The CONTACTOR™

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# Pinches and Profiles

Wider use of mass transfer rate based simulation has encouraged greater recognition that absorbers can operate under pinched conditions of various kinds. This issue of The Contactor uses a case study to look at just what a pinch is, and how you can tell if a column is in fact pinched.

## Case Study — $CO_2$ Absorber in an LNG Plant

The case involves carbon dioxide removal using a solvent with 33 wt% MDEA promoted with 7 wt% piperazine. The gas contains 20 mole% $CO_2$ at 16 barg pressure and flows at 80 $kNm^3/h$ (68 MMscfd). The $CO_2$ content is to be reduced to below 50 ppmv, suitable for liquefaction. The absorber was originally designed with 30 actual trays; however, to emphasize our observations, we have simulated the column as though it contained 40 trays.

Figure 1 shows the simulated temperature profiles of vapor and liquid in the absorber with the solvent flow rate set at 350 $m^3/h$. It appears that the temperature is uniform across the top 20 trays.

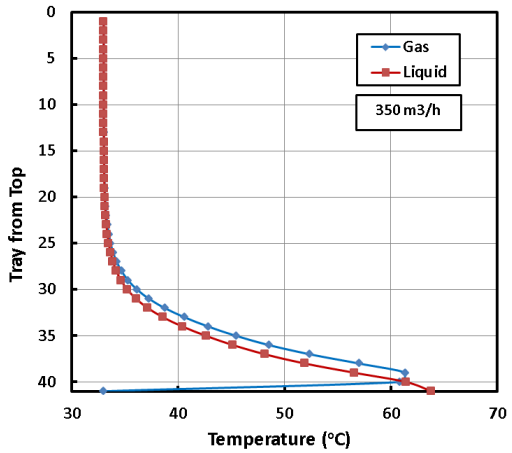


**Figure 1 Gas and Liquid Temperature Profiles at High Solvent Flow Rate**

This *could* be interpreted to mean that all the absorption is taking place in the bottom half of the column. If this is true, the column might be lean-end pinched, meaning that the treating level is determined by the lean loading (and temperature) of the solvent. But is this in fact the case?

Figure 2 shows the *actual* carbon dioxide concentration in the gas above each tray plotted against the tray number (**blue** points and line), as well as the $CO_2$ concentration in the gas in *equilibrium* with the liquid on each tray (**red** points and line). Across the entire column there is a very substantial difference between the actual and equilibrium values of the $CO_2$ concentration. In other words, from a mass transfer standpoint, there is substantial absorption driving force everywhere.

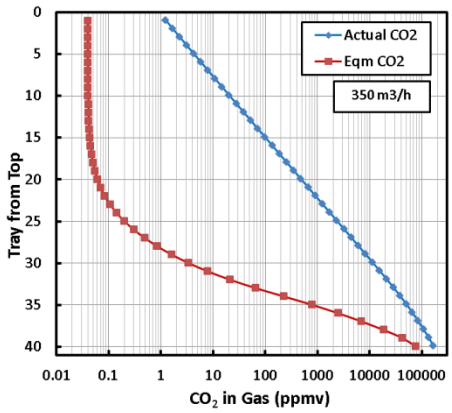


**Figure 2 Actual & Equilibrium $CO_2$ Profiles**

***A column is pinched only if the driving force for absorption is zero, or nearly zero, somewhere in the column.*** If there is more than one component being absorbed from the gas, the column can be pinched with respect to one or both components, or neither.

In the case study, the concentration-difference driving force isn't zero anywhere in the column. Despite our first impressions from the simulated temperature profiles, the absorber under these conditions is not operationally pinched at all.

*Temperature profiles are an unreliable indicator of pinched operation. One must examine the mass transfer driving force everywhere in a column to arrive at a correct assessment*.

Certainly there are more trays than necessary to reach 50 ppmv $CO_2$ in the treated gas, but the solvent flow rate is also too high. When the solvent flow is dropped to 295 $m^3$/h, the temperature profile changes slightly (Figure 3) but it still remains flat across the upper 15 trays.

