The CONTACTOR™

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Effects of Packing Type and Size on Treating: Part 2 — Selective H_2S Removal

Trayed and packed columns have radically different mass transfer characteristics, and both are widely used. The effect of tray parameters such as weir height, numbers of passes and so on are fairly well understood which tends to increase confidence in design.

In a packed tower, however, a discontinuous film flows over solid surfaces through a continuous gas, and mass transfer rates can be affected by packing size, packing geometry, including even the brand. With structured packing, equally the surface treatment of the (usually) sheet metal used in fabrication can influence a column's performance.

Unlike the deep CO_2 removal of LNG production (see *The Contactor*, Vol. 16, No. 7), the objective of high selectivity is to remove H_2S to (usually) < 4 ppmv and to reject as much CO_2 as possible back into the treated gas, i.e., to maximize CO_2 slip. This is done primarily by using a solvent that is reactive towards H_2S but is not reactive with CO_2. Usually, generic MDEA is the solvent of choice. If one wishes to achieve a specified CO_2 target as well, some amount of another more-reactive solvent can be mixed with the MDEA to provide a blend with tailored reactivity; however, that is a subject for another time. Packing size almost directly correlates with the effective interfacial area. Packing geometry is unique to each packing brand of a given nominal size, although the dry surface area is still the primary controlling factor. Lowered confidence when designing for packing may in part be a consequence of such a plethora of sizes, shapes and physical structures such that it can be difficult to assign even a meaningful size to a given packing, let alone quantify its mass transfer performance.

This issue of The Contactor™ takes a close look at performance differences between two structured packings supplied by different manufacturers as a function of crimp size, as well as between five different random packings, selected on the basis that each one has a wide range of available sizes. Candidates that are representative of 1st, 2nd, 3rd, and 4th Generation, metal random packings were selected for study. To avoid any suggestion of bias, none of the packings used is identified by brand. The hydraulic and mass transfer characteristics of each packing used are as specified by the manufacturer. The random packings shown in Table 1 are typical for each Generation, but by no means are they exhaustive. Each succeeding Generation is an improvement on the previous one and each is intended to utilize the interior volume of the packing pieces more effectively, retain more uniform, stable, liquid distribution, and produce lower pressure drop or higher hydraulic capacity. First Generation packings replaced the broken glass, glass spheres, and pieces of stone or coke used in the mid to late 19th century and which had unpredictable efficiency and hydraulic behavior. (We are aware of an absorber packed with broken beer bottles in natural gas service in New South Wales, Australia in the 1980s—this packing was certainly inexpensive and readily available, albeit perhaps not meeting the highest engineering standards.)

Gen 1	Gen 2	Gen 3	Gen 4
 Raschig Rings	 Super IN-TALOX®	 CASCADE MINI-RINGS®	 Raschig Super-Rings®
 Berl Saddles	 FLEXI-RINGS®	 IMTP®	 NeXRings
 INTALOX® Saddles	 Ballast Rings	 Tellerettes®	 INTALOX® ULTRA

Table 1 A Selection of Random Packings Sorted by Generation

In this case study, the raw gas was water-saturated methane with 10% CO_2 and 2% H_2S at 100°F treated using 50 wt% MDEA at 120°F. Gas and solvent rates were kept constant from case to case, with a 48-inch tower diameter and 20 feet of packing in each case. A system or foam factor was not applied to any calculation.

Selective H_2S Removal: Natural and Refinery Gas

Figure 1 shows how the H_2S content of the treated gas depends on packing type and size. In terms of actual H2S removal, the four Generations of random packing all have much the same performance regardless of whether the column is pinched or not. Equivalent mass transfer performance is probably a result of these packings all giving pretty much full gas-liquid access to the inside of the packing pieces, and not just their outer surface. However, the better performance of some packings over others is mostly the result of greater surface area. When the mass transfer rate itself is limiting (not equi-

librium pinched) these results suggest that again random packings are somewhat better performers than their structured brethren.

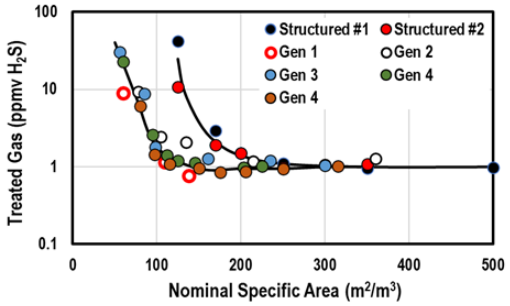

Figure 1 Effect of Specific Area on H_2S in Treated Gas. Structured #1 and #2 Are Two Different 45° Crimp Packings

As Figure 1 shows, at least for the conditions of the case study, structured packings with specific areas below about 200 m^2/m^3 start to show increasingly poorer performance (H_2S > 4 ppmv); whereas, random packings do not start to show lowered performance until the specific area falls below about 100 m^2/m^3. The difference is probably the result of higher levels of turbulence in the gas and liquid flows in random versus structured packing; however, higher turbulence comes at the price of higher pressure drop (or lower gas and liquid handling capacity). So, from the perspective of H_2S removal, random packings show somewhat better performance f*or the same dry specific area*. But from the viewpoint of the temperature bulge (Figure 2), if a satisfactory H_2S content gas is being produced, the temperature bulge is independent of packing type (structured vs. random) and responds mostly to size via packing-size-dependent axial dispersion and mixing.

