



The CONTACTOR™

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Ammonia Destruction in SRUs — 3. Two-zone Furnaces

The effectiveness of ammonia destruction is strongly affected by the configuration and operation of the reaction furnace. This was discussed in general terms in Part 1 (*The Contactor*, 10 [11] 2016) and in terms of the one-zone furnace in Part 2 (*The Contactor*, 11 [2] 2017); both issues can be found at http://ogtrt.com/the_contactor. In this issue we conclude the series with a discussion of ammonia destruction in a two-zone furnace, as revealed by ProTreat® kinetics-based simulation.

Two-zone Furnace

The two-zone one-burner furnace, also referred to as a front side split, is generally applied when the ammonia content in the acid gas exceeds the nominal 2 mol% limit, but it can also be used in cases with less ammonia.

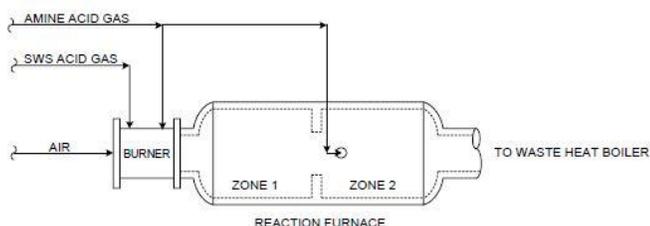


Figure 1 Sketch of Two-zone Furnace

As Figure 1 shows, all the ammonia-bearing sour water acid gas (SWAG) enters the burner in the front zone. The percentage of amine acid gas (AAG) being bypassed to the second chamber depends on the desired flame temperature as well as the concentration of H₂S in the gas. The temperature of the front zone should be kept high enough to ensure adequate ammonia destruction, generally in the range 2300–2700°F. The maximum temperature is governed by the refractory lining's upper temperature limit.

Generally, no more than 60% of the total H₂S in the SRU feed should be bypassed to ensure the atmosphere in the front zone does not operate in the oxidizing region and cause NO_x levels to increase. If the atmosphere in the furnace is in this

oxidizing region, substantial amounts of NO_x and SO_x can be produced which, under the right conditions, can form hot aqua regia, an extremely corrosive material capable of dissolving even gold and platinum. The controls for the amount of acid gas bypass are generally based on the flame temperature in the front zone as well as the concentration of H₂S in the AAG feed.

One of the benefits to using a well-designed two-zone furnace is that the ammonia destruction can be higher compared to the one-zone furnace. To a large extent, greater ammonia destruction results from higher flame temperatures. This temperature control advantage in the front zone comes from the ability to bypass some of the amine acid gas around the front burner relieving some of the acid gas load on the flame. When the heat sink of unburned acid gas is removed from the flame by bypassing it to the back zone, the flame temperature can be greatly increased. High temperatures are known to benefit ammonia destruction. The benefit derives from improved kinetics for the complex and somewhat counterintuitive ammonia destruction mechanism (*The Contactor*, 10 [11] 2016).

A negative aspect of the two-zone design is that the fraction of AAG being bypassed to the second zone does not pass through the burner flame at all. Thus, any contaminants that may be present do not see the high temperatures of the flame. This can pose a problem if the contaminant levels in the clean AAG are excessive. Another negative is that the portion of the acid gas that is bypassed has a much shorter residence time, making contaminant destruction and Claus reaction equilibrium harder to achieve. Finally, since the two-zone design has an additional control point for splitting the clean acid gas flow between the zones, the control system is inherently more complex. Additionally, there may also be safety concerns associated with bypassing acid gas around the front zone—if too much is bypassed, the temperature of the front zone can exceed the refractory thermal limits and compromise the integrity of the furnace lining.

Finally, two-zone furnaces require a relatively large nozzle on the side of the reaction furnace vessel to allow the bypassed acid gas to enter the back zone. This presents mechanical challenges associated with construction and maintenance of the refractory lining which are avoided in the one-zone furnace design.

Case Study

Ammonia destruction in a *two-zone* reaction furnace design is assessed by varying the percentage of clean acid gas that is bypassed to the back zone of the two-zone furnace. Figure 2 shows the two-zone design as constructed in the kinetics-based ProTreat® SRU simulator. This is the furnace part of a larger design of the complete SRU. The AAG and SWAG analyses are the same as in Part 2 of this series and are not repeated here.

