The CONTACTOR™

Published Monthly by Optimized Gas Treating, Inc.
Volume 16, Issue 7, July, 2022

Effects of Packing Type and Size on Treating: Part 1 — LNG Production

In recent years in the gas treating world much attention has been given to two application areas: (a) deep CO_2 removal in LNG production and (2) selective H_2S removal. Columns containing trays or packing have radically different mass transfer characteristics, and both are widely used. Reliably designing an acid gas removal column containing trays appears somewhat more straightforward than with packing, and the effect of parameters such as weir height, numbers of passes and so on are fairly well documented.

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 the brand. With structured packing, even the surface treatment of the (usually) sheet metal used in fabrication can impact the column performance. Liquid and vapour volume loading are not discussed so that the powerful influence of packing geometry is not obscured. 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 mass transfer performance. The effects of liquid and vapour loading are not discussed so as not to obscure

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 implications 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 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 behaviour. (The author is 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 meting the highest engineering standards.)

Gen 1	Gen 2	Gen 3	Gen 4
 Raschig Rings	 Super INTALOX®	 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

We will present two case studies, one in Part 1 and the other in Part 2 of a two-part series The case study here in Part 1 relating to the performance of a CO_2 removal in LNG production was done using a water-saturated feed gas containing 2% CO_2, balance methane at 100°F treated with solvent having 7 wt% piperazine in 38 wt% MDEA at 120°F. Gas and solvent rates, tower diameter (48 inches), and packed depth (30 feet) were kept constant throughout. A system or foam factor was not applied to any calculation.

Deep CO_2 Removal: LNG Production

The range of packings used commercially for CO_2 removal in LNG production encompasses the whole spectrum of random packings, mostly from Generations 3 and 4, as well as structured packings of modest crimp size. Figure 1 compares the absorber performance of four random packings and two structured packings in terms of (a) the CO_2 level achieved in the treated gas, and (b) the magnitude of the temperature bulge within the columns.

The desired CO_2 level in the gas coming from CO_2 removal absorbers is usually < 50 ppmv. To ensure they can meet the treated gas specification, absorbers in this service almost invariably contain a greater depth of packing than necessary, so they tend to be lean-end pinched. This means the treated gas CO_2 content is controlled by the lean solvent loading (moles of acid gas per mole of total amine). In recognition of this fact, the various cases were all run with the lean solvent CO_2 loading set to a value that would comfortably produce gas with less than 50 ppmv CO_2.

Acid gas removal using amines is quite exothermic and usually generates high temperatures in the absorber. A rather large temperature bulge often forms. Its size and location are determined by the relative gas and liquid traffic in the column and, of course, by the exothermicity and rate of the chemical reaction between the acid gas and the amine(s). The magnitude of the bulge is an important parameter that must be controlled because excessively high temperatures cause amine degradation as well as corrosion of the tower shell and internals. The maximum recommended bulge temperature is usually about 185°F (85°C). Unfortunately, absorbers are rarely built with any provision for measuring temperatures anywhere inside the equipment, so often the best that can be done is to infer internal temperatures from simulation. Fortunately, a soundly-based simulator such as OGT | ProTreat® provides a highly accurate assessment of every detail of what is actually happening in the tower. This includes very accurate temperature profiles that can be used to ensure solvent degradation and corrosion rates are known and so kept within limits. The whole assessment can be fully automated when the simulator is connected to OGT | ProBot™.

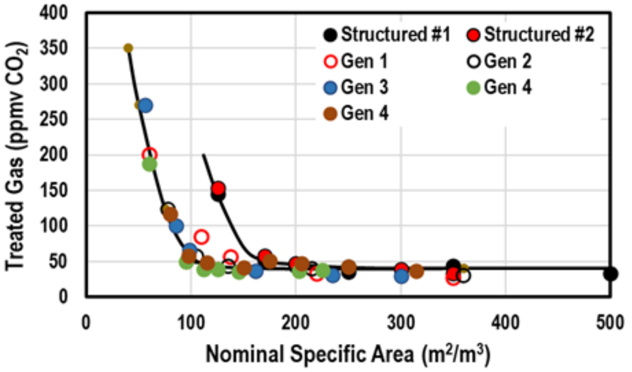

Figure 1 How Packing Type, Style, and Size Affect Treated Gas CO_2 Content in an LNG Unit. Structured #1 and Structured #2 Designate Two Different 45° Crimp Packings

