The CONTACTOR™

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Steam Reheater Performance Under Turndown Operations

With the release of ProTreat® and SulphurPro® version 6.6 comes the introduction of rate-based steam reheaters. These new reheater blocks are able to do both sizing and rating giving you more flexibility and more accuracy when modeling your SRU. In this edition of *The Contactor™*, we'll explore how these pieces of equipment behave while under turndown operations.

There are several different options that can be used when deciding how to reheat a sulphur bearing stream coming from the upstream sulphur condenser before entering the downstream sulphur converter. These include two methods; indirect and direct reheat. Indirect reheat means that the heat source being used to heat the sulphur bearing stream does not mix with that process stream. These would include things like steam reheaters, electric reheaters and indirect fired reheaters. Direct reheat means that the heat source being used to heat the sulphur bearing stream does mix with the process stream. These include hot gas bypass, direct fired acid gas reheaters, and direct fired fuel gas reheaters. Two prior editions of The Contactor (Vol. 13 No. 3 and No. 5) go into much more detail than we will here by giving a comparison for some of the most common methods.

Steam reheat is widely used and well known. It is commonly found as the first stage reheat and almost always found as the subsequent downstream reheat. Although steam reheat has its perks, there are always pitfalls to be found. Most notably, the steam reheats are not always able to heat the process stream high enough for the required downstream converter beds and maintaining that first converter bed temperature can be difficult. They are also very difficult to get the temperatures high enough to perform heat soaks for rejuvenating catalyst. The steam supply pressure and degree of superheat dictate the performance that can be realized. Gas plants, in particular, often carry direct fired reheaters or hot gas bypass in the first stage for these reasons.

Case Study

In this case study, we will be looking at a typical refinery feed processing both amine acid gas and sour water acid gas from the upstream plants.

Table 1 Conditions of Sour Gas to SRU (Wet Basis)

Stream	Sulphur Rate (LTD)	H_2S mol%	CO_2 mol%	NH_3 mol%
Amine AG	117	91.9	6.7	---
SWAG	8	33.1	---	40.9

The feeds are processed in a three (3) bed Claus unit under low level oxygen enrichment at a combined rate of 125 LTPD. The composition of both of these streams on a dry basis can be seen in Table 1.

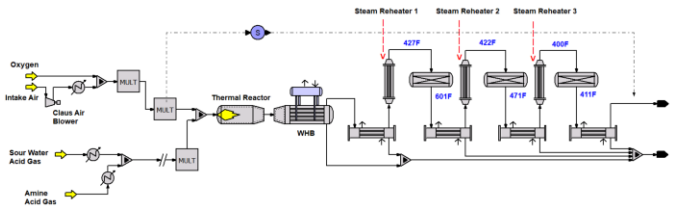

Figure 1 3 Stage Claus SRU Flowsheet

As shown in Figure 1, between each stage's condenser and converter is a steam reheater. Outlet temperatures from each reheater are calculated using the actual dimensions of the exchanger, such as tube count, tube diameter, and tube length, as a function of process throughput rates.

As a baseline, the calculated and measured temperatures for each reheater are shown in Table 2. These will give a good idea as to how the model is predicting the temperatures under normal conditions before looking at two different turndown scenarios.

Table 2 Baseline Conditions of SRU Steam Reheaters Outlet Temperatures

	Steam Reheat 1	Steam Reheat 2	Steam Reheat 3
Calculated	426.8°F	421.9°F	400.7°F
Measured	427°F	422°F	400°F

Table 3 Baseline Conditions of SRU Condenser Outlet Temperatures

	Condenser 1	Condenser 2	Condenser 3	Condenser 4
Calculated	326.5°F	330.9°F	317.3°F	261.5°F
Measured	329°F	332°F	317°F	261°F

Also included are the baseline outlet conditions for the four (4) Sulphur Condensers. The turndown scenarios evaluated here were at turndown rates of 75% of capacity and 30% of capacity for the SRU.

Results

At a turndown rate of 75% of design, The outlet temperatures of the Condensers and Steam Reheaters can be seen in Tables 4 and 5.

Table 4 Steam Reheater Outlet Temps at 75% of Design

Steam Reheat 1	Steam Reheat 2	Steam Reheat 3
429.3°F	425.1°F	404.6°F

Table 5. SRU Condenser Outlet Temps at 75% of Design

Condenser 1	Condenser 2	Condenser 3	Condenser 4
316.9°F	324.3°F	313.8°F	259.9°F

From these tables, we can see that although the temperatures from the upstream condensers are dropping slightly (due to the lower rate through the condenser tubes), the outlet temperature from the steam reheaters increases more than the inlet temperature was offset.

Table 6 SRU Steam Reheater Outlet Temps at 30% of Design

Steam Reheat 1	Steam Reheat 2	Steam Reheat 3
444.2°F	439°F	419.3°F

Table 7. SRU Condenser Outlet Temps at 30% of Design

Condenser 1	Condenser 2		Condenser 3	Condenser 4
303.8°F	310.7°F		306°F	257°F

As for the overall SRU efficiency, the second and third converter beds are best kept as low an operating temperature as possible without condensing sulphur within the catalyst. As the rates within the SRU drop and no further adjustments are made, the temperatures in the reheater outlets would otherwise continue to rise further if the steam was not modulated, exacerbating the excessivedew point margins.

The Claus SRU Recovery efficiency can be seen in Table 8 and as the unit drops rate, the recovery efficiency slightly drops as well. This is to be expected since the second and third converter beds are not operating optimally. Although one could argue that several tenths of a percentage difference in Recovery Efficiency is minor, the general trend is still valid.

Table 8 Overall SRU Recovery Efficiency at Turndown

Full Rate (100%)	75% Rate	30% Rate
97.67%	97.66%	97.40%

Conclusions

This edition of *The Contactor* has demonstrated the changing performance of SRU exchangers with operating loads. Given that the SRU is not a money-maker in and of itself, there must be other incentives for wanting to be able to accurately model heat transfer performance. Operating cost for wasted HP steam and putting more load on the TGU than is necessary are two areas where benefits can be immediately realized: TGU H_2 makeup usage, and TGU reboiler steam. In the end, a penny saved is a penny earned.

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