



The CONTACTOR™

Published Monthly by Optimized Gas Treating, Inc.
Volume 15, Issue 8, August, 2021

How Hydraulics Affects Efficiency in Towers — Part 2: Packing

Liquid moves through a packed column in films flowing over the surface of the packing. The packing surfaces have a whole range of orientations from vertical to horizontal, and each orientation will correspond to a film of different thickness flowing with a different net vertical velocity component. Thus, packets of liquid will move with different vertical velocities and this necessarily results in back-mixing. If there is maldistribution of liquid (and therefore also of vapour), axial dispersion is exacerbated. One should certainly expect axial dispersion to depend on packing size—in fact, it probably scales directly with the packing size in any one family of packings.

For both trays and packing, axial dispersion in the vapor phase is usually less significant than in the liquid. In trayed columns, liquid flows are not subject directly to *axial* dispersion. Instead they experience cross-flow dispersion, and with liquid then moving intact from tray to tray. However cross-flow dispersion parallels axial dispersion because both are in the direction of flow. In packed columns, the liquid flow experiences direct axial dispersion. But in an overall sense, the dispersion in these very different setups is similar in effect.

Although useful in the interpretation of measured performance information as expressed by tray efficiencies and HETP values, the issue of phase dispersion is highly relevant in mass transfer rate-based modelling. In such models, the actual separation is computed directly without considering separate efficiency calculations. On each tray, liquid is taken to be completely mixed. Packed columns present a different challenge. They are simulated by discretizing the total bed depth into a number of segments with each segment corresponding to completely back-mixed liquid. At the other extreme, an infinite number of segments in a packed tower would correspond to perfect plug flow of both phases. Figure 1 compares visually how these extremes might affect a separation. The truth is somewhere between these limits. ProTreat® segments packed towers according to general rules of thumb and internally chosen generalised heuristics to achieve best agreement with a library of performance data. There is rough equivalence between a packed segment and a real tray but *these devices have very different mass transfer characteristics* because of different modes of phase contact, so they perform quite differently.

Packing

Mass transfer in packed vs. trayed columns shows almost the opposite dependence on physical properties. Now a discontinuous liquid flows as a film over solid surfaces through a continuous gas, and mass transfer rates are greatly affected by packing size, packing geometry, and in the case of structured packing, by the surface treatment of the (usually metallic) packing. 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 controlling factor. Indeed, random packings come in such a plethora of shapes and physical structures it can be difficult to assign a meaningful size. Figure 2 shows a selection of random packings.

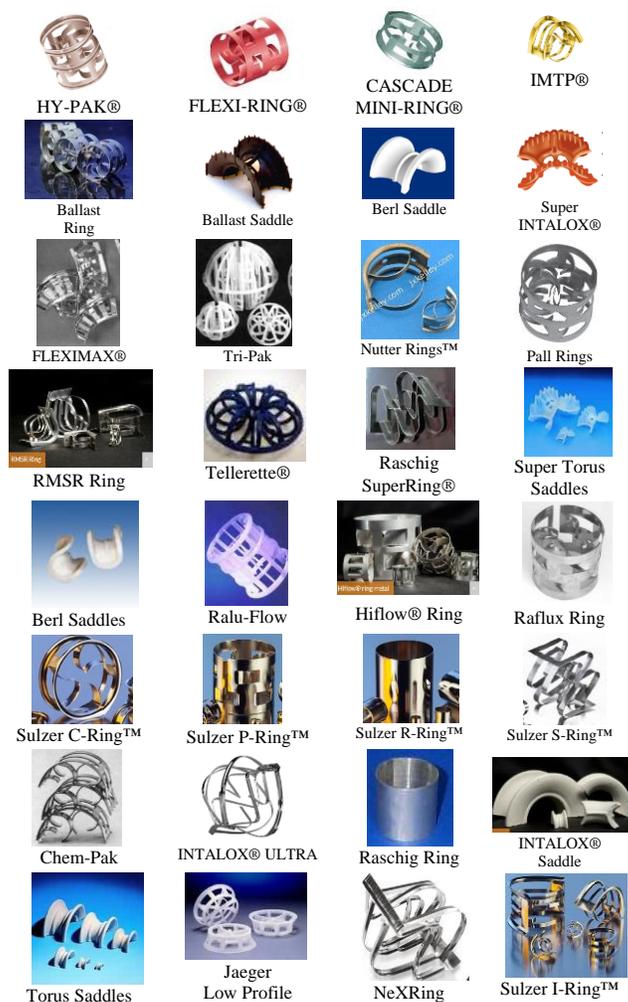
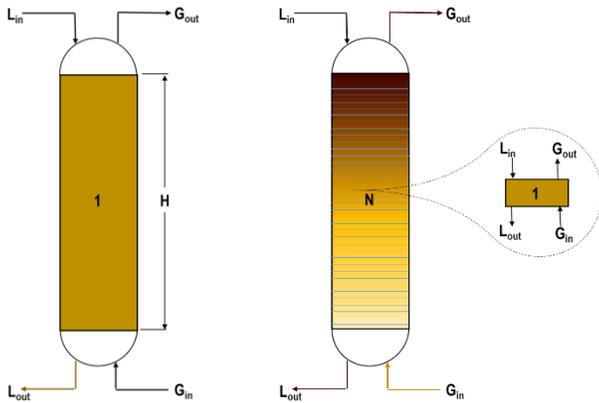


