The CONTACTOR™

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Confidence in Design — Effect of Packing Size

In the June issue, we looked at some general recommendations and possible issues when considering packing, both random and structured. The current issue examines the effect of the size of a particular brand of structured packing (FLEXIPAC-X series) which was selected without prejudice.

The context for the present analysis is the deep CO_2 removal typical of LNG production facilities. The packings considered are FLEXIPAC 1X, 1.4X, 2X, 3X and 4X. From size 1X to 4X, these packings have increasing crimp size, and decreasing specific surface area (dry area per unit packed volume). Thus, for the same gas and liquid rates, they will have increasingly thicker and faster moving liquid films and increasing levels of turbulence in the gas. In other words, their gas and liquid mass transfer coefficients and their interfacial areas all change from one packing size to the next. Table 1 describes the raw gas common to all the cases in the study.

Table 1 Raw Gas Used in Case Study

Conditions	
Temperature (°C)	37.2
Pressure (bara)	64.4
Flow (Nm^3/d)	6,700,000

Composition (mol%)			
H_2S	0.0001	iC4	0.020
CO_2	2.000	nC5	0.006
C1	94.331	iC5	0.010
C2	1.900	nC6	0.030
C3	0.170	CH_3SH	0.0007
nC4	0.030	N_2	1.500

The solvent is 50 wt% GAS/SPEC-1160 flowing at 204 m^3/h and 50°C. The flowsheet is a conventional absorber-regenerator arrangement with the usual flash tank, cross exchanger, trim cooler and flow controller. The regenerator has 13.7m (45 ft) of FLEXIPAC 3X packing in all cases. The absorber has 15.25 m (50 ft) of various crimp designations. In all cases the columns were automatically sized for 70% of flood and diameters ranged from 2825 mm for the smallest crimp to 1885 mm for the largest. Reboiler duty was kept fixed at 13.5 MW and the molar stripping ratio was typically 1.12 in the regenerator overhead line

Table 2 is a synopsis of the simulated treating performance. The smallest size designation has the largest dry area and treats to the lowest residual CO_2 level. Note that although there is an inverse relationship to area and treated gas CO_2 content, it is highly nonlinear—treated gas quality is a *very* strong function of dry area, i.e., packing size.

Table 2 Simulated Treating Performance, Bulge Temperature, and Bulge Position

	Dry Area	Outlet Gas CO_2	Bulge Temper-ature	Peak Temp from Top	Area Ratio Wetted/ Dry
Size	m^{-1}	ppmv	°C	m or Tray No.	unitless
1X	440	0.45	88.9	13.4	0.614
1.4X	340	0.46	96.9	13.1	0.741
2X	220	1.79	114.8	9.0	0.973
3X	110	108	110.3	7.0	1.332
4X	55	516	105.4	7.0	1.691
25T		0.93	88.9	T- 20	

There's a surprizing effect here: wetted area can exceed dry surface area! All the liquid flow is not restricted to the packing surface when the film becomes thick (as it must when packing area decreases by factors of four and eight as it does for the largest crimp. With very thick films, the flow becomes disrupted, large waves form, and a certain amount of gas sparging occurs.

The last line in Table 2 refers to 25 trays which, at 2-ft spacing, would fit just nicely into the 50-ft packed height. In many ways, tray performance is close to the performance of the smallest packing, but this is definitely not because of higher surface area for mass transfer. Indeed, in this case, the equivalent surface area based on the volume between any two trays is around 130 m^{-1}; whereas, the column-average wetted area for 1X packing is twice as large at about 270 m^{-1}. Instead, the intense agitation on the trays gives a mass transfer coefficient almost four times larger than for the 1X packing (This also turns out to be true for all the packing sizes in the FLEXIPAC family).

Perhaps the first lesson to be taken from this is that packing, regardless of type, is no more challenging to a true mass transfer rate based simulator than trays. Secondly, one cannot simply scale up the effect of packing size in any simple or logical arithmetic way. Packing performance is a complex function of packing size, hydraulics, and chemical reaction kinetics. Additionally, the effective wetted area active on a structured packing is not limited to the packing's dry area, so scale-up based on dry area could be wrong by several fold. In short, scale-up based on random and structured packing *size* is simply not feasible; for example, one cannot predict the performance of 2X packing from knowing how 1X performs. The only way forward is with mass transfer rate-based simulation capability such as that offered by ProTreat®, soundly based on principles of mass transfer.

In gas treating, there is much to be learned from looking at column profiles of temperature and composition (or component flow), and understanding the effect of packing size on separations performance is no exception. The gas-phase CO_2 profiles in Figure 1 for 1X and 1.4X packing are nearly coincident. Thus, it can be seen that for such small-crimp packing the final treating level is determined by the partial pressure of CO_2 in equilibrium with the entering lean amine, not by mass transfer rates. In other words, the absorber with very fine packing is completely lean end pinched. The treated gas CO_2 content is almost the same with 25 trays on 600 mm tray spacing as with 15 m of fine packing, but the absorber does not exhibit quite the same degree of lean end pinching as the packing (although it is still pinched because the top 6 trays reduce the CO_2 in the gas by less than 1 ppmv). However, with 2X and larger packing treating ceases to be lean end pinched.

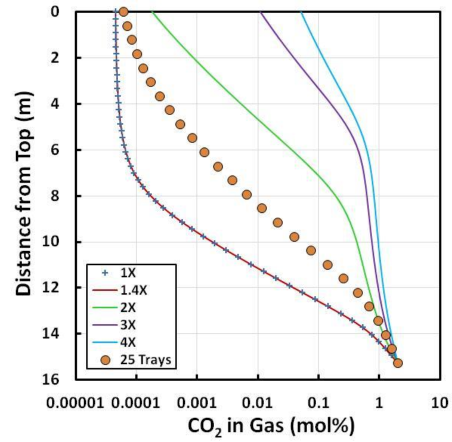

Figure 1 Absorber CO_2 Profiles in the Gas for Various Packing Sizes and for Trays

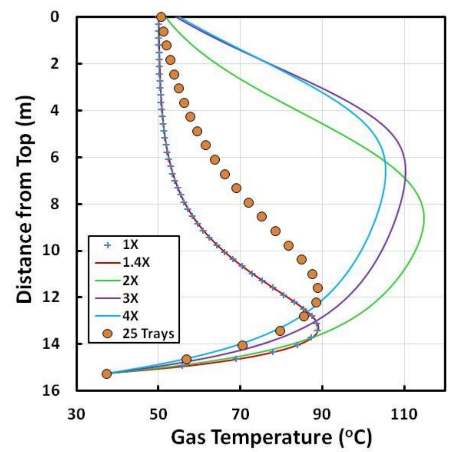

Figure 2 Absorber Temperature Profiles for Various Packing Sizes and for Trays

Figure 2 shows that coarse packing results in a larger temperature bulge which moves up the column. Actually, the absorber with 2X packing is already bulge pinched.

As we have shown repeatedly, ProTreat provides detail and accuracy without using adjustable fitting parameters of any kind.

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

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