Under the Microscope†

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The water content of glycol being used to dehydrate a gas determines the achievable dry gas moisture content. This in turn is strictly a function of how the glycol regenerator is constructed and operated. In most glycol dehydration units, the regenerator is an externally reboiled column with the final stage of regeneration taking place in the reboiler. However, sometimes a very high (expensive) reboiler duty is necessary to reach the desired treated-gas dryness. Rather than relying only on steam generated in the reboiler as the stripping medium, introducing an additional relatively dry stripping gas can provide just the boost needed to lower the residual moisture content of the regenerated solvent to the desired level. Indeed sometimes the stripping gas doesn't have to be all that dry to achieve remarkably low solvent residual moisture content; it depends on the absorber pressure.

The reason a process gas such as methane or nitrogen can so effectively remove water from glycol is very simple: unlike water vapour, stripping gas cannot condense into the liquid glycol and so it is a diluent for the water stripped from the solvent. Steam generated by a reboiler is a stripping medium too, but being only water vapour, it is not a diluent for evaporated moisture. Sometimes the column and reboiler combination is only slightly more effective than the reboiler alone. Supplementing with stripping gas puts a whole new perspective on the range of solvent dryness levels reachable by the process.

A Stahl column is a stripping column that uses a stripping gas rather than just heat to remove water from glycol, and often to a much lower level than can be achieved using a reboiler. The Stahl column itself is fed with already partly dried glycol coming from the reboiler of a conventional glycol stripper (Figure 1).

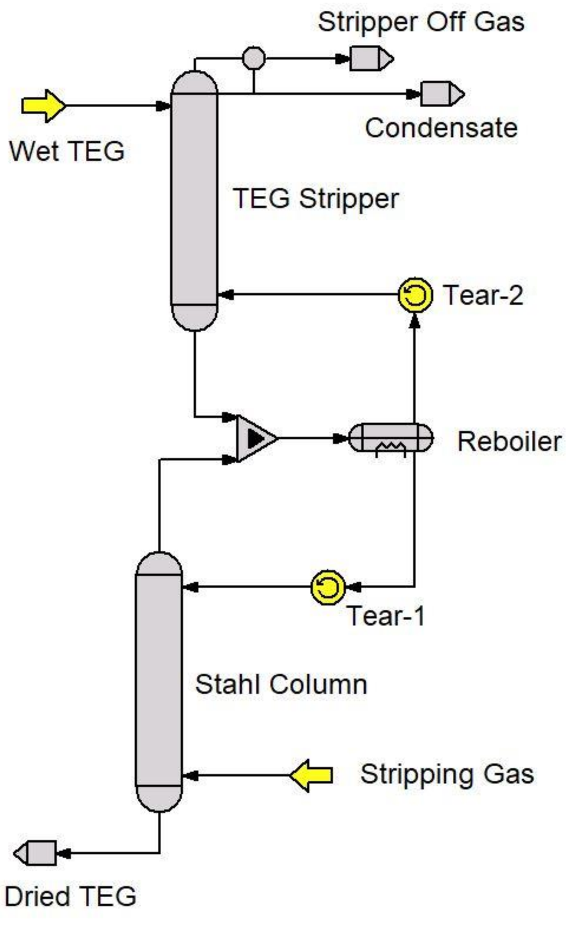

Figure 1 Typical Stahl Column Arrangement

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Both the Stahl column and the conventional stripper are usually packed (trays are no longer in vogue for this service). Structured packing is usually the internal of choice, although if in dirty service, random packing may be preferred. However, sometimes a stripping goal that is only slightly beyond achieving can be reached just by sparging stripping gas directly into the reboiler of the stripping column, avoiding the expense of a Stahl column altogether. The addition of stripping gas might be viewed as providing a diluent for the water being driven from the glycol. Figure 2 shows this configuration.

