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Behavior of HCN in Sour Water Strippers

HCN is a common refinery gas that finds its way into the sour water system and eventually must be processed in the sour water stripper (SWS). As an acid, it is captured by ammonia and this can result in a surprising distribution within the stripper itself. What follows is a case study in which different levels of HCN in the sour water are treated in the flow arrangement shown in Figure 1. The sour water is as shown in Table 1. The HCN levels

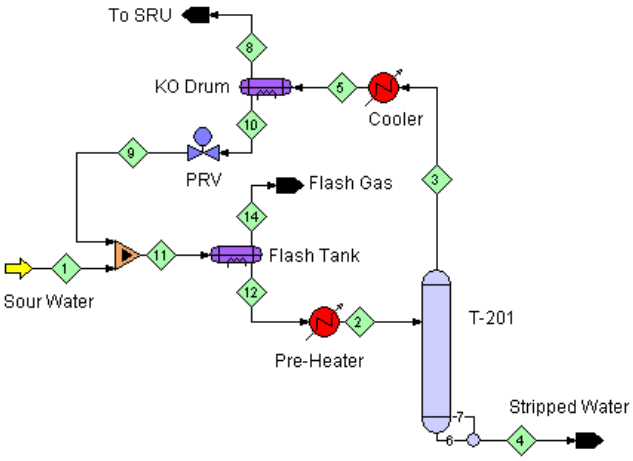


Figure 1 Simplified SWS Flow Sheet

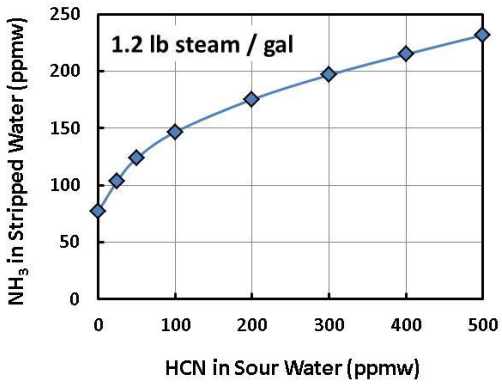
range from 0 to 500 ppmw. Two reboiler steam flows are considered: 1.2 and 1.4 lb of 60 psig saturated steam per gallon of sour water.

Table 1 Sour Water Being Treated

Temperature (°F)	100
Pressure (psig)	9
Flow (bbl/d)	16,500
Composition (ppmw)	
CO_2	50
H_2S	8,000
HCN	0 – 500
NH_3	4,500
Thiocyanate	30
Chloride	35

The stripper contains 33.5 total ft of IMTP 40 random tower packing distributed between three roughly equal beds. Sour water feed (Stream 11) is preheated to 245°F and the tower top and reboiler pressures are 22 psig and 24.5 psig, respectively.

ProTreat® simulation treats the stripping of CO_2, H_2S, HCN and ammonia in the SWS on a strictly mass transfer rate basis. As shown in Figures 2, the presence of HCN in sour water has a decidedly negative effect on the residual ammonia level in the effluent water. This is notably the case



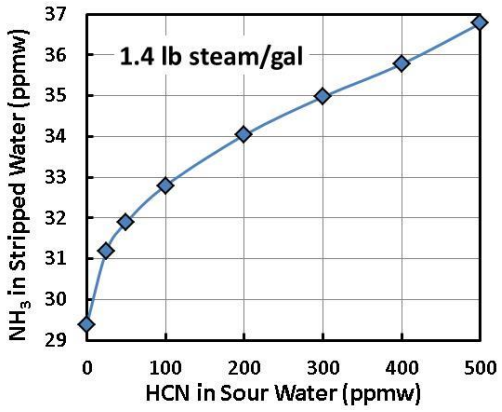


Figure 2 Effect of HCN on Ammonia in the Stripped Water

if the boilup rate is on the low side. Being an acidic component, HCN reacts with ammonia

$$HCN + NH_3 \rightleftharpoons NH_4^+ + CN^-$$

and this results in a certain amount of HCN and ammonia being dragged down the column in the water. In other words, because the ammonium and cyanide ions are nonvolatile, the *total* ammonia and HCN present exert a lower partial pressure by virtue of the fact that part of the ammonia and HCN exist as ions. This has interesting implications for HCN concentrations inside the stripper itself.

