

Ammonia Destruction in SRUs — 2. One-zone Furnaces

This is the second of a three-part series dealing with ammonia destruction in furnaces and focuses on destroying ammonia in a one-zone reaction furnace of an SRU. Nearly complete destruction of ammonia is needed to prevent plugging downstream units in the SRU with ammonium salts.

One-zone Furnace

The one-zone furnace, also referred to as a straight-through design, operates with all the amine acid gas (AAG) and sour water acid gas (SWAG) premixed and fed to the furnace via a single burner. Although this design is used when the feed gas contains no ammonia, it can also be used successfully when ammonia is present *in small concentrations*.

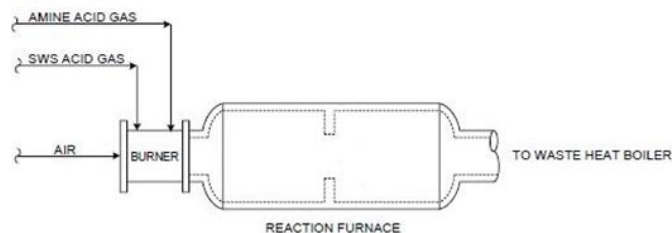


Figure 1 Sketch of One-zone Furnace

One benefit of the one-zone furnace is that all the acid gas passes through the burner flame and is exposed to the highest possible temperature for contaminant destruction. Insufficient destruction of hydrocarbons in the reaction furnace can have disastrous effects on the converter beds downstream, especially if they contain aromatics. Another benefit is the relatively straightforward nature of the control scheme because controls do not have to address splitting gas between zones.

Case Study

Ammonia destruction in a one-zone reaction furnace design is assessed by varying the amount of preheat provided to the AAG and SWAG feeds. Figure 2 shows a one-zone design with preheating

of the amine acid gas (AAG), the sour water acid gas (SWAG), and possibly the combustion air. The case of no preheating is represented by the same flowsheet but with zero preheater heat duty. Table 1 shows acid gas compositions and flow rates.

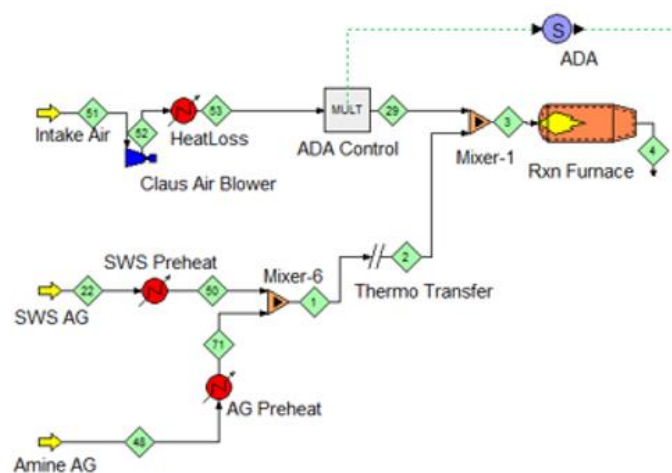


Figure 2 One-zone Furnace Schematic

Table 1. Acid Gas Feed Compositions (mole %)		
Component	AAG	SWAG
H ₂ O	1.4	25
H ₂ S	92.1	33.5
CO ₂	5	0
NH ₃	0	41.5
CH ₄	0.5	0
H ₂	0.0012	0
N ₂	0.9988	0
Flow Rate (lbmol/h)	462	200

Downstream of the furnace the flowsheet is typical of a three-bed Claus unit. Residence time in the reaction chamber is arbitrarily set to a typical value of 1.1 seconds. The length-to-diameter (L/D) ratio is 3.5 for the furnace. Note that the residence time required to destroy ammonia depends on both temperature and NH₃ concentration in the feed gas. A one-zone design is modeled in ProTreat® using

a single reaction furnace block consisting of burner plus reaction chamber with the AAG, SWAG, and Combustion Air all mixed together before entering the furnace itself.

