The CONTACTOR™

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Mass Transfer Pinches in Amine Treaters

Part I: Lean-End Pinch Using MEA

Absorbers used in amine-based gas treating almost invariably show a maximum temperature at some position along the height of the column, or occasionally at the very top or bottom. However, their operation usually falls squarely into one of four modes: (1) lean-end pinched, (2) rich-end pinched, (3) bulge pinched, and (4) not pinched at all. Understanding and awareness of pinches and their causes can be very useful in diagnosing column malperformance, and in design and optimization.

An operational pinch of a component occurs in a column when the *actual* partial pressure or concentration of the component in the vapor leaving a tray approaches closely to the *equilibrium* vapor pressure or concentration of that component on the same tray. When this happens, the driving force for absorption (or stripping) of the component essentially vanishes and its absorption ceases.

Before the advent of selective treating when it became both possible and desirable to leave a substantial amount of carbon dioxide in the treated gas, most gas treating was lean-end pinched. This issue of The Contactor™ aims to describe with some precision just what a lean-end pinch is. Traditionally MEA was used to remove all the carbon dioxide and hydrogen sulphide from the gas. Contactors had 20 trays and the treated gas contained concentrations of the acid gases that were essentially in equilibrium with the lean solvent entering the top of the absorber.

Case Study: Classic Gas Treating with MEA

Before selectivity became an important consideration, gases were treated with MEA, and later with DEA and DGA®, to remove the acid gases completely. Figure 1 shows the gas and liquid temperature profiles across a 20-tray absorber treating 2 x 10^6 SCMD of 1% H_2S and 2% CO_2 in predominantly methane at 66 barg. Solvent flow is 1325 L/min of 20 wt% MEA. Across the upper 10 trays the phase temperatures change by less than 1^{o}C, and no change is discernable across the top five trays. This has the outward appearance of a lean end pinch because temperature change is often taken as a good indication of the extent of acid gas absorption. However, true *pinch* conditions can be certified only by examining composition profiles.

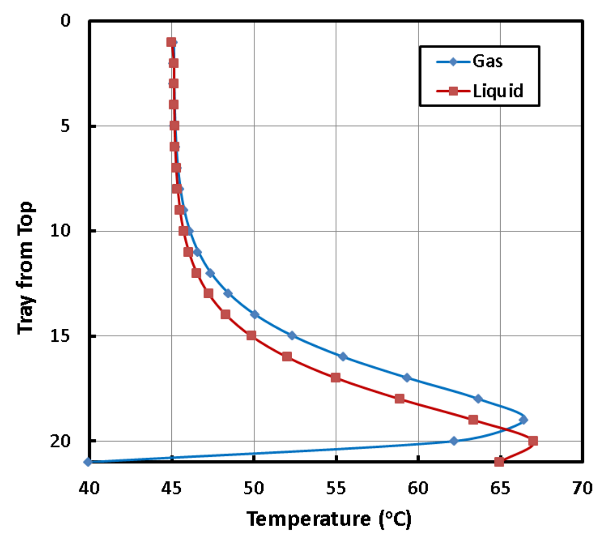

Figure 1 Gas and Liquid Temperatures in an MEA Absorber

The actual concentrations of H_2S and CO_2 (ppmv units) over each tray are compared with the equilibrium values in Figures 2a and b. Note the *logarithmic* concentration scales.

Across the upper six trays there is no discernable departure of the H_2S concentration from the purely equilibrium value, both of which remain constant (Figure 2a). Clearly, hydrogen sulfide absorption is truly lean-end pinched—the treated gas is in nearly perfect equilibrium with the lean solvent. The pinch criterion that the actual concentration is at the equilibrium value is met and hydrogen sulfide absorption is pinched across the upper five or six trays. Carbon dioxide absorption is nearly (but not quite) pinched but only on the very top tray. Using a few more trays would generate a more clearly defined pinch condition for CO_2 absorption.

