HYDROCARBON ENGINEERING

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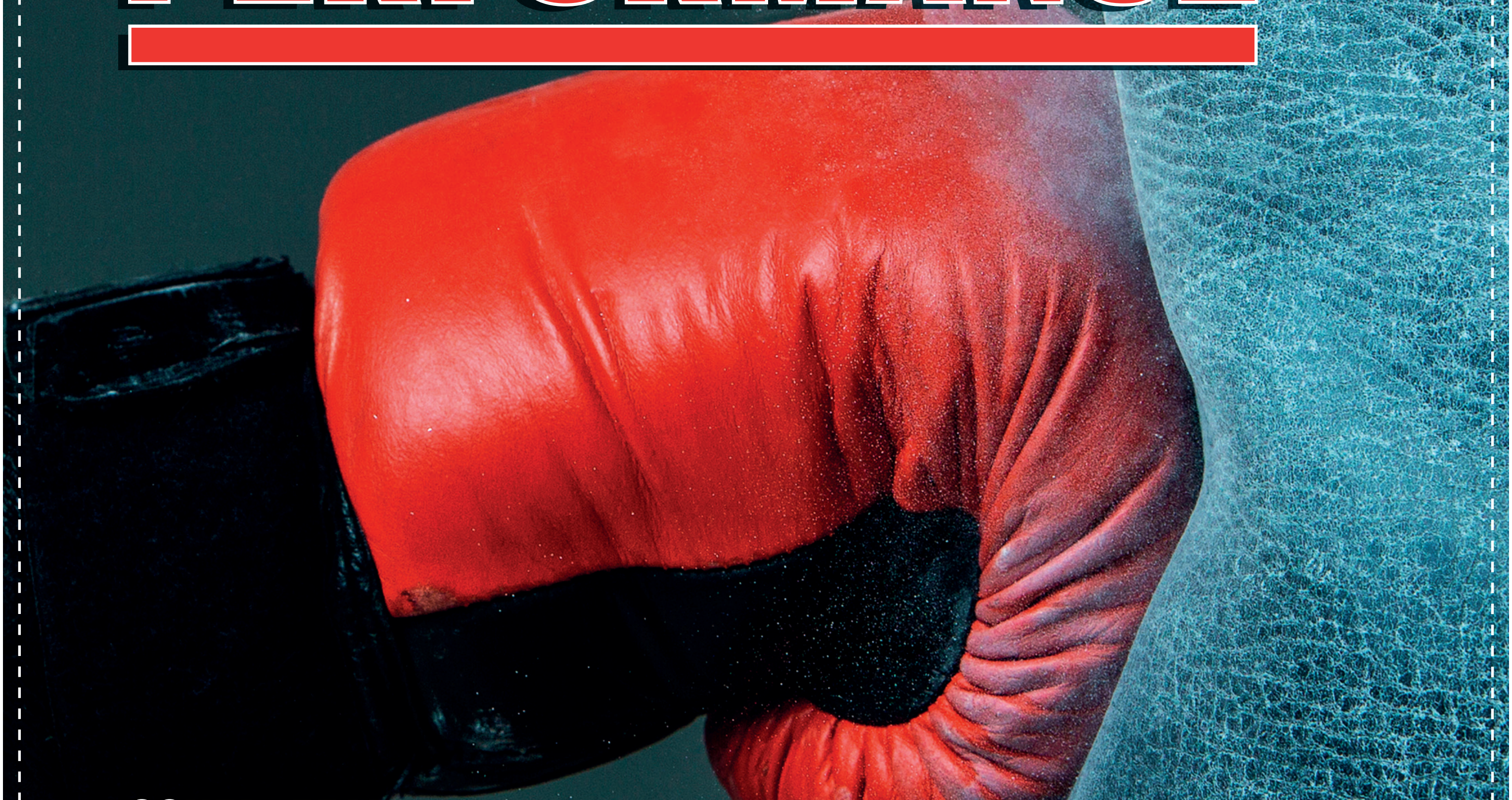
SCOT ULTRA POWERS PERFORMANCE

POWER PERFORMANCE



COVER FEATURE

John Specht, Shell Global Solutions International B.V., the Netherlands, and Pat Holub, Huntsman Corp., USA, profile two projects that helped a tail gas treatment unit to improve its operability and lower operating costs, while meeting tough emission requirements.

The processing of more sour crudes or complex, contaminated gases and meeting stringent emission regulations are challenging tail gas treating (TGT) operators like never before. However, continuing improvement through new technology offers the potential to meet such challenges with a cost effective, easy to apply solution.

The Shell Claus offgas treating (SCOT) process is the industry's most widely selected tail gas clean up process with 250+ references. It can achieve sulfur recovery levels of up to 99.98%, thereby realising very low levels of sulfur dioxide (SO_2) emissions. However, operators' requirements are always changing. For instance, refiners are keen to process more sour crude slates, so gas plants today often have to process highly contaminated and complex gases containing organic sulfur compounds, while SO_2 emission regulations are tightening around the globe.

Consequently, many operators find that the TGT unit is a key constraint and are having to compromise on reliability, capacity, operating costs or type of feedstocks.

