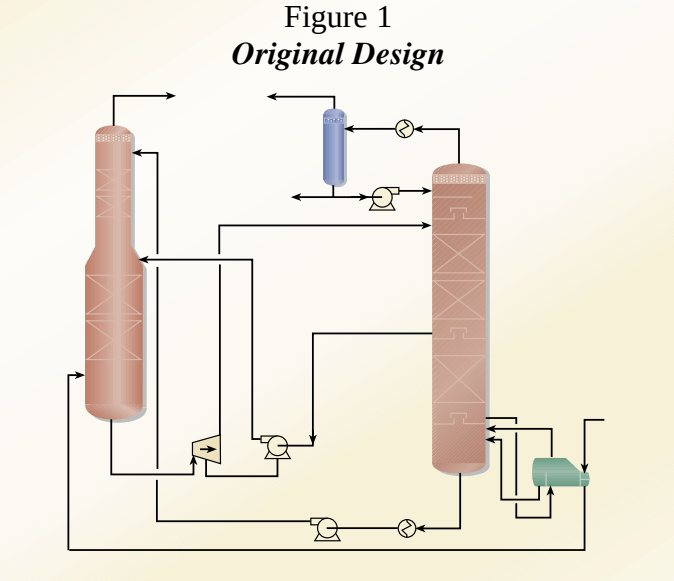
CO_2 Removal Unit Revamp

By Lamar Davis, Edward Zbacnik, Avinash Malhotra, and Mahesh Gandhi

Recently, China's Yunnan Yuntianhua Company awarded Kellogg Brown & Root (KBR) a contract to provide the basic engineering and design for revamping a 1,000-tonnes-per-day ammonia plant to 1,500 tonnes per day. The plant's Benfield CO_2 removal system is the focus of this article (see Figure I). New tower packing made the large capacity increase feasible. In addition to increasing the plant's capacity, the revamp will also reduce the energy required per unit of CO_2 by 27 percent. UOP, the owner and licensor of Benfield technology, supplied KBR with the CO_2 system design changes. The plant modifications should be on line in 2002.

Figure 1
Original Design



The original CO_2 removal unit was designed to treat 137 mmscfd of synthesis gas at 399 psia containing 18 mol percent CO_2. The absorber exit gas contained less than 1,000 ppm CO_2 and the regenerator produced a CO_2 product that contained more than 99 mol percent CO_2. In the revamp, the product design specifications remain unchanged.

In the old design, the synthesis gas entering the regenerator reboiler supplied all the system's 133.5 mmBtus per hour of regeneration heat. A regenerator condenser removed 110.4 mmBtus per hour and a lean solution cooler removed 52.6 mmBtus per hour from the process. A 30 percent potassium carbonate solution, which contained a nominal three percent DEA activator, had a total lean solution circulation rate of 4,800 gallons per minute that split into two streams. A 25 percent stream went to the trim section. The remainder went to the absorber's bulk section.

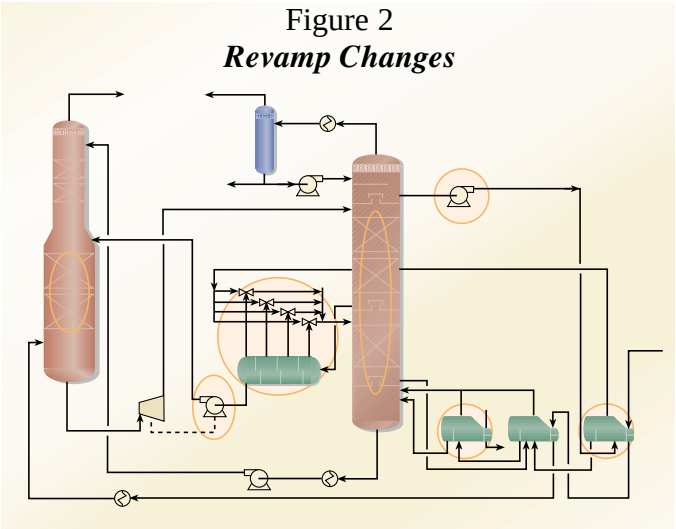
Packing in the absorber consisted of two 23-foot beds of 1.5-inch Pall Rings in the top 8.5-foot diameter section and two 23-foot beds of two-inch Pall Rings in the bottom 11.5-foot diameter section. Packing in the 14-foot diameter regenerator consisted of two 30-foot beds of two-inch Pall Rings in the top section and one 30-foot bed of 1.5-inch Pall Rings in the bottom section.

