

The CONTACTOR™

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Effect of Packing Size on Absorber Bulge Temperature

In the July issue of The Contactor™, we discussed how the exact shape of absorber temperature profiles, as well as the position and value of the temperature bulge depend on the chemical system and the operating conditions of the absorber. In the current issue, we discuss how *packing size* alone directly and very significantly affects temperature profiles even when all the operating conditions are kept the same. Perhaps it's not too surprising that the *position* of a temperature bulge is packing-size dependent. But *the bulge temperature itself can be much higher when large packing sizes are used*, a finding that may seem somewhat counter intuitive.

There are two different scenarios: (a) design of a new column, and (b) revamp of an existing column. In the first scenario, one is free to choose the column diameter so as to achieve a specified flood condition. Large packings have lower pressure drop and flood later than small packings do. In this case column diameter and the vapor and liquid velocities through the column depend on packing size. One might expect somewhat different mass transfer performance because mass transfer coefficients depend on phase velocities. In the second scenario, the column diameter is fixed regardless of packing size, so the vapor and liquid velocities are also fixed and independent of packing size.

Revamp of an Existing Absorber

To isolate the effect of packing size from all other parameters, we start with the revamp case. The tower to be revamped with new packing is 10-ft diameter with sufficient height to hold a 40-ft depth of random packing. The packing series under consideration is IMTP in all commercially available sizes from #15 to #70. Solvent and flow rates are constant at 1,000 USgpm and 250 MMscfd, respectively. Inlet gas is at 850 psig with 2% CO₂. The solvent is 32 wt% MDEA with 8 wt% piperazine.

Figure 1 shows temperatures profiles for these packings as predicted by ProTreat® simulation. There are two striking observations:

- Small packings have a sharp temperature bulge very close to the bottom of the absorber, but the bulge becomes ever broader as larger packings are used, and
- *Much* higher bulge temperatures are predicted to occur with large packings — the larger the packing, the higher the temperature

Why do the profiles become so broad, and why is the bulge temperature so much hotter with very large packings when there is almost complete absorption of CO₂ (> 99.9%) and identical heat released in all cases?

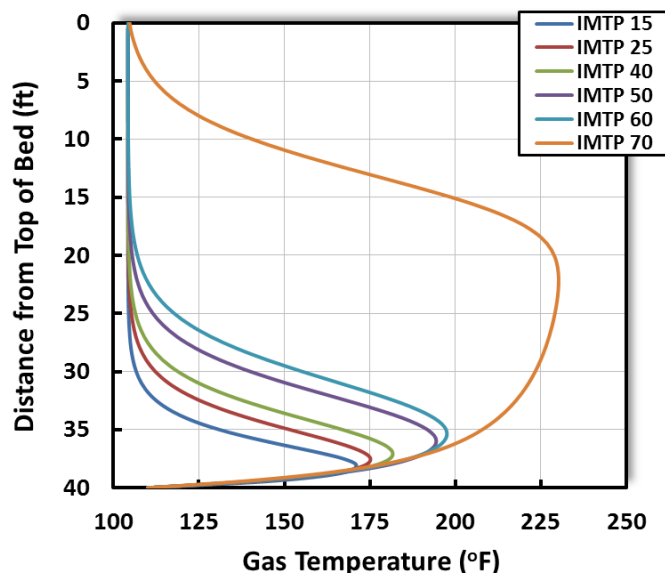


Figure 1 Revamped Absorber Temperature Profiles and Packing Size Dependence

Apart from the effect of temperature, the mass transfer coefficients do not vary widely from one packing to another. However, as Table 1 shows, the interfacial area varies markedly and, of course, at the same gas and liquid flow rates, flooding is further advanced with small packings. Note: values of the area in the table have been rounded, and sizes correspond roughly to packing diameter.

It is simplest to address the breadth and position of the bulge first.

