The CONTACTOR™

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Numerical Segmentation of Packed Beds

Trays and packing are different kinds of hardware which require different approaches to modelling in a rate-based process simulator. While both trays and packing bring liquid and vapor into intimate contact, the character of that interaction is quite different. Trays provide discrete zones for liquid and vapor to intermingle above the active area of each tray — with one contact zone per tray. In contrast, a packed bed is a continuous contacting device with uninterrupted gas-liquid contact from the top to the bottom of the bed. Compared to trays, packings support relatively quiescent liquid film flow next to a continuous vapor, rather than vapor being energetically dispersed through the liquid.

Because packing and trays hydraulically function so differently, this dissimilarity must be reflected in their respective computational models. Simulations of trays can follow the obvious path of simulating one rate-based tray for every physically installed real tray. On the other hand, simulating a packed bed requires numerical segmentation.

Packing segments are features of the computational model that do not directly correspond to any dimensional aspect of a packed bed. From a computational perspective, packing segments provide break-points of the counter-current flows in the bed. Choosing the right number of segments is a balancing act between two competing factors:

- Sufficient segments to adequately represent phase and driving force changes in a continuous process, and
- The need to account for the natural non-uniformity and mixing in the axial direction.

On one hand, finer segmentation provides more precision in property and composition profiles because it gives a closer approximation to a continuously changing profile. Since properties are calculated at every boundary between segments, increasing the number of segments causes more frequent updating of properties and driving forces for the heat and mass transfer rate calculations.

On the other hand, increasingly finer segmentation also causes the liquid and vapor phases to approach plug-flow behavior. In real physical packed beds, there are several influences which actually prevent this ideal plug-flow behavior. Some of these factors are:

- Variations in flow paths which can be caused by nonuniform loaded packing density, angle of rotation between layers of packing, installation of wall wipers etc. Some flow paths are shorter and some are longer, so axial velocity, even across, or through, a single packing piece, is not perfectly constant in either phase.
- Even well-designed and installed liquid and vapor distributors provide good – but not perfect – distribution of the feed streams over the cross section of the tower

These, and other, departures from ideality are present to some extent in every real packed bed. Thus, finding the right level of segmentation for a model is a balancing act. Too few of segments fails to capture changing properties and too fine of segments will overestimate driving forces.

For most simulation work using ProTreat®, there will never be a need to delve into the complications of packing segmentation. ProTreat's default segmentation has been determined to produce results that compare well with measured plant data in a variety of applications. It accounts for a reasonable and typical amount of axial back-mixing balanced with frequent enough intermediate property and driving force calculations to give good precision.

When designing new towers or doing revamps, OGT recommends using ProTreat's default segmentation. Should there be a desire to make the simulation results more conservative, we recommend adjusting the target treating level, amine circulation rate, or other physically meaningful parameter to a conservative value. One should avoid adjusting segmentation as a way to make designs more conservative.

In some cases, matching plant operating data may require adjustments. In general (but not always), using finer segmentation (more segments) yields better predicted treating performance while coarser segmentation (fewer segments) leads to worse treating performance. However, if matching plant data requires significant adjustment away from default segmentation, this may be an indication of maldistribution, nonuniform packing density, or other issues in the tower.

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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 www.ogtrt.com/seminars.