The CONTACTOR™

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Why What's in Your Tower Matters

Simulation software users are accustomed to seeing column performance reported as the number of theoretical stages required to make a given split. But when was the last time your packing vendor shipped seven theoretical stages of packing to your job site, or installed three theoretical trays in your column? In many hydrocarbon separations theoretical trays are a good way to think about what it takes to make a given split—efficiencies are routinely 80% or better. In gas treating, however, efficiencies frequently run as low as 5%. To compound matters, efficiencies are not constant—they vary markedly with position in the column, with vapor and liquid traffic, and with composition, temperature and pressure, and they depend on the component being removed. All this renders completely ***non***-predictive any model that has to use theoretical stages, making them unreliable outside their range of direct experience. If the application or conditions are new, you are taking a leap of faith, asking your model to do something beyond its abilities, namely, ***predict*** *performance*.

Most solvent vendors recognize the truth of this statement and use a mass transfer rate-based simulation tool. Indeed, many use ProTreat™, sometimes in conjunction with an in-house model, to generate proposals and designs. A simulation tool is ***not*** rate based just because it includes chemical reaction kinetics—as discussed in *The Contactor* Vol. 4 Issue 3, rate based means *mass transfer* rate based, nothing more, nothing less.

Users of process simulation software often like to validate their tools against data, and rightfully should. But ***solvent vendor "runs" are NOT data***—only plant performance or field data are data, and the plant performance or field data must first be validated before they can be used reliably to benchmark a simulation tool. The reliability of solvent vendor runs depends on the simulator that the vendor used. There's little value in using the results from one simulation tool as data for another because the tools are just that: they're tools whose purpose is to approximate reality. If you measure the results from one tool against those from another, you're implicitly assuming one of them is right when in fact neither may be. The proper way to test a simulator is against real, measured, and validated, plant or unit performance data. Tower internals do not figure into theoretical stage calculations, and anyway, it's often nearly impossible even to estimate an efficiency or an HETP. But tower internals can make a huge difference to performance, especially selective treating.

The following case study is an example that clearly shows the necessity to incorporate detailed tower internals information into the simulation. It's not enough just to get the pressure drop and hydraulic capacity right—what's truly important is to get the right separation.

Case Study

The plant in question came on stream just over a year ago but has been unable to meet the standard treating specification of ¼ grain gas with 2% CO_2 at anything more than 60% of the design gas rate. This is with gas at half the expected H_2S content and with the unit running at maximum reboiler load and maximum circulation rate. The column is under-trayed and barely making the ¼ grain specification, yet at the same time it is over-treating with respect to CO_2.

It was obvious that the equilibrium-stage simulator used for the original design completely missed the CO_2 slip and its overriding importance to the H_2S treating. Although the existing column could conceivably be retrayed with more trays on closer spacing, simulation showed that treating would be marginal at design conditions, at least with generic MDEA. Retraying would also involve significant downtime and lost revenue. In fact, lost revenue would exceed the cost of a new column; thus, a new column, properly designed, was potentially a more viable option. So what kind of column should be built? Should it be trayed or packed, or maybe even both? What packing makes sense? What tray characteristics are best, and what's the effect of number of passes and the like?

The sour gas contains a maximum of 750 ppmv H_2S and 3.6% CO_2 at nearly 1000 psia. Summer conditions are the most demanding with 110°F gas and 120°F lean 50 wt% MDEA. Design gas rate is 330 MMscfd. The very low H_2S to CO_2 ratio makes this a very challenging gas to treat without removing grossly excessive amounts of CO_2. In other words, simultaneously meeting a ¼ grain H_2S and 2% CO_2 specification won't be easy.

Structured packing is a possible tower internal for this application, and Mellapak Plus M252.Y is about the largest area packing useable in amine service without running into plugging concerns. Figure 1 shows this packing is unable to achieve the 4 ppm H_2S specification at all. Also, the deeper the bed, the more CO_2 is absorbed—excess CO_2 pickup worsens H_2S removal. Other packings are inadequate, too.