Because packing shapes and structures vary so widely, packing <u>size</u> itself is such a nebulous, ill-defined quantity that it is unsuited for use as a basis for comparison between packings. What packings present to the gases and liquids flowing through and over them however, is surface area. This seems like a much more promising parameter to use when making comparisons. Figure 1 compares packings on the basis of what is termed their *specific area*, which is the area of the dry packing per unit of packed volume. Figure 1(a) shows that, in terms of actual treating, the three Generations of packing all have much the same performance even when the column is not pinched, i.e., when performance is mass transfer rate-controlled. Equivalent mass transfer performance is probably a result of these Generations of packing all giving pretty much full gas-liquid access to the inside of the packing pieces, and not just their outer shell as would be the case with Raschig Rings (1st Generation). The better mass transfer performance of some packings over others is mostly the result of greater surface area. When mass transfer is rate limiting (not pinched) these results suggest random packings are better performers than structured packing, possibly because of lower

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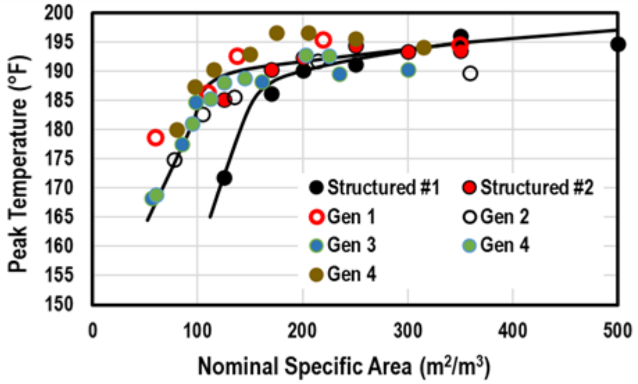

Figure 2 How Packing Type, Style, and Size Affect the Absorber Temperature Bulge in an LNG Unit. Structured #1 and Structured #2 Designate Two Different 45° Crimp Packings

back mixing. As Figure 1(b) shows, however, random and structured packings appear to show equivalent peak temperatures when the < 50 ppmv CO_2 treating goal is being met. What is potentially interesting though is that the greater the specific area (faster absorption rates or more efficient packing) the hotter the temperature bulge. This is because small packings show lower axial dispersion (mixing) than large packings do. Practically then, there is a lower limit to packing size just from a mass transfer performance point of view. Smaller, more-efficient packings are likely to have higher temperature maxima and therefore, solvent degradation and corrosion rates will tend to be more severe. Thus, when selecting packing, it might be better to do so on the basis of cost per unit of specific area, with enough area to achieve the treating goal but not so much as to cause excessive temperatures from the heat of absorption. Of course, this is predicated on achieving satisfactory hydraulic (flood and pressure drop) performance.

Summary

These comparisons are as unbiased as we can make them because OGT | ProTreat® uses only data supplied by the manufacturer of the individual packings. *Mass transfer performance* in LNG-treating applications does not seem to depend strongly on the Generation of random packing so long as the outer walls of the packing pieces are sufficiently open for the interior of each piece to be as accessible to the liquid and gas flows as the exterior. In other words, 3rd and 4th Generations are roughly equivalent and even 1st and 2nd Generation packings are not strikingly inferior (except in flood capacity and pressure drop). These observations pertain to gas treating with chemically reactive solvents, in this case specifically CO_2 removal in LNG production. We will have a lot more to say about this in Part 2 where the case study is based on selective CO_2 removal

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To learn more about this and other aspects of gas treating, plan to attend one of our training seminars. For details visit <u>www.ogtrt.com/seminars</u>.

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