The CONTACTOR™

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Stability Limits for Amine Regenerators: Feed Temperature

Amine regeneration is possibly the most neglected part of gas treating plant operation. This is somewhat surprising given that the performance of a gas plant is so often determined by solvent lean loading. Lean loading is set in the regenerator.

It seems that every year more and more plants convert from primary and secondary amines (and potassium carbonate) to MDEA or one of its promoted cousins. Use of this solvent is driven by the desire for selectivity in H_2S removal on the one hand, and by MDEA's lower regeneration energy requirements on the other. Therefore, the example we will study in this note is based on MDEA

Most amine regenerators are operated with enough boilup to provide a reasonable flow of condensable† stripping steam to every tray or all the packing in the column. Sometimes, however, regenerators are purposefully operated with such a low flow of energy to the reboiler that only the lowermost trays receive condensable stripping steam. This seems to be the norm for post-combustion carbon capture plant designs, and it occurs frequently when the CO_2 section of an ammonia plant is retrofitted with activated (piperazine-promoted) MDEA. The transition from over-boiled to under-boiled can be rather sudden, leading to unexpected plant instability‡. The transition does not result solely from throttling reboiler energy (steam, hot oil) flow. It can equally well be caused, for example, by increased solvent load on the regenerator or by gradual loss of heat transfer efficiency in the cross exchanger, perhaps as a result of fouling, and leading to colder-than-intended rich amine entering the regenerator. The fundamentals-based engineering science used in the ***ProTreat***™ process simulator so accurately models a plant's internal workings as to make ***ProTreat*** itself a virtual plant. The simplest and most accurate way to explore such instability is by applying ***ProTreat*** simulation to a specific example.

Case Study

A 20-tray regenerator with kettle reboiler is stripping 32,000 lb/hr of 50 wt% MDEA solvent loaded with H_2S and CO_2 to 0.28 and 0.23 mol/mol, respectively. This 2-ft diameter column is fed on the third tray from the top and operates at a head pressure of 0.95 kg/cm^2(g) (13.5 psig). In this issue of *The Contactor* we ask what the effect of rich amine feed temperature is on performance? The next issue (Volume 5, Issue 5) will enquire about the effect of reboiler duty.

A reasonable reboiler duty for this particular case is 2.25 MMBtu/hr (660 kW). Simulations were run with rich amine feed temperatures from 185 to 215°F in 5°F increments. Figure 1 is a set of typical regenerator temperature profiles, and it shows that

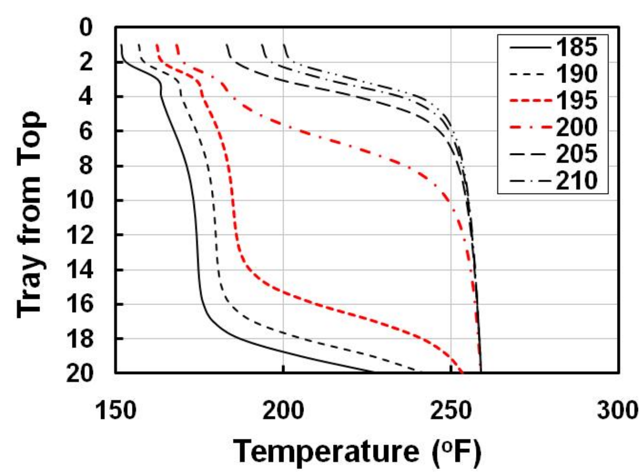

Figure 1 Effect of Feed Temperature on Regenerator Temperature Profile

† As long as there is a vapor flow to a tray, the tray will see a nonzero water concentration; however, the water content may not be adequate to transfer any heat to the liquid via condensation. Normally, regenerator vapors have high water content and stripping energy is provided by steam condensation.

‡ Here instability does not imply inoperability. It means an unexpectedly large change in a performance variable caused by a change in a control variable.

when the feed temperature is dropped from 200°F to 195°F there is a sudden collapse in the temperatures throughout most of the column. As shown in Figure 2, this is the same temperature range over which the lean loadings also experience a sizeable change. Perhaps the most striking fact is