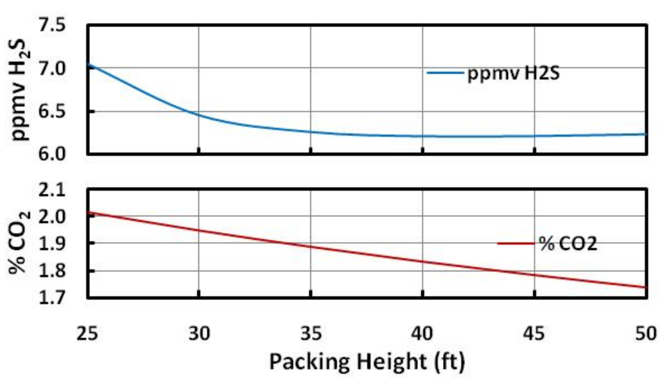

Figure 1 Effect of packing height on treating

Preliminary simulation work indicated that 20 trays would be needed to minimize contactor H_2S leak but that more trays always led to more CO_2 removal, well beyond what was required. In fact, single pass trays were unable to meet the H_2S specification when gas and solvent flowed at maximum rates. Figure 2 maps 1-pass tray gas rate versus solvent rate showing regions in which the ¼ grain H_2S specification can and cannot be met. For operation at 4 ppmv H_2S, treated gas CO_2 ranged from 1.65% to 1.05% (plant limit was 350 gpm).

The small amounts of H_2S and CO_2 to be removed need only low solvent flows and 1-pass trays are at the edge of the spray regime. Two-pass trays throw the trays fully into the spray regime where mass transfer characteristics are radically altered. Figure 3 shows 2-pass tray performance.

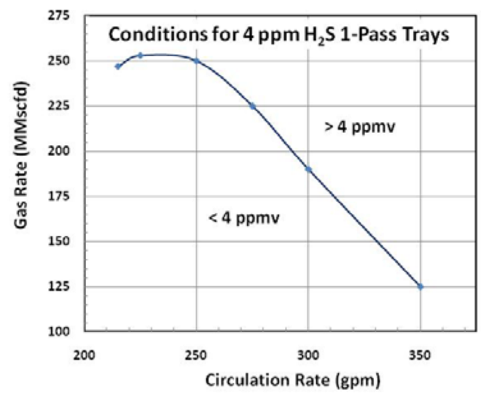

Figure 2 One-pass tray operating regions

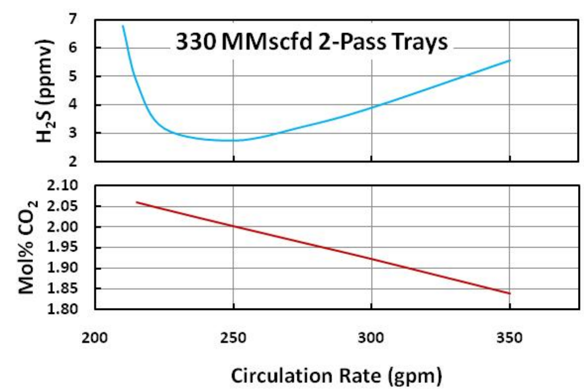

Figure 3 Two-pass tray performance

Clearly, 2-pass trays out-perform 1-pass in this operation. Interestingly the best performance is obtained at considerably less than the maximum available circulation rate in this plant, but that's a story for another issue of *The Contactor*™.

Do the type and details of tower internals make much difference to treating performance? Absolutely! They can make a huge difference—the difference between success and abject failure. And only a real mass and heat transfer rate based simulator is at all capable of telling the difference quantitatively and with confidence.

To learn more about this and other aspects of gas treating, plan on attending one of our seminars. Visit www.ogtrt.com/seminars.cfm for details.