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Increasing treating capacity

Challenges in increasing amine system capacity at a Texas NGL plant

Erik Stewart
GAS/SPEC Technology Group
and
Mike Lloyd
Duke Energy Field Services

INEOS LLC

As part of a Federal Trade Commission mandated remedy to the merger of The Dow Chemical Company and the Union Carbide Corporation, INEOS plc was able to purchase both Dow's Ethanolamines and GAS/SPEC MDEA-based specialty amine businesses. This purchase became effective on February 12, 2001.

INEOS LLC was set up as the newly acquired company, which includes the GAS/SPEC Technology Group. All the key Ethanolamines and GAS/SPEC personnel were retained by INEOS LLC. All GAS/SPEC products, technology and know-how became the exclusive property of INEOS on a global basis.

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Increasing treating capacity

Mike Lloyd, Duke Energy Field Services, and Erik Stewart, Dow Chemical Company, USA, describe the challenges encountered in increasing amine system capacity at a Texas NGL plant.

Wilcox facility entrance.

Duke Energy Field Services produce NGL fractions at the Wilcox facility in Texas. The plant is well situated to process gas, which flows through its existing pipelines from the south Texas area. In 1999, Duke completed an expansion project that included addition of an Ortloff designed deep ethane recovery cryogenics plant. The Ortloff design has proven to be a good process for mitigating the sublimation of CO_2. This 200 MMSCFD system includes amine treating and dehydration equipment to condition the feed for this unit. A low CO_2 specification of 50 ppm was required to meet the pipeline specification on the recovered ethane.

The inlet processing comprised the new compression of the pipeline gas, followed by treatment with amine to reach the low CO_2 specification. Next, the gas was dried with glycol, followed by treatment with molecular sieves and finally, ethane recovery (Figure 1).

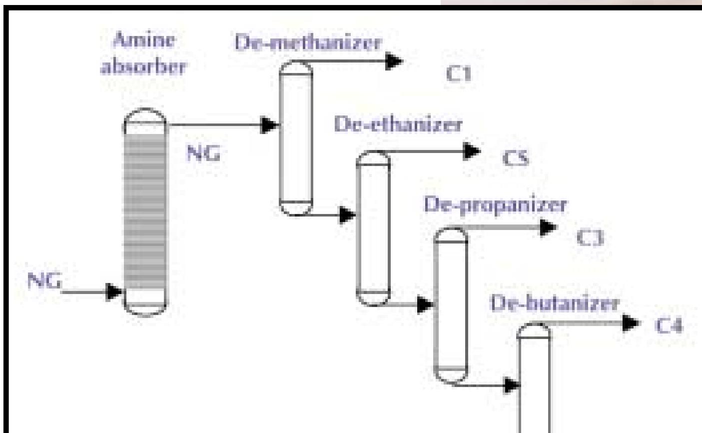

Figure 1. Plant layout for Duke Wilcox.

Original amine absorber with inlet gas knockout vessel.

The existing facility was a lean oil plant. Utilisation of heater, pumps, and other existing equipment was desired to reduce capital cost. A new amine absorber with high mass transfer was designed to assure the low CO_2 specification. By including a 30 tray design with 3.5 in. weir heights, the initial plan was to use generic methyldiethanolamine (MDEA) in the new amine system. Other amines such as monoethanolamine (MEA) or diethanolamine (DEA) have faster reaction kinetics for CO_2, but higher heats of reaction and lower maximum solution concentrations force these molecules to use more regeneration energy to do the same job. It was concluded, as the plant neared startup, that the mass transfer available in the unit, though extensive, would still not enable MDEA to reach the 50 ppm specification. Therefore, the search for a potential replacement amine was initiated.

Simulation

The GAS/SPEC technology group within Dow Chemical Company simulated the plant requirements. The simulation for this plant focused on minimising regeneration duties by optimising rich loading and absorber temperature profile, as well as optimising stripping tower operation to minimise reboiler duty. The goal was to maintain additional regeneration capacity for any future plant expansions.

With this in mind, GAS/SPEC® CS-2000 solvent was specified for the application. Only 1025 GPM of the available 1200 GPM circulation rate would be required to treat the 200 MMSCFD of inlet gas. Lowering the circulation rate further would be limited by the temperature profile reaching a 185 ˚F maximum temperature guideline. This is a general limit to prevent a rich equilibrium pinch point from occurring on the hottest tower trays. When pinched, the trays at equilibrium will no longer remove CO_2 and the tower profile will flatten out, allowing CO_2 to climb higher in the tower. In hydrocarbon plants, the CO_2 degassing often simulates foaming type upset. The outlet CO_2 will 'run' or elevate and the treated gas temperature will also elevate above the inlet lean amine temperature.