Figures 3 and 4 are HCN concentration profiles (ppmw) in the water. ProTreat® simulates packed beds by dividing the total packed depth into a large number of discrete segments (in much the same way that the area under a curve is calculated by dividing the x-axis into a multitude of thin slices). In these plots, the segment number is roughly equivalent to the distance in feet from the top of the packed bed. The concentration is of HCN in the water at the position indicated, in this case in the water leaving each one-foot-high packed segment.

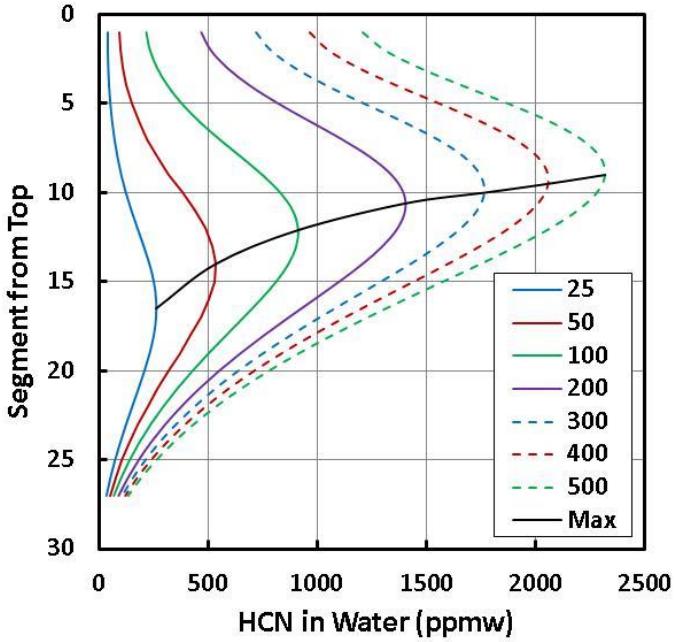


Figure 3 HCN Profiles with 1.2 lb Steam per Gallon Sour Water (Stream 1)

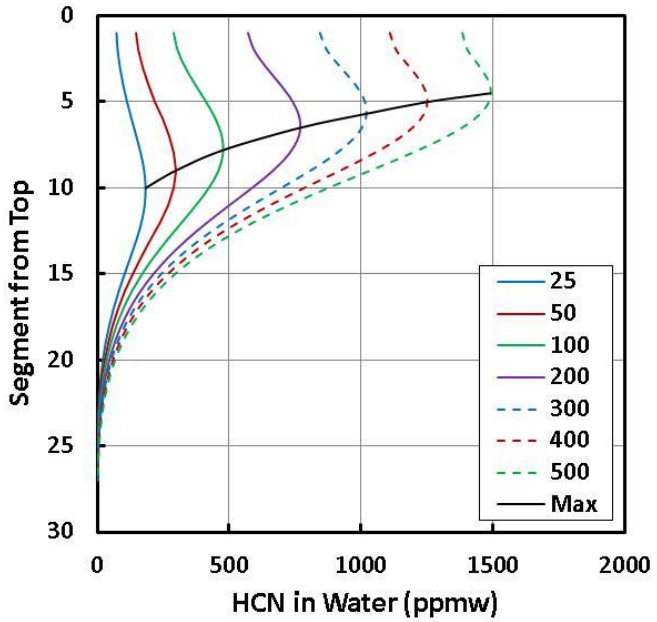


Figure 4 HCN Profiles with 1.4 lb Steam per Gallon Sour Water (Stream 1)

There is always an HCN bulge in the stripper somewhere below the feed point (in this case, the feed is always to the top of the packing), and the higher the HCN concentration in the sour water, the higher is the concentration at the bulge. The line labeled 'Max' marks the position of the maximum in these plots. The maximum HCN concentration can be many times larger than the value in the feed. For example, with 50 ppmw HCN in the sour water, the peak concentrations at 1.2 and 1.4 lb steam per gallon of water are 500 ppmw (10 times the feed) and 300 ppmv (6 times the feed), respectively. Cyanide ion concentrations are correspondingly high. This may go some way to explaining the unusually high levels of corrosion sometimes seen in refinery SWSs handling HCN.

These results are an indication of the power of the ProTreat® mass transfer rate-based simulator when used for diagnostics. No other simulation tool provides this kind of information.

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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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