We designed the revamped plant to treat 190 mmscfd of syngas containing 17.7 mol percent of CO_2, representing a 38 percent syngas increase and a 36 percent CO_2 increase. UOP used its proprietary flash, solution activator, and structured packing to achieve the revamp's goals (see box). The equipment layout and the revamp's new-equipment requirements remained very similar to the original plant's.

To remove the additional CO_2 from the synthesis gas, we increased the overall solution flows. The total lean solution flow to the absorber became 6,400 gallons per minute and we changed the flow split from 75/25 to 85/15. This change reduced the overall revamp cost and allowed us to use the existing lean solution cooler. However, we had to modify the existing semi-lean solution pumps to accommodate the higher flows. Although the new activator improved the absorption kinetics, we also had to replace some of the existing random packing with structured packing to accommodate the higher hydraulic loads and mass transfer requirements in the regenerator's entire top and bottom sections and the absorber's entire bottom section.

Figure II shows the revamp's changes. We installed a four-stage flash system to recover heat and reduce the revamp's overall heat requirement. We also installed a reboiler and

Figure 2
Revamp Changes



Flash System	LoHeat™ is UOP's flash system on the lean solution exiting the regenerator. The lean solution flashes to a lower pressure. Ejectors or a vacuum pump return the flashed steam to the regenerator tower.
Solution Activator	ACT-1™ is UOP's amine-based solution additive.
Structured Packing	UPak™ is UOP's new structured packing for Benfield towers.

condensate feed pump to recover heat from the synthesis gas and regenerator reflux and to produce motive-steam for the ejectors. The revamp's design heat duty was 131.7 mmBtus per hour versus the original design's 133.5 mmBtus per hour. The 131.7 consisted of 85.8 for the carbonate reboiler, 44.3 for the condensate reboiler, and 1.6 for an external steam source using an exchanger that the plant owner had installed before the revamp.

A 98°F lower feed temperature entering the absorber and the flash system reduced the revamp's cooling duty. The regenerator condenser removed 88.5 mmBtus per hour and the lean solution cooler removed 44.1 mmBtus per hour. A boiler-feed-water preheater, external to the Benfield unit, lowered the feed temperature. The revamped unit should use 35,900 Btus per pound mol of CO_2 versus the original design's 49,500. The lower feed temperature also eliminated surplus liquid from the system and, therefore, helped to minimize activator loses.

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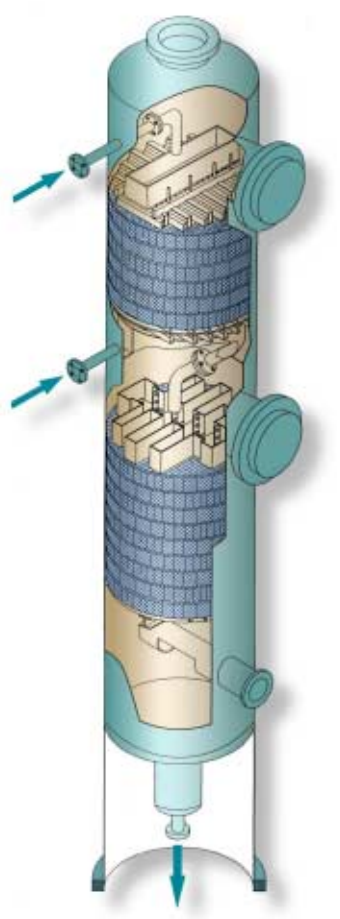

For More Information

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