The CONTACTOR™

Published Monthly by Optimized Gas Treating, Inc.
Volume 13, Issue 8, August, 2019

Trays and Packing Perform Very Differently

A given height of tower mass transfer section can contain a variable albeit limited number of trays depending on the tray spacing, or it can hold an equal depth of packing having a wide range of sizes. So to what extent does a tower's mass transfer performance depend on its internals? One sometimes hears the opinion that a tray on 2-ft spacing should perform about the same as a 2-ft bed of packing. Is that really true?

A Direct Comparison

The purpose of tower internals, of course, is to provide intimate contact between a gas or vapor stream and a liquid. Sometimes pressure drop is an important consideration, and usually a tower's capacity for handling vapor and liquid flow is important. Trays and packing characteristics differ a lot in these respects. Pressure drop and capacity are hydraulic parameters, and they tend to be the primary focus of tower internals suppliers. However, our concern here is with mass transfer performance. This is a much more complex issue and is addressed only very peripherally by internals suppliers who limit their attention to tray efficiency for distillation systems such as i-C_4/n-C_4 and C_6/C_7. In many hydrocarbon systems, tray efficiencies are 70 to 85% and HETP values are typically a couple of feet. In amine treating and other chemically reactive systems, and in systems where very high purities are sought, these commonly reported values of efficiency and HETP are so far from the truth as to be meaningless at best, and deceptive at worst.

As an example, consider the removal of CO2 from a gas containing 18% of this component using a solvent with 33 wt% MDEA spiked with a substantial amount of piperazine. The absorber is 54-inches diameter with 20 standard valve-type trays on 2-ft spacing. Alternative columns might contain steel Raschig Rings in the same tower packed to a depth of 40 feet with all operating under identical conditions. This isolates differences in absorption to differences in tower internals. Figure 1 shows how residual CO_2 in the treated gas varies with packing size and it also contrasts packing performance with trays. The important parameter that distinguishes one packing from another, and packing from trays, is the total interfacial area active for absorption. This varies over more than a factor of 10 from standard valve trays to the smallest random packing. Performance, as measured by treated gas CO_2 content varies by a factor of about 700,000! Even differences between adjacent packing sizes can be as high as 35 times. How accurately do you think you can estimate the HETP for a given packing type (random vs. structured), brand and size? Almost certainly without sufficient accuracy to arrive at a close enough fix on the treated gas composition. And compared with relatively small packing, trays perform extremely badly in this application. The total interfacial area on the 20 trays in this 20-tray column is only a little more than 500 ft^2 compared with just under 7,000 ft^2 with 40 feet of ½-inch random packing. This is a total (vs. selective) removal application so maximizing the contact area consistent with acceptable pressure drop is the right direction. However, as the next example shows, this may not be the case in selective treating.

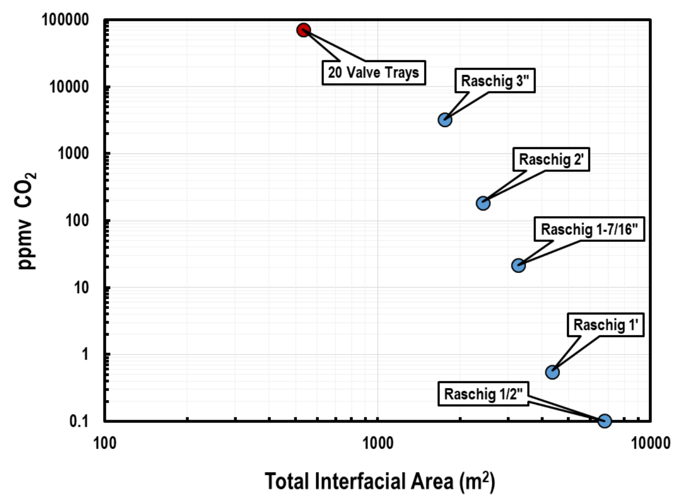

Figure 1 CO_2 Removal with a Piperazine Activated MDEA Solvent. Performance Depends Heavily on Tower Internals. Note log Scales

Selective Treating

In this second example we consider a selective treating case in which H_2S is to be preferentially removed for a 3-psig gas containing 20% CO_2 and 8% H_2S. For selective treating where CO_2 slip and H_2S removal are to be maximized, an appropriate solvent is streaight MDEA because it does not react with CO_2 which, therefore, tends to be left in the gas stream.