Table 1 Dry Area and Flood vs. Packing Size

Size	Specific Area [†] (m ² /m ³)	% Flood
15	290	94.6
25	230	71.5
40	155	65.3
50	100	52.4
60	85	49.7
70	60	47.4

The #15 packing has nearly five times the area of the #70 packing. One should expect, therefore, that the CO₂ will absorb in a much shorter packed depth. Indeed, this is what happens.

Almost all the gas is absorbed in the bottom 10 feet of the #15 packing. With #60 packing the bottom half of the bed is used, and with #70 packing, all but the top five feet are highly active. The width of the temperature bulge corresponds roughly to the actively absorbing region of the bed.

The lesson is that because larger packings have smaller surface areas, they need a greater proportion of the packed bed for absorption, and the temperature bulge is therefore broader. Of course, at the extreme ends of the absorber, phase temperatures return closer to the temperature of the entering liquid or gas. The remaining question is why larger packings produce much hotter bulge temperatures.

Packings with smaller dry area necessarily have smaller wetted area, and they also have smaller liquid holdup volume. In the case considered here, there is the same total extent of absorption regardless of the packing size. Thus, there is the same heat released into a smaller liquid volume as into the larger one. Consequently, the smaller liquid volume associated with a larger packing must become hotter.

Interestingly, this effect is barely discernable in the outlet gas and liquid streams. The relative coldness of the feed gas and liquid streams dominate the top and bottom temperatures and confine the high temperatures to the column interior, away from the ends. However, keeping tower interior temperatures below a critical value is paramount in controlling what could become runaway corrosion. If one is unaware of how hot the temperature bulge can really become, it's impossible to account for it in design. Ideal stage simulators, even with efficiencies and other embellishments are incapable of

predicting this aspect of packing behavior. Only the ProTreat® simulator's mass transfer rate basis allows accurate assessment.

Designing a New Absorber

New column design for a specified flood rating presents an even greater response to packing size. Figure 2 shows profiles for a design case using identical gas and liquid flows, compositions and inlet temperatures to the revamp case. Again, the absorber contains 40-ft of packing but now is sized for 70% flood.

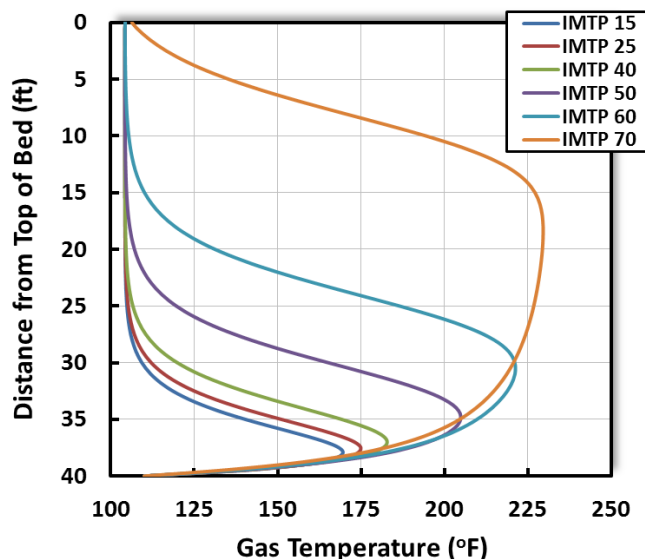


Figure 1 Temperature Profiles in New Absorber, Designed for 70% Flood

Part of the reason for broader bulges in this scenario is that at high loads the liquid flow becomes retarded, the liquid film coefficient drops and absorption slows. The value of temperature at the bulge is about the same in either case, perhaps indicating liquid holdup volume is somewhat insensitive to liquid and vapor loads. The interaction amongst operating parameters in the design case is quite complex because now hydraulics change even more with packing size.

Only the ProTreat simulator's use of a highly accurate mass transfer rate model tuned to extensive operating data is capable of reliably predicting the location and magnitude of critically important temperature bulges in packed columns, whether in revamp, troubleshooting, or design.

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.

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[†] Specific area is dry packing area per unit of packed volume.