Thus, for this application, the amine solution circulation would be required to remove heat from the absorber to maintain the absorber profile. The amine concentration and rich loading were a secondary consideration. The plant would operate well below the maximum guidelines for GAS/SPEC for this type of service.

This critical absorber profile for the simulated performance is shown in Figure 2.

The bulk CO_2 removal is accomplished in the first ten trays, with the final polish to the 50 ppm target in the upper 20 trays. This is demonstrated in Figure 3.

Startup

The plant startup occurred in April 1999. Duke had intended to use old lean oil pumps, in conjunction with one new

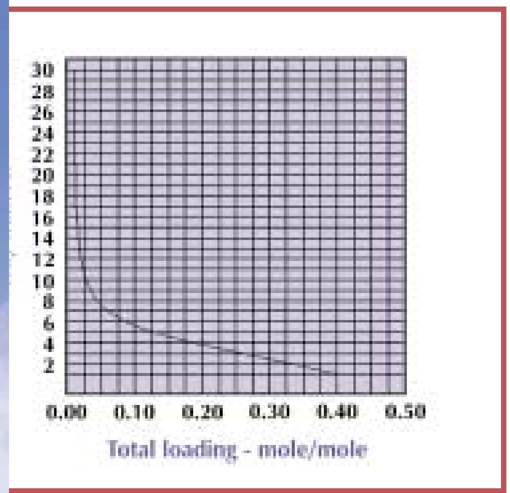

Figure 2. Absorber temperature profile.

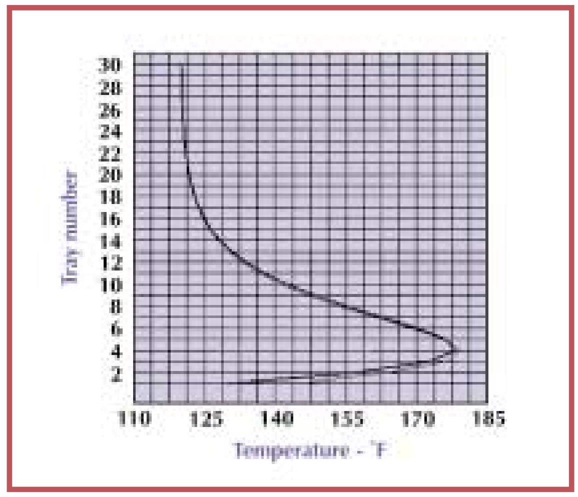

Figure 3. Absorber CO_2 removal.

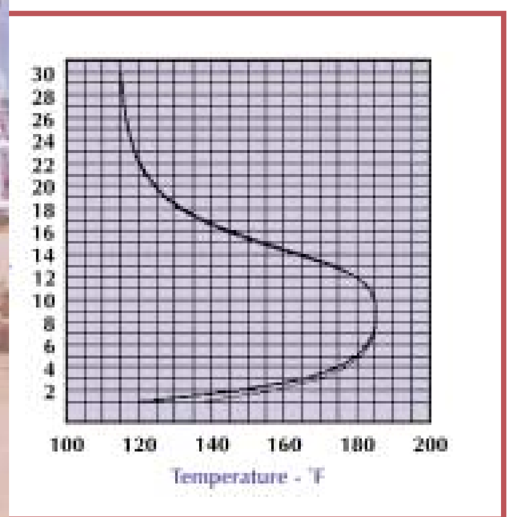

Figure 4. Equilibrium pinched absorber

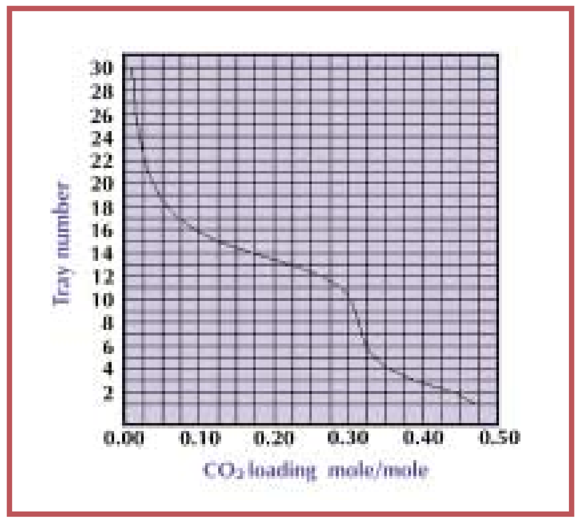

Figure 5. Equilibrium pinched CO_2 profile.

