very much with burn strategy. Therefore, the air supply to each reheater also does not change very much; instead, we change the amount of excess acid gas sent to the reheater beyond the amount required to consume all the oxygen.

The case study is based on the typical refinery SRU (Figure 1). The unit feed and operating conditions are given in Table 1. Two amine acid gas compositions were used: Test Run 1 with 92% H_2S and Test Run 2 with 83% H_2S. The model includes only the conversion section of the SRU. It does not include the Tail Gas Treating Unit (TGTU).

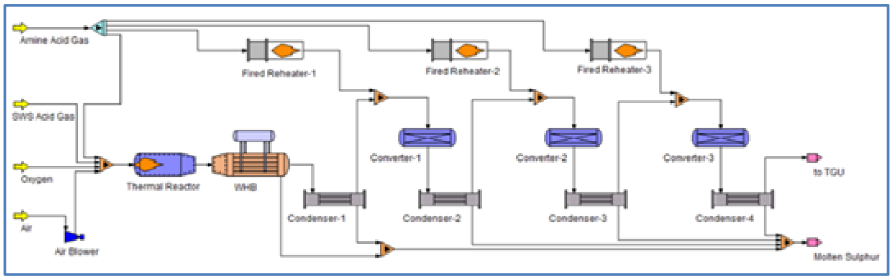

Figure 1 Flowsheet for Case Study

As already mentioned, it is difficult to know the extent of Claus conversion that will occur in a reheater because it has strong dependence on the size and configuration of the equipment. From a modelling perspective, the uncertainty is bounded by running the models in two different reaction modes to represent the two limiting cases. One allows all reactions to come to equilibrium by Gibbs energy minimization, simulating long reheater residence time. The other prevents the Claus reaction from occurring at all, representing a small reheater with a residence time of 0.1 sec or less.

Table 1 Operating Conditions for Case Study

AAG feed rate	450 lbmol/h	
AAG composition (wet basis)	Test Run 1 H_2S = 92% CO_2 = 5% CH_4= 0.5	Test Run 2 H_2S = 83% CO_2 = 14% CH_4= 0.5
SWAG feed rate	81 lbmol/h	
BTEX in SWAG	1900 ppmv	
Oxygen enrichment	29%	
1st Converter Outlet	650°F	
2nd Converter Outlet	~ 485°F*	
3rd Converter Outlet	~ 420°F*	
*Temperatures of 2nd and 3rd converters set to maintain 25°F approach to sulphur dew point		

Effect on Sulphur Recovery

Perhaps this study's the most important observation is that the reheater burn strategy can affect the overall sulphur recovery in the SRU. Figure 2 shows that changing the reheater burn strategy can lead to almost a 0.5% loss in sulphur recovery, forcing a larger work load onto the TGTU. (Recall that the TGTU has to handle *all* of the unrecovered sulphur. Dropping sulphur recovery from 97.3 to 96.9% means an increase from 2.7 to 3.1% *not* recovered, or 15% more sulphur load to the TGTU!) The cause is that unconverted and unburned acid gas passing through the reheater is fed to the 3rd sulphur converter which then has more work to do. If the reheaters are large enough to permit Claus reaction equilibrium the effect will be insignificant as the converging lines in Figures 2 and 3 show.

Effect on COS Entering TGTU

In sulphur plants, COS is an undesired by-product created when hydrocarbons are present while burning acid gas. Depending on catalyst and operating conditions, an appreciable amount of COS is destroyed in the converters. For example, in this case study, the three converters destroyed 92%, 45%, and 27% of the COS fed to them. The amount of COS sent to the TGTU is small but important because it is much harder to remove from the tail gas, so it greatly contributes to emissions.

Since burn strategy has a strong influence on reheater flame temperature, it also has a strong influence on the amount of COS generated in the reheater. Lower flame temperatures favor COS formation. This relationship is born out by Figure 3 which shows that the amount of COS going to the TGTU increases when the reheater gets more acid gas than is stoichiometrically required.

Conclusions

In a typical FR with short residence time unburned acid gas puts additional load on the following converter bed. In the last converter, this directly causes lower overall recovery across the SRU and more load on the TGTU. There is more acid gas through the burner, so the flame temperature is higher and this inhibits COS formation. Many other parameters can influence the performance of a particular unit, e.g., catalyst aging and oxygen enrichment. Exothermic traditions from S2 to S8 upon cooling can confound interpretation of plant measurements. These and other reasons make a high quality tool such as the SulphurPro simulator one of the best ways to study and understand the details of SRU operations.

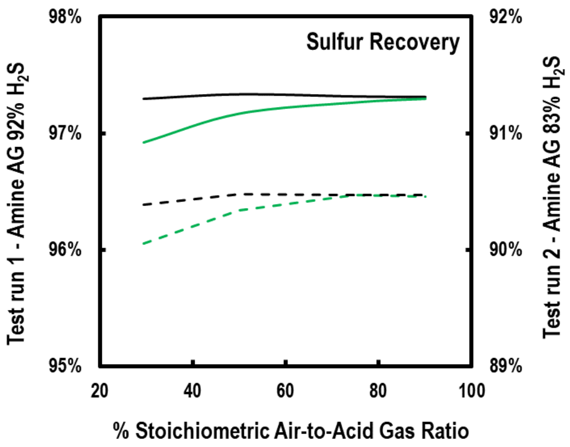

Figure 2 Sulphur recovery changes with burn strategy. Green lines represent cases with no Claus reaction. Black lines represent cases with Claus reaction proceeding to equilibrium. Solid lines represent Test Run 1 with higher H_2S concentration in Amine Acid Gas, dashed lines represent Test Run 2 with lower H_2S concentration.

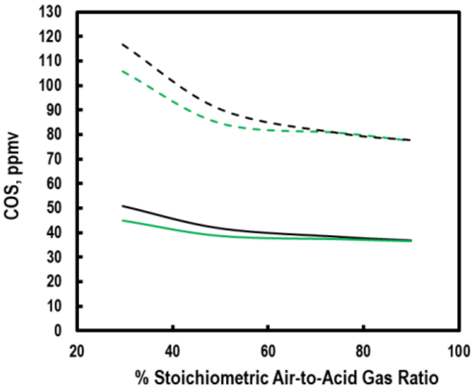

Figure 3 COS sent to TGTU depends on burn strategy. Green lines represent cases with no Claus reaction. See Figure 2 for the meaning of color coding.

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