Again in this example, all operating conditions remain identical amongst the various cases with ony the tower internals changing from case to case in a tower of constant diameter. Twenty trays on 24-in spacing occupy 40 feet of tower height and this was used as the bed depth for all packing sizes.

Figure 3 shows how CO_2 slip varies from one packing size to another and compares packing performance with trqays. Figure 3 shows similar information for H2S removal, reported in terms of the H_2S leak (concentration) in the treated gas. Packing and trays are collated using the common factor, total interfacial area in the column.

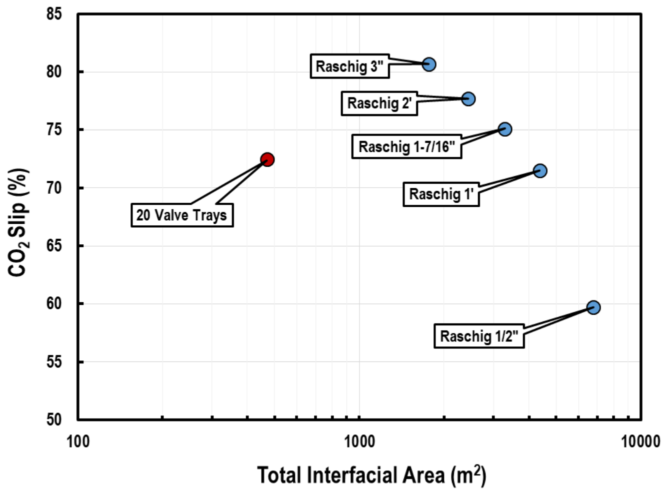

Figure 2 CO_2 Slip Using MDEA Solvent in a Selective Treating Application

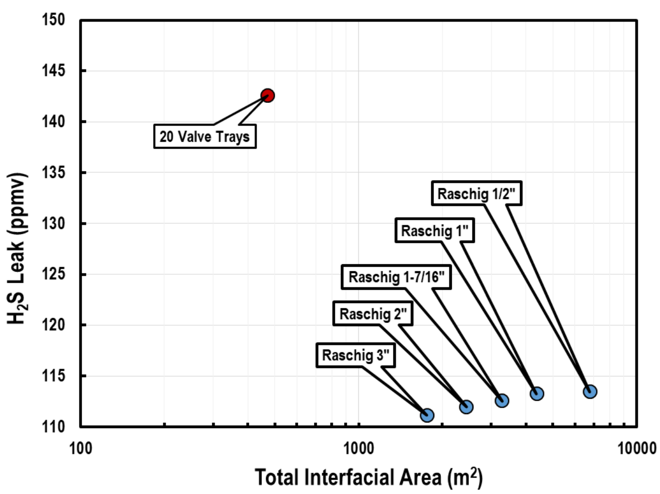

Figure 3 H_2S Removal Using MDEA Solvent in a Selective Treating Application

Caron dioxide slip is quite responsive to total interfacial area and the greater the area the more CO_2 is absorber, i.e., the lewss is slipped through the column. Interestingly, trays do not follow the same trend as in the CO_2-only case. This is caused by the fact that the liquid-side mass transfer resistance is less for trays than for a large packing because the liquid flow is highly disturbed by the passage of gas through the liquid on a tray.

It is also notable that the smaller packings do a worse job of H_2S removal than the trays do and that small packings are worse than large ones. The effect of packing size is a direct result of increased CO_2 pickup with small packings. This corresponds to increased solvent consumption by CO_2' leaving less reactive component for H_2S absorption. The disparity between trays and packing results from the fact that the gas flow itself through packed beds is quite turbulent whereas the same gas flows through a liquid pool in the form of jets and bubbles which are actually quite a bit less turbulent.

Summary

The primary messages are as follows:

- The rule of thumb that a tray and 2 feet of packing have about the same performance is completely false, at least in the context of amine treating.
- Treating is highly dependent on packing size. Although not explitily demonstrated here, treating is also dependent on packing type (random vs. structured) but also on packing brand (Raschig Rings, Pall Rings, saddles, etc.).
- Column performance is also very dependent on the treating process, especially on the specific amine or amine mixture being used.

The chances of correctly (let alone accurately) guessing the HETP or tray efficiency in gas treating applications, especially ones using chemically reactive solvent components, is virtually nil. The only secure way to assess performance is through a strictly and completely rate-based simulator that accounts for mass transfer rates in a thoroughly scientific way. ProTreat is such a simulator and is considered the most reliable and accurately predictive software in the industry.

~·~·~·~·~·~·~·~·~·~·~·~·~~·~·~·~·~·~·~·~

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.