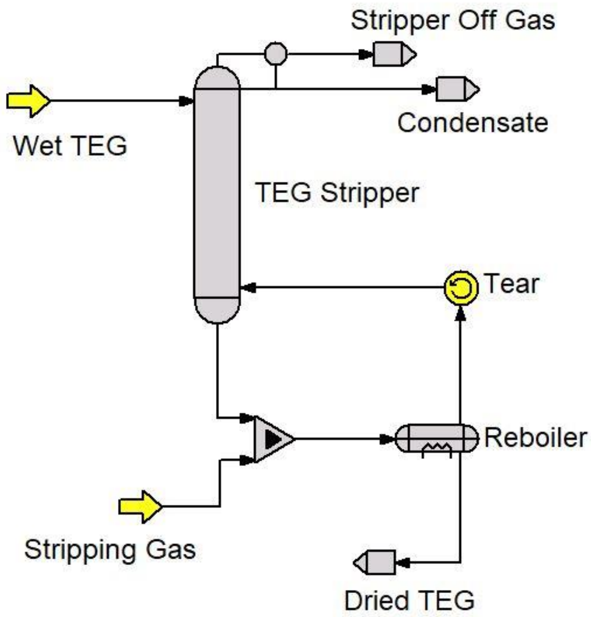

Figure 2 Direct Injection of Stripping Gas

In ProTreat® simulation, it is easy to set up a detailed and quite accurate model of a Stahl column, a model of the entire regeneration system, or a predictive model of the complete glycol dehydration unit. In this article, a Stahl column is put under a microscope and a Case Study is used to dissect its performance as a function of stripping gas flow and packing depth, leading to some interesting process insights. A Stahl column is also compared with direct injection of stripping gas into the reboiler (and with the use of no stripping gas at all) using the benchmark of final lean glycol moisture level.

Case Study

The setting for the case study is the prevention of hydrate formation by using TEG to dehydrate methane prior to transferring the gas to an LNG production facility. Rich glycol flows at 20,000 kg/h and has a TEG content of 95.4 wt% with 4.0 wt% water and 0.5 mol% CO_2 with trace amounts of C_1–C_6 hydrocarbons. The rich solvent enters at 170°C.

The 900-mm diameter TEG stripper contains 3.2 meters of 1-inch Pall Rings and 45% of the condensate is returned to the column as reflux. The reboiler consumes 1.2 MW of energy and the stripper overhead is at 1.05 bara. The 400-mm diameter Stahl column is packed with Mellapak™ M250.X structured packing. Stripping gas is methane with a moisture level of 8 gm/Nm^3 (475 lb/MMscf). In the context of truly dry gas this is a rather high moisture content—pipeline specification gas is typically about 8 lb/MMscf—but it is perfectly capable of producing a rather dry solvent (≈130 ppmw H_2O). The high pressure dehydrated gas in this case has a water content of around 1.5 lb/MMscf and it would be uneconomical to waste such dry material as stripping gas. Stripping gas rate was varied over the range 100–600 Nm^3/h (0.83–5.0 Nft^3/gal TEG) and packed bed depths of 0–15 m were considered. The case study consists of a series of simulations run using the ProTreat® mass and heat transfer rate-based simulator with a Sulzer Chemtech .dll for the characteristics of Mellapak™ and MellapakPlus™ packings.

How Effective Is Stripping Gas?

For the specific case of a 3.2-m (10-ft) packed TEG Stripper bed and a 37°C (100°F) stripping gas at a rate of 150 Nm^3/h (1.25 SCF/gal TEG), Table 1 compares (1) lean solvent dryness using a Stahl column, (2) direct injection into the reboiler, and (3) using no stripping gas at all. Differences between process configurations are much more apparent when results are listed in terms of water content rather than wt% TEG.

Table 1 Wt% H_2O in Lean Solvent for Three Cases

Stahl Column with 3.2-m (10-ft) Bed of M250.X	0.213
Stripping Gas Fed Directly into Reboiler	0.814
No Stripping Gas at All	0.971

Table 1 shows that even a short Stahl column with a minimal amount of stripping gas produces lean solvent with already not much more than a quarter of the moisture obtained by injection of the same stripping gas directly into the reboiler, and less than a quarter of that obtained without any stripping gas at all. Using stripping gas can improve lean solvent quality (dryness) to some extent, but a Stahl column can produce a very much drier lean solvent, hence a much drier product gas. ProTreat helps determine what equipment is necessary, reducing capital spending, and how best to operate it, lowering operating costs.

Effect of Stripping Gas Flow Rate

Simulations were run at seven stripping gas rates between 100 and 600 Nm^3/h to expose the dependence of lean solvent moisture content on this parameter. Table 2 shows the results.

Table 2 Effect of Stripping Gas Rate on Residual Moisture in Lean Solvent (Gas is 1% Water).
Stahl Column: 3.2-m (10-ft) M.250X Packing

	Wt% Water in Lean Solvent	
Gas Rate (Nm^3/h)	**Stahl Column**	**Direct Injection**
100	0.300	0.859
150	0.214	0.813
200	0.156	0.770
250	0.116	0.729
300	0.088	0.688
450	0.044	0.585
600	0.026	0.496

Residual moisture responds readily to changing stripping gas rate. This is a potentially useful way to control lean solvent quality and ultimately treated gas dryness. And optimizing stripping gas flow saves money on energy consumption and wasteful over-stripping.