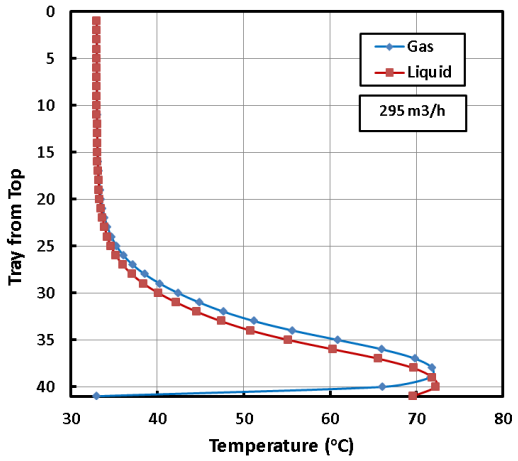


**Figure 3 Temperature Profiles at 295 $m^3$/h**

Again, this might be suggestive of a lean-end pinch because not much appears to be happening at the lean end of the column. However, Figure 4 shows that, if anything, the column is on the cusp of a pinch, *not at the lean end, but at the rich end*, right at, and below, the temperature bulge!

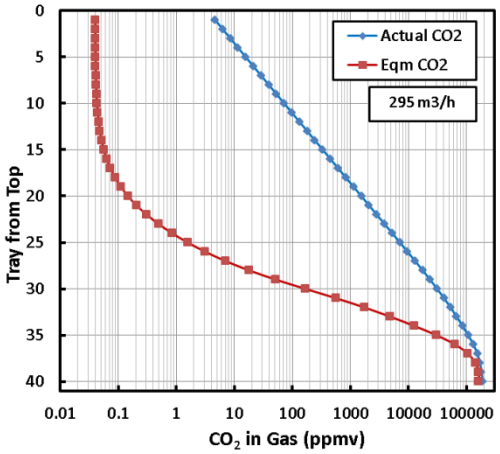


**Figure 4 Concentration Profiles at 295 $m^3$/h**

The absorber is still making much better than 50 ppmv gas so, in view of an impending pinch, we *cautiously* drop the solvent flow by another 5 $m^3$/h. Figure 5 shows the result. The entire *bottom* half of the column has lost all the driving force for absorption. The absorber now appears to be unequivocally *rich-end pinched*.

The temperature profile is interesting, too. Figure 6 shows that what was a fairly localized bulge in the bottom quarter or so of the column (Figure 3) has suddenly grown to occupy the entire bottom half. And it spreads until it meets sufficiently cold solvent. Furthermore, adding trays will not help—they will simply add to the dead zone.

In this case study there is potential for playing off tray count against solvent flow to optimize performance. But without a mass transfer rate model, the sudden transition and the true meaning of a pinch would remain at best obscure.

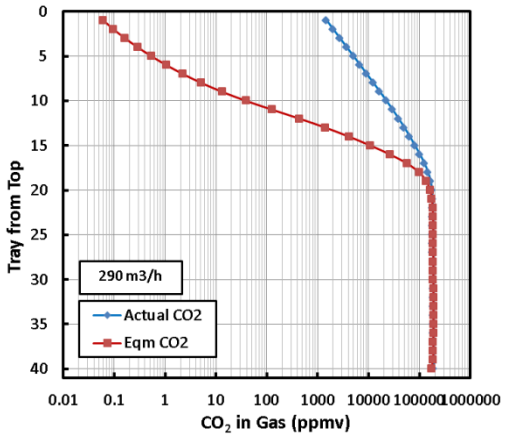


**Figure 5 Concentration Profiles at 290 $m^3$/h**

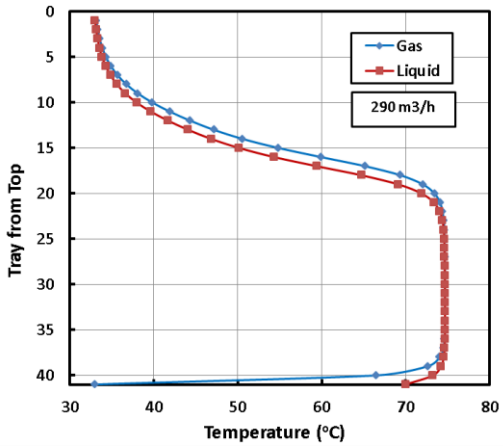


**Figure 6 Concentration Profiles at 295 $m^3$/h**

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