

The CONTACTOR™

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Reboiler Types and Regenerator Performance

In the ProTreat® simulator, the reboiler built into regenerators is of kettle type. This issue of The Contactor™ answers two questions asked fairly often: (1) How can I model a thermosyphon type reboiler? and (2) what is the difference between kettle and thermosyphon reboilers in terms of their effect on overall regenerator performance?

In a kettle reboiler, the column bottom liquid flows to the kettle where direct-fired, steam- or oil-heated tubes partially vaporize it. The vapor generated returns to the column bottom via a vapor return line. The remaining liquid is withdrawn from the reboiler, usually via an overflow weir and sump arrangement. Because the vapor is directly generated by boiling on the surfaces of heated tubes, a kettle reboiler is a very close approximation to a theoretical stage.

The circulation in a thermosyphon reboiler is driven by the density difference between the entering liquid and the two-phase mixture that recirculates back to the tower sump (an everyday example is the action in a coffee percolator). The recirculating flow may be driven purely thermally, or it may require use of a pump on the tower bottoms if the natural liquid head is insufficient to drive the flow at the desired rate. The entering liquid is partially vaporized, but *all* of the resulting vapor-liquid mixture is returned to the tower sump via the return line. The returning vapor-liquid mixture is separated in the sump. The vapor flows upward, while the liquid joins the flow from the bottom tray or packing support plate and returns for another pass through the reboiler. The product liquid is drawn directly from the tower sump (or the liquid line joining sump to reboiler). It is not drawn from the reboiler itself. The question is how effective this is compared with the ideal or equilibrium stage of a kettle reboiler. Obviously it cannot exceed the ideal, but how close can it come?

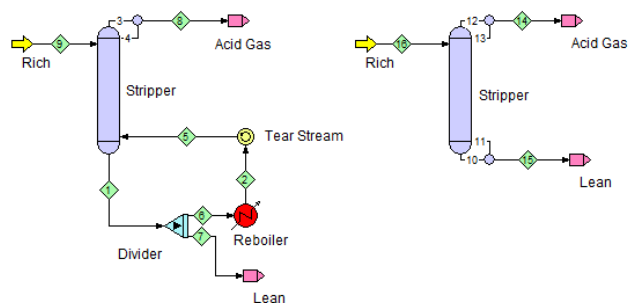


Figure 1 Thermosyphon and Kettle Reboilers

Figure 1 compares the PFDs for thermosyphon and kettle reboilers. In the thermosyphon setup, the lean solvent stream is drawn from the liquid line returning the combined liquid flows (column bottoms plus liquid portion of the 2-phase reboiled return — Stream 2) rather than from the reboiler itself.

The most direct way to examine the difference between these schemes is by looking at a specific example. Table 1 shows the conditions of the rich solvent feed stream for this example.

Table 1 Rich Solvent Feed Conditions

Temperature (°F)	200
Pressure (psia)	30
Flow (USgpm)	200
Wt% MDEA	50
CO ₂ Loading	0.50

To carry out the comparison on an equitable basis, the same rich solvent, the same column (4-ft diameter with 20 conventional valve trays and 2-in weirs) and the same thermal energy input (12 MMBtu/h) are used for both cases. Circulation rate

through the thermosyphon reboiler is varied by varying the percentage of lean solvent that is withdrawn from the circulation loop. Figure 2 shows how solvent lean loading drops linearly with increasing fractional circulation of tower bottoms. But, it can achieve ideal stage performance only in the limit of all the bottoms being recirculated, i.e., no product stream being withdrawn.

