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Efficient Sulphur Conversion: Hot Gas Bypass or Direct Reheat? Part II

Sulfur-bearing gas from a sulfur condenser is of necessity cool and requires reheating to elevate it above the sulfur dew point and to prevent sulfur condensation inside the next converter bed. There are at least five ways to carry out the reheat step: (1) heat exchange with steam or other indirect heating medium, (2) using a hot gas bypass (HGBP), (3) an acid gas burner, (4) burning fuel gas instead of an acid gas slip stream, and (5) using a gas/gas exchanger.

In the March issue of *The Contactor*™, the first three reheat options of Hot Gas Bypass (HGBP), Direct Inline Acid Gas Burners, and steam reheat were discussed, compared, and contrasted. A case study looking at the two options compared with Steam Reheat was also presented and discussed. The results of this case study were that one option had no apparent significant advantage over the other *when used on the first conversion stage only*. The present issue of *The Contactor* takes the case study one step further and examines HGBP and Inline Burners applied to reheats of all condenser product streams.

Figures 1, 2, and 3 show the PFDs with the particular reheat option used for both conversion stages.

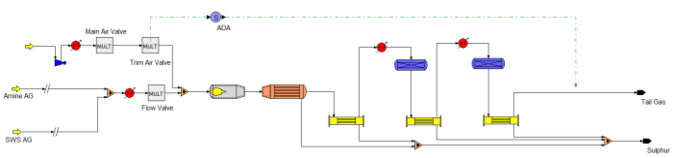

Figure 1. Indirect Steam Reheat

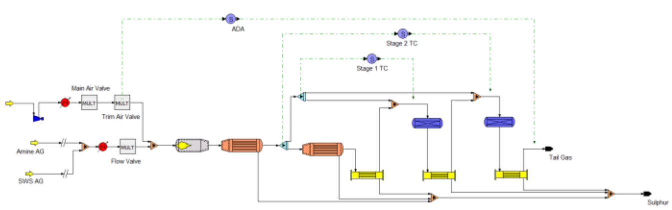

Figure 2. Hot Gas Bypass Reheat

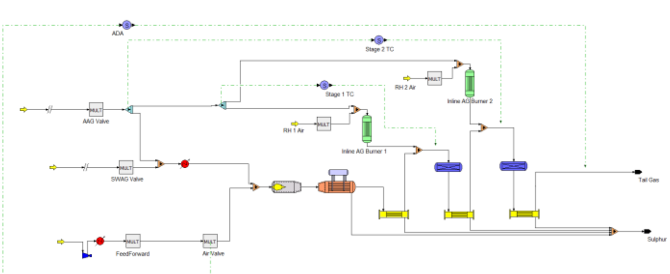

Figure 3. Direct Fired Acid Gas Reheat

Tables 1, 2, and 3 show the same conversion and recovery tables as shown in *The Contactor* Part I but after they have been updated to reflect reheats applied to both stages. The tables show that in terms of sulfur conversion and recovery, steam reheat is clearly the better option of the three simply because there is no sulphur bypassed around converter/condenser stages. Direct fired acid gas reheating has the lowest conversion and recovery.

	Thermal Stage		1st Stage	2nd Stage
	WHB	Cond1	Cond2	Cond3
Conversion %	58.3		71.91	73.11
Cum. Conv. %	58.3		88.28	96.85
Recovery %	6.48	50.47	30.13	8.89
Cum. Recov. %	6.48	56.89	87.02	95.91

Table 1. Steam Reheat at 30% Turndown

	Thermal Stage		1st Stage	2nd Stage
	WHB	Cond1	Cond2	Cond3
Conversion %	65.7		49.96	69.55
Cum. Conv. %	65.7		82.85	94.78
Recovery %	5.06	32.68	33.69	22.45
Cum. Recov. %	5.06	37.75	71.44	93.89

Table 2. Hot Gas Bypass Reheat at 30% Turndown

	Thermal Stage		1st Stage	2nd Stage
	WHB	Cond1	Cond2	Cond3
Conversion %	58.3		71.3	70.70
Cum. Conv. %	58.3		87.17	95.31
Recovery %	3.18	53.71	31.97	11.63
Cum. Recov. %	3.18	56.89	85.92	94.42

Table 3. AAG Inline Burner Reheat at 30% Turndown

These comparisons were all made at a turndown of 30% to highlight the differences between the different options—the differences are accentuated at low throughputs. Similar to the findings of Part I, there were not large differences between the steam reheat and AAG Inline Burner reheat options across the first stage. However, when multiple stages are considered, the differences become more apparent.