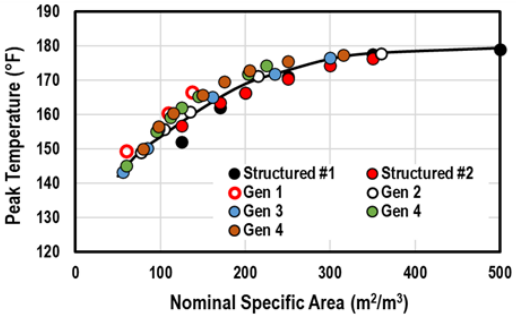

Figure 2 Effect of Specific Area on Absorber Peak Temperature.

Referring to Figure 3, when the specific area of either structured packing is below 250 m^2/m^3, better than 55% of the CO_2 is slipped through the absorber, i.e., is not removed but remains in the treated gas. With random packing of area < 100 m^2/m^3, better than 65% of the CO_2 remains in the treated gas. However, for the same specific area, structured packing slips more CO_2 than random.

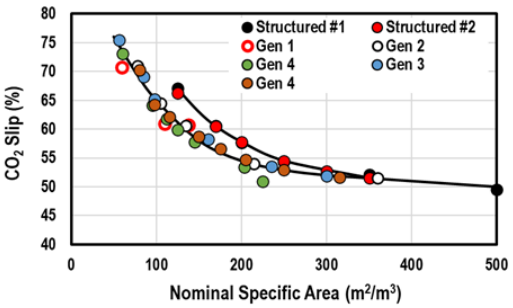

Figure 3 Effect of Specific Area on CO_2 Slip Through Absorber.

Flooding (Figure 4) appears to be a linear function of specific area although it is interesting to note that the larger (smaller specific area) 2nd Generation random packings shows reduced tower capacity (earlier approach to flood), whereas the smaller packings fall in line with Generations 3 and 4. There is some variability in capacity amongst 4th Generation random packings, but their mass transfer performance is pretty much interchangeable.

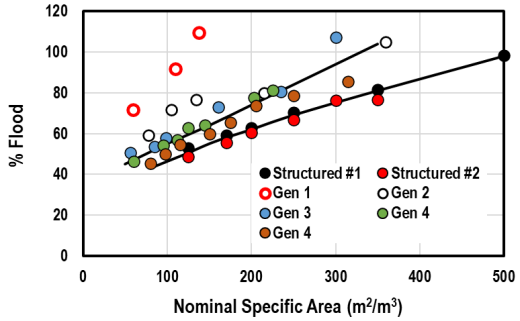

Figure 4 Effect of Specific Area on Flood Performance (Hydraulic Capacity).

These assessments are predicated on using specific surface area as the comparison basis because surface area provides a uniquely quantifiable measure of mass transfer performance, especially in chemically-reactive absorption systems where surface area is the critical, deciding parameter. The theory of chemically-reactive mass transfer suggests that for liquid-phase diffusion-controlled systems with fast chemical reaction, the absorption rate is a function mostly of wetted interfacial area. This work bears that out. It should be pointed out though, that these results may not pertain to distillation or other nonreactive mass transfer separations because then there are no fast reactions, and the importance of interfacial area must be shared with mass transfer resistances in the vapor and liquid phases.

The temperature peak in an absorber is an important parameter that must be controlled to ensure acceptable amine degradation rates and to ensure corrosion rates are within allowances. The peak temperature is rarely measured and even its location is unknown. Thermal imaging is a practical way to provide an estimate of this information in the field; however, high precision mass transfer rate-based simulation is an excellent way to expose this critical process data, and the OGT | ProTreat simulator is state of the art.

Dry specific area (not an amorphous packing size) captures most of the influence of packing parameters on mass transfer performance in gas treating, and the most definitive tool to apply in making a well-balanced decision is the OGT | ProTreat® simulator. Even packing brand is relatively unimportant to mass transfer, although it is crucially important to pressure drop, hydraulic capacity, and in very low-pressure applications such as CO_2 capture or in vacuum service and, of course, it has costs implications.

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