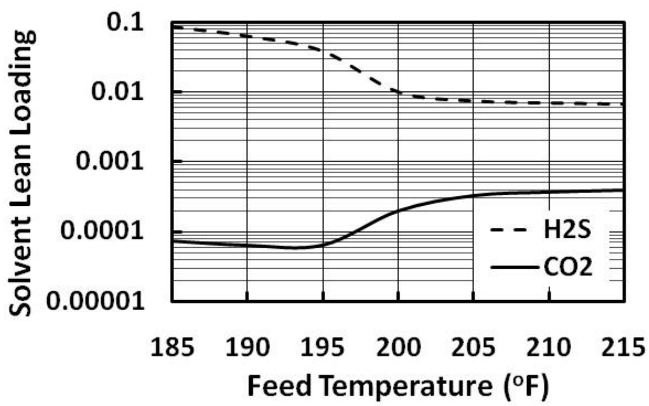

Figure 2 Effect of Feed Temperature on Solvent Lean Loadings

that the H_2S and CO_2 lean loadings *move in opposite directions* in response to regenerator feed temperature. A glance at the loading profiles in Figures 3 and 4 shows why. Referring to Figure 3, with the feed at 195°F the top part of the column is so cold it is actually acting as an absorber for H_2S: the H_2S stripped from the solvent on the bottom few trays and in the reboiler is being reabsorbed in the rest of the column. A hotter rich feed also allows more of both gases to flash from the solvent on the feed tray.

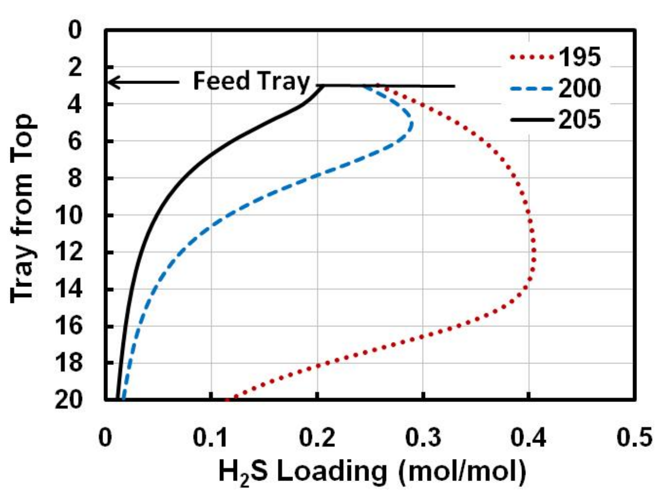

Figure 3 Effect of Feed Temperature on H_2S Loading Profile

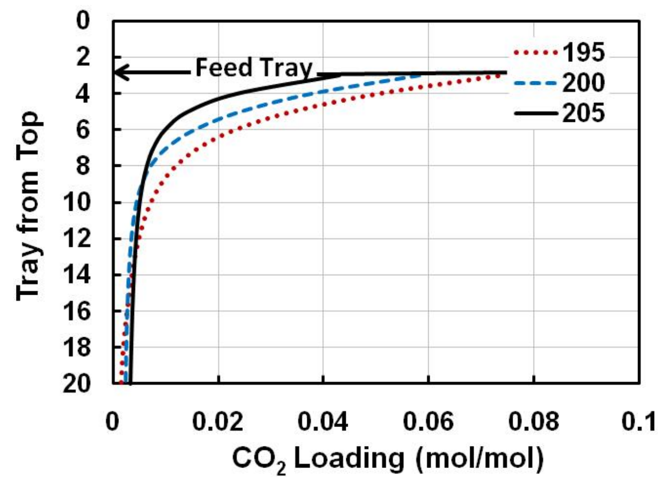

Figure 4 Effect of Feed Temperature on CO_2 Loading Profile

As shown in Figure 4, CO_2 is actually stripped throughout the entire regenerator, regardless of the feed temperature. The higher H_2S loadings at lower temperature actually assist CO_2 stripping because higher H_2S loading forces a higher CO_2 equilibrium vapor pressure. This increases the driving force for CO_2 stripping and helps reduce the stripped solvent lean loading. This can be seen in the figure towards the bottom of the column where a slightly leaner lean loading is reached at lower temperature. However, the effect is fairly small with CO_2 loading being reduced only by about 0.0003 loading units overall between 215 and 195°F.

ProTreat™ simulation allows one to examine tray-by-actual-tray composition and temperature profiles in a regenerator. This lets us to ascertain precisely what mechanistically is determining system behavior and where stability boundaries lie. With such information it is possible then to set, with some certainty, reasonable feed temperatures or temperature approach specifications on cross exchangers, for example, to avoid sudden failure to achieve adequate H_2S lean loadings.

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To learn more about this and other aspects of gas treating, plan to attend one of our workshops in Houston and Abu Dhabi in 2011-12. **On-line registration is now open**. For details, please visit www.ogtrt.com/seminars.

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