pump, to achieve the required circulation rate. But at startup, only the new pump would operate. This limited the available circulation to approximately 600 GPM, while the gas rate at startup would be 130 MMSCFD. Thus, the available liquid to gas ratio in the tower would be about 10% below the minimum simulated. With this limitation, the absorber profile became severe as the temperature profile reached a rich equilibrium pinch point. The skin temperature scans of the absorber column showed an extended flat profile at high temperatures in the bottom eight to nine trays. Tower differential pressure was high and unstable. The treated gas exiting the absorber was 5 - 15 ˚F higher than the inlet lean amine and the CO_2 content was reduced to only 1500 ppm. All of these conditions supported the hypothesis that a rich equilibrium pinch was occurring with the under circulation. When plant gas rates were lowered and circulation maximised, these conditions would improve. When circulation rate fell off, the increased gas rates, coupled with the temperature increase throughout the day, would cause absorber conditions to worsen.

Simulations were completed to characterise the equilibrium pinch point. The tower temperature profile and CO_2 removal is demonstrated in Figures 4 and 5.

The maintenance required for the pump motors from the lean oil plant would appear to take one to two weeks. However, the de-ethaniser, requiring the low outlet CO_2 levels, was due to startup the next day. The amine circulation rate was going to be short, while the required production rate had to be treated.

The plant had only been filled to an amine content of 38 wt%. One option to lower the required liquid to gas ratio would be to adjust the additive level in the solution. This would result in an increase in reboiler duty, but the reboilers were not the limiting factor in the plant. The amine addition would correct the equilibrium pinch and move the temperature bulge down in the absorber to remove heat with the rich amine. The amine strength was increased to about 50 wt%. As the addition was put into the lean pump suction, an immediate change in the absorber profile was noted, with rich bottom temperature increasing and the outlet treated gas matching the lean amine feed. The treated gas CO_2 levels dropped below the 50 ppm specification, eventually reaching the lower limit of detection of 5 ppm. There was no delay in the startup of the new cryogenics plant.

Flash tank

As the plant gas inlet rates increased, the Wilcox amine system began to encounter over pressuring of the flash tank. At 160 MMSCFD inlet rate, the flash tank pressure valve was 100% open, flowing up to 2 MMSCFD . The pressure relief valve was relieving at 160 psig, and there was a discrepancy between the absorber level transmitter and the sight glass. Dow simulations showed the flash gas rates should be much lower than what was being experienced,

Amine regeneration area.

even at full inlet gas rates to the plant. Since the amine contactor did not have a vortex breaker, it was concluded this was the likely cause.

One of the identifying clues was the determination that the flash gas composition was almost identical to the inlet gas composition. A two phase flow in the rich amine line from the absorber was evident because of vibration and sound. To confirm vortexing as the root cause, the high level shutdown in the absorber was disabled and the amine level was allowed to rise in the bottom of the tower. This action reduced the vapour rate in the flash gas, proving that vortexing has been occurring. At the first shutdown, packing was added to the tower bottoms to prevent vortexing.

Expansion

Once the circulation pumps had been repaired, the plant had excess amine capacity and reboiler duty available in the plant. A new contactor was designed to take advantage of this situation. Once this second contactor was added, the lean amine flow was split and sent to both towers. The plant could then operate over 10% above its original nameplate capacity. Duke has used this added capacity to enable treatment of additional inlet gas.

Conclusion

The Duke Wilcox plant required treating capabilities not possible with generic MDEA. Dow optimised the design simulations, utilising GAS/SPEC CS-2000 solvent to minimise regeneration energy for future capacity expansion. On startup, only 60% of lean amine circulation rate was available to treat a higher portion of the design feed gas rate. This caused an equilibrium pinch point in the amine absorber, elevating the outlet CO_2 content of the treated gas. A one to two week time period was projected to repair the lean amine plant pump motors, to provide adequate amine circulation rates. Before the pump repair would occur, startup of the deep ethane recovery was planned, which would not tolerate the additional CO_2.

By adjusting the formulation of GAS/SPEC CS-2000 solvent to improve the absorber profile, the required CO_2 pickup was possible. The cryogenics plant could then be started on time.

Other plant limitations were fixed on a long term basis, and the use of GAS/SPEC CS-2000 solvent allowed the plant to operate above nameplate capacity energy optimisation, once the circulation rate could be provided.

INEOS

INEOS LLC
Head Office
2925 Briarpark Drive, Suite 870, Houston, TX 77042
713.243.6200 main 866.865.4747 customer service
www.ineosllc.com

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