Figure 2 A Selection of Commercial Random Packings

With structured packings, surface treatments such as embossing of the sheet metal improves the ability of the liquid to spread, but perforations are even more important. Communication is poor between adjacent sheets of packing if the metal sheets are imperforate. Figure 3 illustrates how perforations can open up communication and allow the evening out of liquid flows. Thus, flow over perforate sheets is much more uniform than over imperforate sheets, and lack of per-

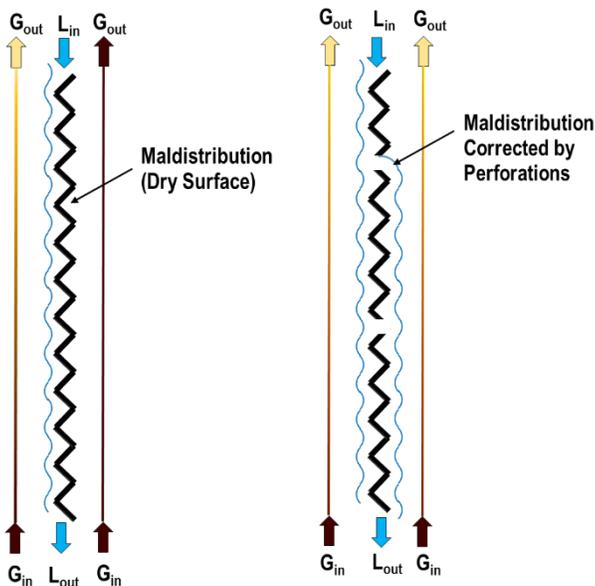
forations only encourages the continuance of liquid (and vapour) maldistribution and uneven flows. Although the liquid is still agitated as it flows over both random and structured packings, it is much less so than the liquid on a tray because its movement is constrained by the thin nature of the film flow itself.



(a) Fully Back-mixed Bed is a CSTR (It Has One Mass Transfer Segment) (b) Highly Segmented Bed Is in Plug Flow — No Back-mixing

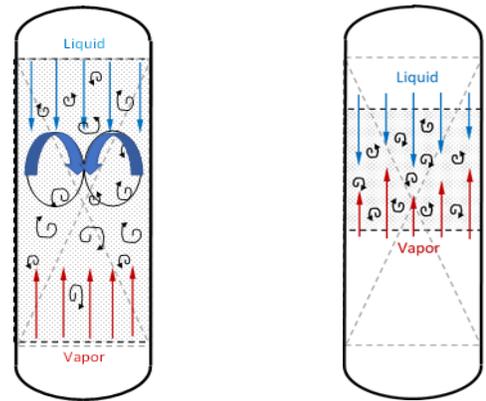
Figure 1 Axial Dispersion in a Packed bed

Structured packings made from wire gauze rather than embossed sheet metal (both are perforated) excel at spreading liquids over much of the packing surface area, particularly when the liquid is flowing at low rates. However, they are certainly more costly than sheet metal and their use is hard to justify at high liquid flows. Gauze packings tend to be small crimp and find their greatest use in low production-rate distillation of fine chemicals (small-diameter equipment) which again limits their use to the low flow rates needed to avoid column flooding from small crimp size.



(a) Maldistribution on a sheet of Structured Packing (b) Packing Sheet Perforations Can Correct Maldistribution

Figure 3 Effect of Sheet Perforations on Liquid Flow over Structured Packing



a) Fully-mixed Bed Has One Mass Transfer Segment (b) Partially Back-mixed Bed has Several Segments

Figure 4 Back Mixing in a Packed bed

Summary: Trays and Packing

Both structured and random packings exhibit strong dependence of effective interfacial area on liquid flow rate, but trays show only a weak dependence. And unlike packing which shows strong correlation of HETP with the design (type) of packing, trays show only weak relationship of efficiency to tray geometry. Exceptions are trays with push valves and guide vanes. Another exception is so-called high (hydraulic) performance trays such as ULTRA-FRAC® and Shell ConSep* where there is no real crossflow, and point efficiencies are the best that can be achieved because phases are centrifugally separated with very short pointwise (no crossflow) contact. These trays, however, have the advantage of enormous processing capacity albeit at the cost of relatively lower efficiency and higher capital cost. Crossflow trays have higher efficiency but with lower gas and liquid handling capacity because the gas-liquid separation is gravity driven rather than through induced centrifugal force.

Structured packing is often selected over trays, especially in glycol dehydration units because of the inherently greater capacity of structured packing. Super high-capacity trays such as ULTRA-FRAC and ConSep are sometimes specified in revamps to achieve a large capacity boost but are rarely specified for new equipment because they leave little room for a capacity increase at a later time.

Efficiency can be improved by increasing the gas-liquid interfacial area either by using finer packing or by using smaller valves such as mini-valves and higher gas velocities through the tray openings. Low viscosity also favours finer gas dispersions in the liquid and thinner more-turbulent film flows on packing surfaces. The effect is more pronounced with packing than trays. Low viscosity also favours increased diffusion coefficients in the liquid and, for liquid-side controlled separation processes, this can provide substantial benefits.

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

ProTreat® and **The Contactor™** are trademarks of Optimized Gas Treating, Inc. Any other trademarks are the property of their owner.