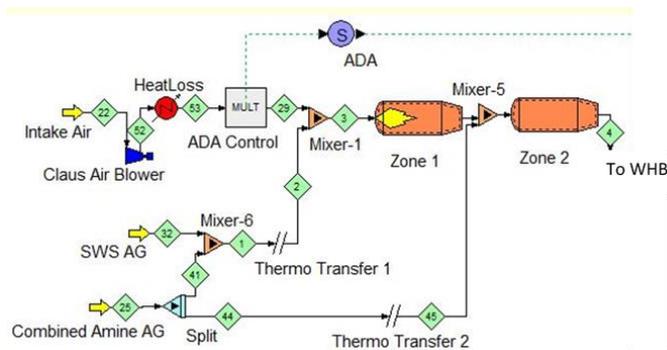


Figure 2 Two-zone Furnace Schematic

For the two-zone furnace, an acceptable ammonia level was achieved with acid gas bypass of around 30%. The ammonia concentration in the effluent from zone two was approximately 90 ppmv on a wet basis at this percentage bypass. In Figure 3, the concentration of ammonia in the effluent from the back zone is shown as a function of the percentage bypass.

As the bypass percentage approaches zero, ammonia from the back zone approaches 230 ppmv. As already seen with the one-zone furnace, the outlet *without preheat* was approximately 343 ppmv ammonia. The difference in this zero-bypass case results from the mixing characteristics that are assumed in the front- and back-zones of the two-zone furnace. In the front zone, the burner mixing characteristics are set equivalent to a *High-Intensity Burner* by selecting this option in ProTreat®. This selection accounts for mixing imperfections in the chamber of a commercial-size unit but with burners having good mixing characteristics. The back zone is set to the *Perfectly Mixed* option because there is no burner located in that zone.

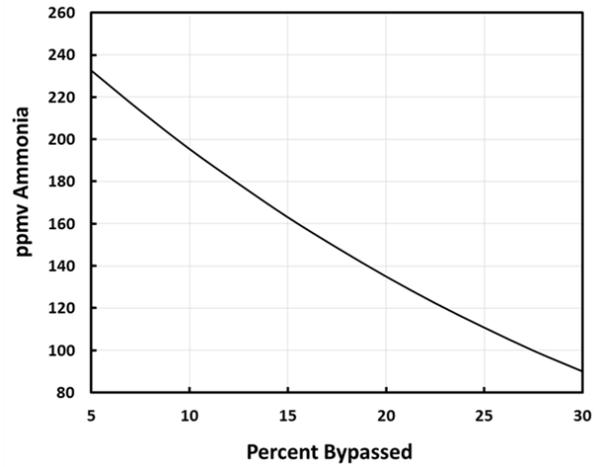


Figure 3 Effect of AAG Bypass on NH₃ Destruction

As the bypass percentage is increased, the concentration of ammonia from the back zone decreases almost linearly. This is due in part to the increasing temperatures in the front zone

Residence time has an interesting effect. As Figure 4 shows, ammonia concentrations from each zone decrease as the total residence time in the two combined zones increases. They trend exponentially with residence time.

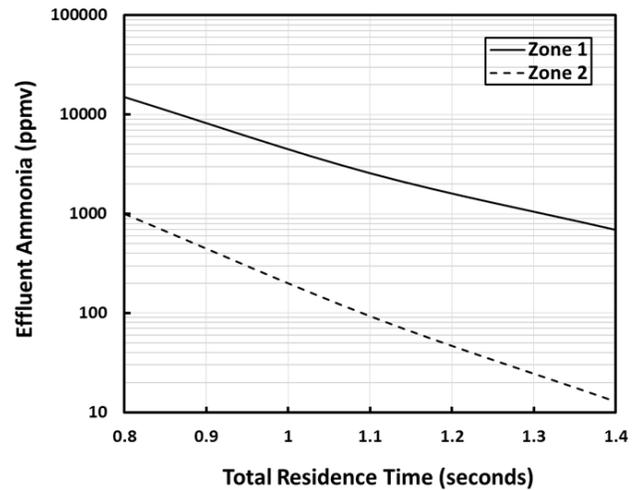


Figure 4 Effect of Residence Time on NH₃ Destruction

Three main factors affect ammonia destruction: residence time, furnace temperature, and quality of mixing of air and acid gas entering the burner. An almost uniformly homogeneous mixture ensures complete and even combustion of the acid gas and ammonia destruction.

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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