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The Case of the Corroding Regenerator

This case study arose from a serious corrosion problem in a regenerator column stripping CO_2 from an MEA solvent being used for recovering CO_2 from a coal-fired power plant flue gas. The regenerator was experiencing repeated episodes of very rapid corrosion of its carbon steel shell, requiring frequent shutdown for patching the shell. Our investigation focuses on CO_2 loading profiles in the regenerator and what influences them.

The process flowsheet is a completely conventional one typical of amine treating and includes a lean-rich exchanger with trim cooler for lowering the lean amine temperature to one suitable for CO_2 absorption. The CO_2 content of the quenched combustion gas was about 12% mixed with nitrogen and several percent oxygen from excess combustion air. There were parts per million of CO, N_2O, NO, HCN, and methane. The solvent was a filming 17 wt% MEA solution, and the target rich CO_2 loading was 0.42 mol/mol.

The regenerator was a 26 valve-tray column with rich amine fed to the fifth tray from the top. The upper four trays were 1-pass reflux trays on 24-inch spacing, and the rest were 2-pass on 30-inch spacing. The original design assumed the rich amine feed was preheated to 206°F with the column reboiled using 38,500 lb/h of 50 pound saturated steam. Condenser temperature was 105°F, and 10% of the reflux was absorber wash water.

After operating for several years with only minor corrosion, the regenerator had begun to experience severe corrosion to the extent that repeated shutdowns had become necessary to cut out and patch parts of the shell that had reached the code thickness limit. High corrosion rates started becoming a regular problem. Of course, oxygen in amine systems is known to cause problems such as amine degradation which can generate corrosive degradation products. (The system included solvent reclaiming.) It can also directly oxidize and otherwise corrode carbon steel components. That's why the amine as provided by the solvent supplier contained a filming inhibitor.

Analysis by Simulation

Everything that could have reasonably been done to prevent corrosion was already being done routinely. Therefore, the most plausible explanation for corrosion was abnormally high levels of CO_2 in the regenerator. At *design* conditions, ProTreat® simulation did not show anything suspicious in terms of excessively high expected CO_2 loadings anywhere in the column. Profiles of temperature and loading across the stripping trays are shown in Figures 1 and 2, respectively.

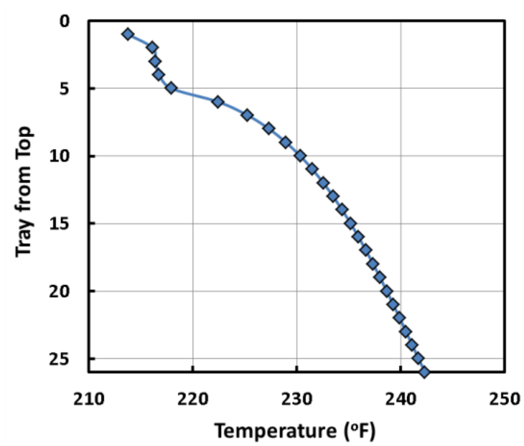

Figure 1 Regenerator Temperatures — Design

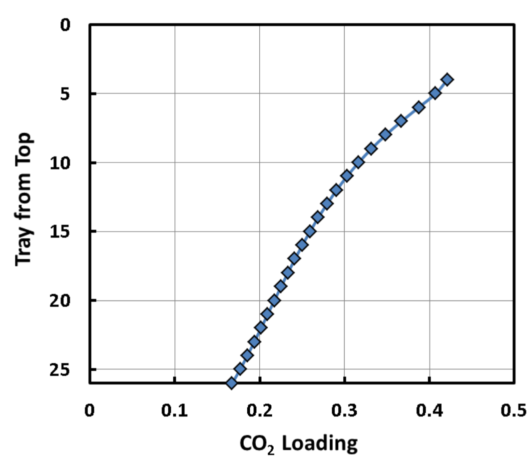

Figure 2 Regenerator CO_2 Loadings — Design

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The relevant operating parameters for a case *with known corrosion issues* included a rich amine temperature of 192°F and a reboiler steam flow of 35,400 lb/h (8% below design). Under these conditions the stripping ratio went from a respectable 2.5 to only 0.7 moles of water per mole of acid gas in the stripper overhead. The regenerator temperature and CO_2 loading profiles took on the forms shown in Figures 3 and 4.