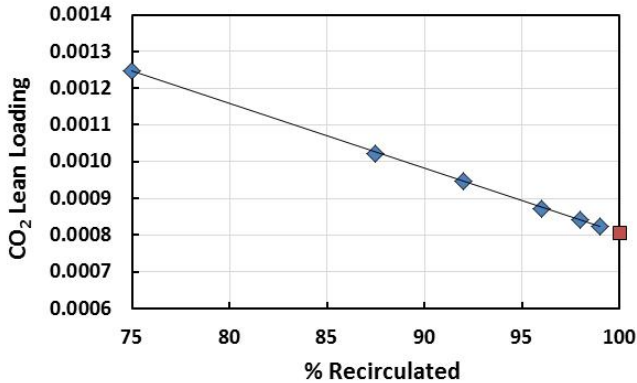


Figure 2 Lean Loadings Worsen as the Circulation Rate through a Thermosyphon Reboiler Decreases

Figure 3 shows that the return flow from the thermosyphon reboiler increases exponentially with reboiler circulation rate. In other words, to achieve better quality lean requires ever increasing total circulation rates. In the end, kettle reboiler performance is simply unreachable without ridiculously high recirculation rates (and corresponding adjustments in unit sizing).

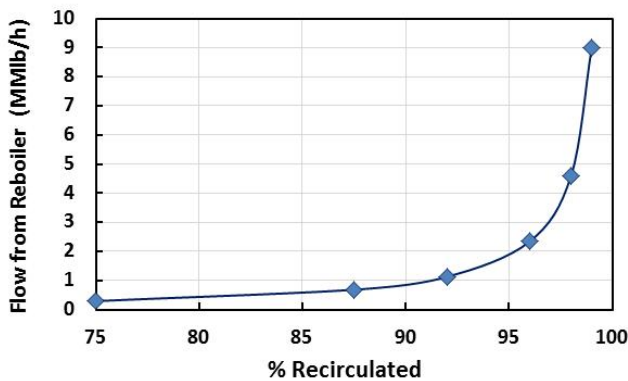


Figure 3 Lean Loadings Worsen as Circulation Rate through a Thermosyphon Reboiler Decreases

Figure 4 makes this point even more emphatically. Here we see that the lean loading produced by a kettle reboiler can be achieved only in the limit of infinite circulation rate through a thermosyphon reboiler.

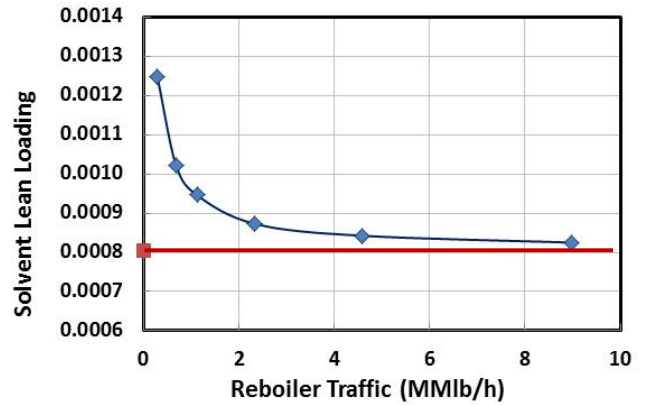


Figure 4 Even to Approach Kettle Reboiler Performance, a Thermosyphon Reboiler Must Return an Enormous Two-phase Flow to the Column

In this example, ProTreat® simulation showed that if 50% of the column bottoms were withdrawn as product lean, and 50% were passed back through the thermosyphon, the lean solvent loading would be twice as high as in a kettle reboiler using the same energy input. It is worth noting also that although the liquid part of the two-phase flow returned by the thermosyphon is simulated to have a CO₂ loading of only 0.0003, it is mixed with solvent coming from the last tray in the column, or from the packing support plate, with a loading of 0.003 moles CO₂ per mole MDEA, negating much of the stripping the thermosyphon reboiler actually achieves.

The reboiler plays a very important role in regeneration. Not only does it supply the steam necessary to provide the heat of desorption, and provide a diluent or carrier for the stripped CO₂, but it also does a considerable portion (but not all) of the stripping. OGT does not necessarily advocate kettle reboilers per se, and many factors besides stripping performance for a given energy input go into making the best reboiler choice for a given unit installation.

To learn more about this and other aspects of gas treating, plan to attend one of our free seminars. Visit www.ogtrt.com/seminars for details on free one-day seminars scheduled 2013.

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