The HGBP case had an overall recovery and conversion that is slightly more than 2% below the base case, steam reheat. Sulfur recovery is relatively evenly divided between all three condensers. Simulation also indicates that the dew point margin is negative at the original design inlet temperature for the second converter during turndown. This means there is the possibility that liquid sulphur can form and deposit on the catalyst, which would cause deactivation through plugging of catalyst pores. Increasing reheat temperature to raise the dew point margin and prevent liquid sulphur formation lowers the achievable sulphur conversion as indicated by the chart in Figure 4.

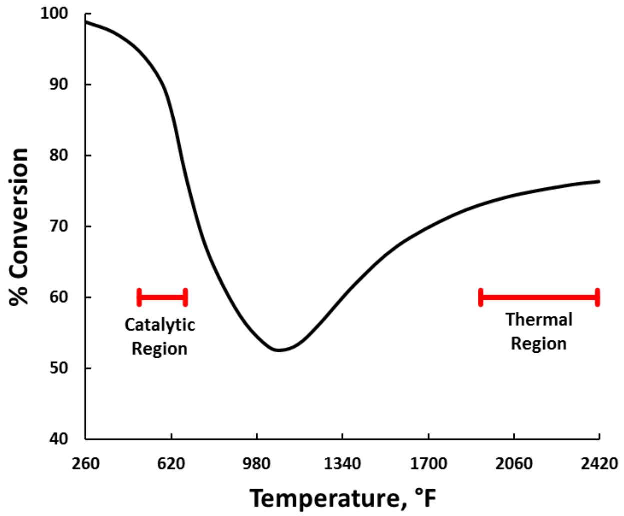

Figure 4. Thermodynamic Capabilities of the Claus Reaction

The inline AAG burner case shows that at 30% turndown, the overall conversion and recovery are around 1.5% lower than the indirect steam reheat case. Unlike the HGBP, the inline AAG burner shows a recovery distribution between the condensers that is comparable to steam reheat.

In Part I, the differences between these three reheat options was quite negligible. However, when the HGBP and inline AG burners are applied to *both* stages rather than just the first one, these differences become more apparent and show that steam reheat has a clear advantage overall. This is not to discredit the other options as there are often quite valid reasons to use any one over the rest.

	Thermal Stage		1st Stage	2nd Stage
	WHB	Cond1	Cond2	Cond3
Conversion %	60.8		72.03	50.47
Cum. Conv. %	60.8		89.05	94.57
Recovery %	0.00	58.79	28.84	6.02
Cum. Recov. %	0.00	58.79	87.63	93.65

Table 4. Steam Reheat at 100% Rate

	Thermal Stage		1st Stage	2nd Stage
	WHB	Cond1	Cond2	Cond3
Conversion %	63.5		64.46	55.91
Cum. Conv. %	63.5		87.04	94.29
Recovery %	0.00	49.80	31.71	11.87
Cum. Recov. %	0.00	49.80	81.51	93.38

Table 5. Hot Gas Bypass Reheat at 100% Rate

	Thermal Stage		1st Stage	2nd Stage
	WHB	Cond1	Cond2	Cond3
Conversion %	60.8		71.84	65.45
Cum. Conv. %	60.8		88.24	94.93
Recovery %	0.00	58.72	30.57	10.05
Cum. Recov. %	0.00	58.72	86.81	94.01

Table 6. AAG Inline Burner Reheat at 100% Rate

Some of the advantages and disadvantages of a few reheat methods are summarized in Table 7. In particular, although steam reheat has low cost, there are circumstances in which it is inferior to other methods, or it may not really be a viable option at all, especially if sulfur is likely to condense in one or more converter beds.

Method	Advantages	Disadvantages
AAG Fired	• Good temp control • Free fuel source	• Risks O_2 break-through • Bypasses sulfur • Higher bed DPs • Risks COS/CS_2 • Expensive • Rich AGs only
Fuel Gas	• Good temp control	• Risks O_2 break-through • Soot and HC breakthrough • Expensive • $$$ fuel source • No refinery FG
HGBP	• Least costly • Free heat source	• Poor temp control • Bypasses sulfur • Higher bed DPs • Corrosion
Steam	• No O_2/HC break-through • Less costly • No sulfur bypassing	• Hard to maintain 1st conv temp • Hard to perform heat soaks

Table 7. Comparisons of Some Reheat Methods

This study was conducted using the SulphurPro® rate-based sulfur plant simulator. This modeling tool uses reaction kinetics and heat transfer rate calculations to provide a very clear and comprehensive picture of the overall plant and the behavior of each unit operation. The rigorous fundamentally-sound approach of reaction kinetics leaves nothing to the imagination.

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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.

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