Findings

The ammonia concentration for the combined SWAG and AAG stream is about 12.5 mole percent (wet basis). This is well above the typical maximum ammonia concentration for a one-zone design and as the results will show, it needs longer residence times. The informal industry standard for the maximum acceptable ammonia concentration in any reaction furnace effluent is 100–150 ppmv (wet basis). This is to prevent the precipitation of ammonium salts in downstream sulphur condensers.

After running the simulation using the Pro-Treat® kinetic model, for the one-zone furnace without preheat, the ammonia concentration in the calculated effluent was predicted to be 343 ppmv. This is two to three times the advised limit. *If this same simulation were run using a simple equilibrium-based furnace calculation, the ammonia level in the effluent would be only about 0.5 ppmv ammonia.* The cause of the huge discrepancy is the equilibrium model's failure to account for the actual kinetic rates for each of the important reactions. An equilibrium model assumes all reactions come to equilibrium—in reality, nothing could be further from the truth, especially for ammonia destruction.

With preheating of both AAG and SWAG feed streams (but not the combustion air) sufficient to provide a combined acid gas temperature of 380°F, the ammonia level in the effluent dropped to 309 ppmv. Preheating of *just the combustion air alone* to 450°F was also studied. (There is nothing to corrode the steel with hot air and there are no hydrocarbons to crack, so air preheat can be used to provide higher temperatures.) This produced 268 ppmv ammonia. This was better performance than with acid gas preheat alone because the mass flow of the combustion air was considerably larger than the mass flow of acid gas.

Both cases left ammonia in the furnace effluent well above the advised limit; however, the results indicated some ability to mitigate ammonia levels by preheating in a one-zone furnace design. With preheat alone, in some cases the ammonia levels may be sufficiently reduced to meet the advised limits in a one-zone reaction furnace.

Figure 6 shows how the amount of acid gas preheat can be expected to affect residual ammonia in the reaction furnace effluent. Increasing reaction furnace temperature improves ammonia destruction by increasing reaction rates.

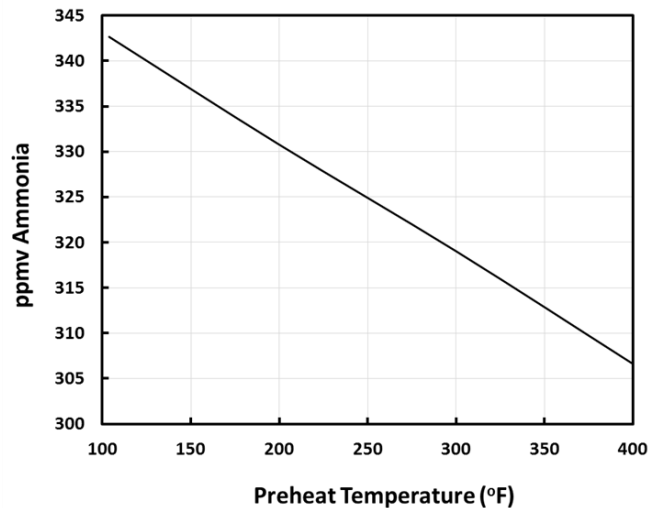


Figure 3 Simulated Effect of Preheat on NH₃ in Effluent from Furnace

Another simulation study was done to assess the effect of furnace residence time using acid gas preheated to 380°F. To meet the 100-150 ppmv industry guideline with a one-zone furnace, more residence time would be required for this particular case. Table 2 shows that an ammonia level of 95 ppmv could be achieved by increasing the residence time to 1.4 seconds. Incidentally, a residence time of 1.32 seconds was found necessary to reach ~100 ppmv NH₃ when all streams were preheated to 450°F.

Table 2. Effect of Furnace Residence Time			
Time (seconds)	Combined AG Preheat (°F)	Combustion Air Preheat (°F)	Effluent NH ₃ (ppmv)
1.1	---	---	343
1.1	380	---	309
1.1	---	450	268
1.4	380	---	95
1.32	450 (+ air)	450	~100

It is possible to destroy ammonia adequately in a one-zone furnace to acceptable levels and lower. However, this may require outfitting with adequate preheaters as well as enough volume to provide the necessary residence time. But, one-zone furnaces may experience problems with flame stability, particularly if the gas is lean in H₂S, and the furnace may be more susceptible to flame out. This will lead us to two-zone furnaces in Part 3.

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

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