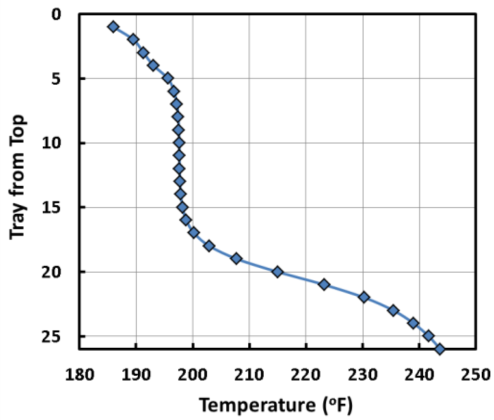

Figure 3 Regenerator Temperatures — Corrosion

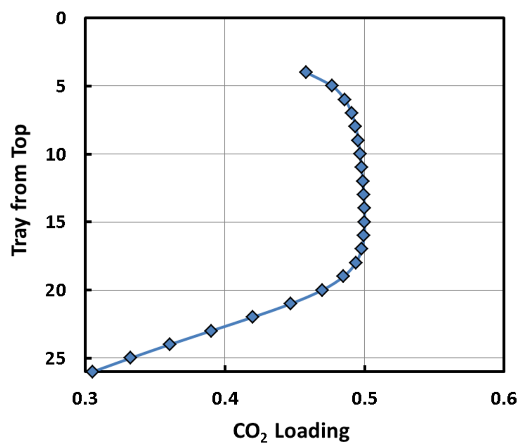

Figure 4 Regenerator Loadings — Corrosion

The normal stripping-tray temperatures shown in Figure 1 had collapsed to a very cold condition across the upper 10–15 stripping trays in Figure 3. More telling is the CO_2 loading profile. Temperatures in the upper part of the regenerator are so low that the solvent is actually reabsorbing CO_2 as it runs down the column. Over a substantial part of the tower the CO_2 loading exceeds 0.5 mol/mol. *This is a very corrosive, hot solution with high carbonic acid content*.

A parametric study was done to determine the effect of rich solvent feed temperature on regenerator characteristics when the reboiler duty was on the low side, i.e., minimal. Figures 5 and 6 show temperature and loading profile responses to

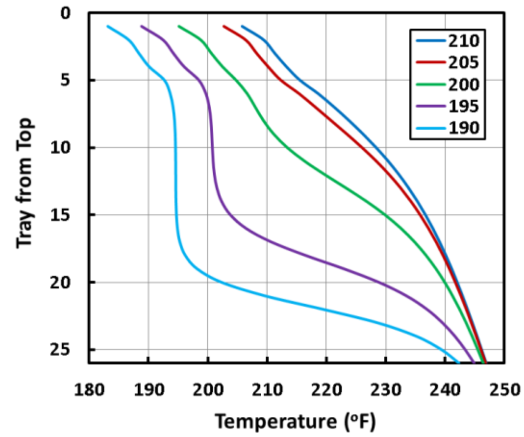

Figure 5 Regenerator Temperatures — Sensitivity

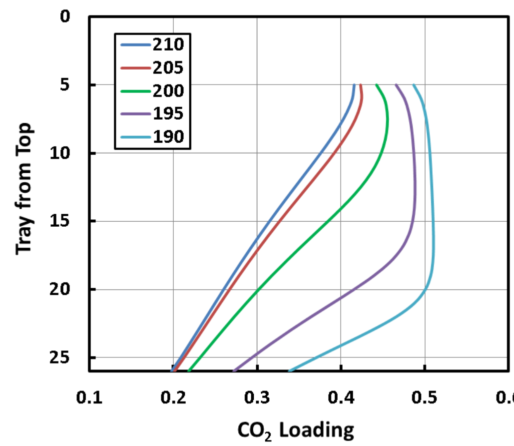

Figure 6 Regenerator Loadings — Sensitivity

changing rich amine feed temperature.

At rich amine temperature below about 195°F, loading profiles in the regenerator migrate into the high-corrosion-rate zone where loading is over 0.5 on many hot trays. ProTreat's corrosion model indicates a 200 mpy corrosion rate (6 month service life) for mild steel at these conditions.

Rich amine temperature is set by exchanger geometry, reboiler temperature, and indirectly by power plant load (determining available CO_2 and therefore solvent rate). Loading curves shift because hot feeds strip more deeply. One must either lower the CO_2 recovery rate by feeding less flue gas to the system, or increase reboiler duty. In this case, corrosion is potentially highly sensitive to small changes in certain operating parameters.

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