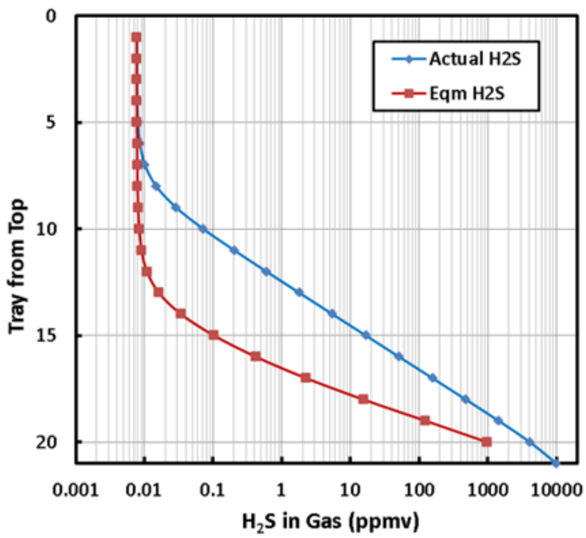

Figure 2a H$_2$S Distribution in the Absorber

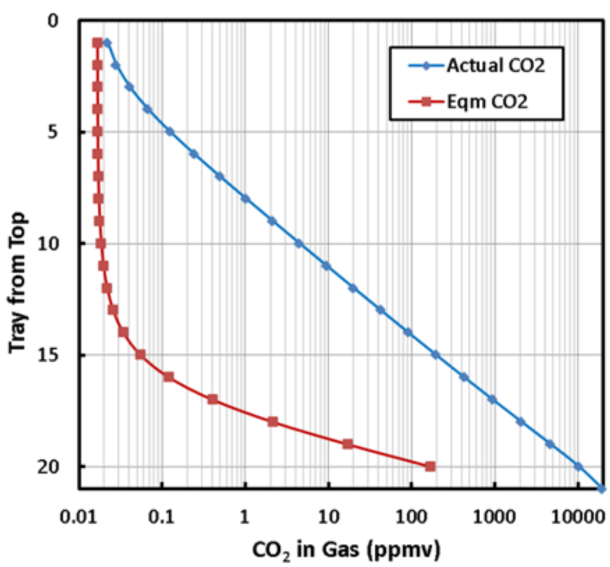

Figure 2b CO$_2$ Distribution in the Absorber

A lean-end pinch does not mean that *both* acid gases have their removal limited by a close approach to equilibrium at the top (lean end) of the column. As seen here, H_2S removal is finished by the time gas reaches the sixth tray from the top. But carbon dioxide continues to be absorbed across the whole column.

Temperature profiles alone cannot be relied upon to indicate pinch conditions, at least not for lean-end pinches. It is mandatory that one examine a real-tray by real-tray plot of *equilibrium* and *actual* compositions across the column before judgment can be passed. ProTreat® offers the ability to do just that by providing both the actual and equilibrium acid gas concentrations over the solvent on each tray.

If one wishes to treat gas to lower H_2S but the absorber is already lean-end pinched with respect to H_2S, there is absolutely nothing to be gained (and possibly something to be lost) by adding trays. Indeed, adding trays may have the *reverse* effect because the extra trays may absorb even more carbon dioxide, increasing the back pressure (vapor pressure) of hydrogen sulfide over the partially loaded solvent and reducing H_2S pickup, not increasing it. In a lean-end pinched absorber, the way to improve the level of treating is to reduce the vapor pressure of the acid gas(es) over the lean solvent. The easiest ways to do this are (a) to reduce lean loading by harder stripping, and (b) to lower the lean solvent temperature.

Pinch conditions in the operation of amine absorbers are more ubiquitous than many engineers realize. To provide an optimal design for a plant and to troubleshoot defective operations, one must be cognizant of where pinch conditions are on the operating diagram. The best way to do this is unquestionably through mass transfer rate based simulation. ProTreat® allows you to analyze operations in insightful detail, avoid missteps, and make the right design and operational decisions from the outset.

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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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