Effect off Packing Height

Table 3 shows that even a *very short* (2.5 ft) packed bed will halve residual moisture compared with gas injection directly into the reboiler. Returns from bed depths over 20 feet are progressively more marginal because the constraint imposed by the water content of the stripping gas is being approached—there are other ways to get more performance, such as a slightly higher stripping gas rate.

Table 3 Effect of Packed Height on Residual Moisture in Lean Solvent; Stripping Gas Rate is 150 Nm^3/h

Packed Height, ft (m)	*Wt% Water in Lean Solvent*
2.5 (0.76)	0.416
5 (1.52)	0.319
10 (3.05)	0.213
15 (4.57)	0.172
20 (6.10)	0.152
30 (9.14)	0.135
40 (12.19)	0.127

Being able to determine the quantitative effect of packing type, size, brand and material on stripper and Stahl column performance allows savings in packing cost, bed depth and tower height in both new construction and retrofits. Sensitivity to changing operating conditions is also easier to assess with ProTreat's rate-based modeling, allowing the right allowances to be made via design flexibility.

Solvent Stripping in Reboiled vs. Stahl Column

Figures 3 compares the solvent moisture profile in the reboiled column with how the profile looks in the Stahl column. A reboiled stripper without stripping gas does almost all its work at the very top of the column and in the reboiler. In the interior of the stripper itself almost nothing happens beyond a little heat transfer. ProTreat® simulation in this figure clearly shows that a Stahl column strips quite effectively throughout its entire packed height.

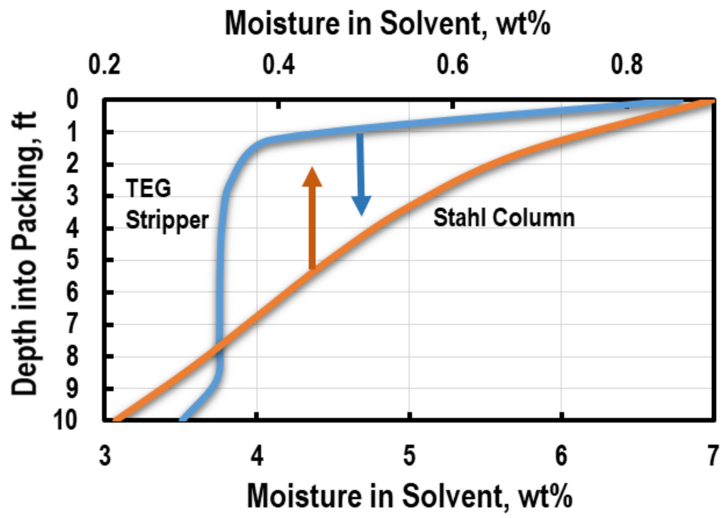

Figure 3 Solvent Moisture Profiles for TEG Stripper (—) and Stahl Column (—)

It may be worth pointing out that because the stripping gas from the Stahl column passes through to the glycol stripper, the stripper also enjoys the benefit of this stripping gas flow. The result is that the higher the stripping gas flow rate entering the Stahl column, the more of the packed height in the reboiled stripper is actively engaged in removing water from the solvent. Simulation shows that ultimately, the flat portion of the stripper's moisture profile disappears altogether and the entire unit performs effectively. This benefit needs less stripping gas than might be imagined.

Summary

A Stahl column uses a noncondensible gas as a diluent for the evaporated water. For that reason the entire column is effective in removing water from the glycol solvent. A Stahl column is vastly superior to a simple reboiled stripper because it uses a carrier for water vapor, whereas a simple reboiled column relies exclusively on boiling. Furthermore, the stripping gas retains its effectiveness when it leaves the Stahl column and enters the glycol still. The TEG stripping column does useful work in water removal when there is a stripping gas flowing—without stripping gas it is relatively ineffective.

In terms of economics, glycol regeneration is done at atmospheric pressure so only thin-walled vessels and light weight equipment are necessary. This makes the capital cost of a Stahl column fairly low. The operating cost is just a relatively small flow of high moisture content process gas, which later may be used elsewhere as fuel.

ProTreat® rate-based simulation lets one determine accurately the potential financial benefit of using a Stahl column to reduce reboiler size and energy consumption in a new design, and with the design trimmed of excess fat. Operationally, if one must process a higher gas flow in an existing unit, or produce a drier gas, a Stahl column may be a lot more effective than adding or replacing an expensive reboiler. And the additional credit that can be taken for more cost effective operation of the conventional still can be accurately assessed. ProTreat process simulation removes all guesswork and provides not only the ability to reliably and precisely assess the costs and benefits of design decisions and operating process-change proposals, but allows maximizing return on investment.