New technology steps up

As part of its commitment to innovation and continuous improvement, Shell Global Solutions recently developed the SCOT* ULTRA process, which offers a step change in the performance of the well established SCOT process. It features Shell and Huntsman Corp.'s jointly developed highly selective JEFFTREAT** ULTRA family of solvents, which can

Figure 1. A consequence of the solvent's high CO_2 co-absorption was a low flame temperature, which caused insufficient destruction of ammonia and led to reliability problems.

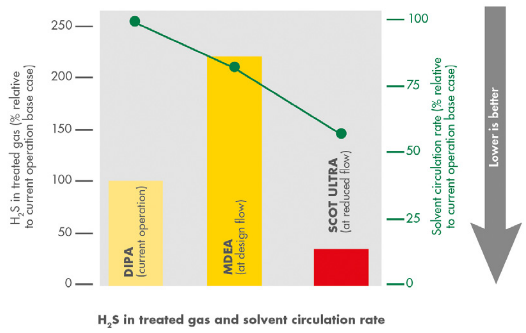


Figure 2. The SCOT ULTRA process achieved the lowest H_2S level and simultaneously had the lowest solvent circulation rate, which is a key driver of operating costs.

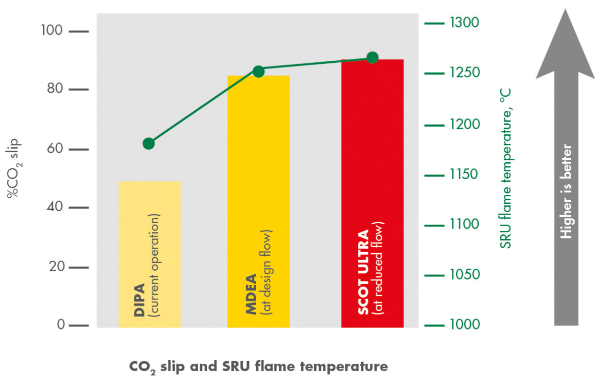


Figure 3. The SCOT ULTRA process' absorption characteristics mean that the CO_2 slip is higher than with the DIPA and MDEA-based solutions.

achieve deep decreases in hydrogen sulfide (H_2S) emissions and improved selectivity for H_2S over carbon dioxide (CO_2).

In addition, it also features Criterion Catalysts & Technologies' (Criterion***) C-834 high activity, low temperature SCOT catalyst, which adds further value by increasing the destruction of organic sulfur compounds at low operating temperatures.

The JEFFTREAT ULTRA family of solvents offers several advantages over conventional methyl diethanolamine (MDEA) or diisopropanolamine (DIPA) solvents in revamp applications. For example, its higher selectivity means that it can achieve deeper H_2S removal specifications. In case study 1, the H_2S in the treated gas is just 39% of that in the base case. Not only that, the solvent circulation rate is also reduced to 57%, which can translate into reduced steam, cooling and power costs.

C-834 catalyst is designed to provide exceptionally high activity in low temperature operations. Running a TGT unit at a lower temperature gives operators the opportunity to prolong cycle length. They can also reduce energy consumption by using indirect heating instead of line burners.

Crucially though, through its superior hydrolysis and hydrogenation performance, the catalyst offers increased destruction of the organic sulfur compounds (carbonyl sulfide and mercaptans) that gas projects are increasingly encountering. For example, case study 2 shows that the customer could benefit from a 76% reduction in carbonyl sulfide content in the SCOT offgas compared with another conventional low temperature TGT catalyst.

In addition, the catalyst also offers a low pressure drop, which is a key parameter for TGT units; the catalyst bed represents the area with the largest pressure drop in a SCOT unit and there is often not a lot of excess pressure drop for these units.

The new SCOT ULTRA process could, therefore, be particularly valuable for operators tasked with economically meeting stringent SO_2 emission regulations, including World Bank standards (150 mg/Nm^3), or those that require deep removal of carbonyl sulfide and mercaptans. While the highly selective JEFFTREAT ULTRA family of solvents bring H_2S levels down to extremely low values, the C-834 catalyst also destroys the carbonyl sulfide. This is where the integration of the catalyst with the amine brings the added value of the SCOT ULTRA process.

The key components that make up the SCOT ULTRA process have already been successfully deployed and operated commercially, and offer performance advantages in both green and brownfield applications. In the latter, Shell can evaluate systems for brownfield conversion potential; a simple swap of solvent and/or a catalyst change can improve performance when the original plant design supports the operation of the technology.

By making this change, in addition to meeting more stringent emission regulations and having enhanced destruction of organic sulfur compounds, gas plant operators can also benefit from lower operating costs. This is because the circulation rates can be reduced dramatically, which means much lower energy requirements.

Although this article's focus is brownfield applications, the SCOT ULTRA process also offers advantages in grassroots developments. It offers lower capital costs compared with conventional SCOT technology. This is chiefly because the absorber column height can be shorter and its improved performance at higher temperatures requires no chiller. The operating costs are also less, mainly because of the lower circulation rate, which cuts the system's energy requirements. This impact is typically much higher for greenfield applications because the process design will be customised to best suit the solvent properties.

In addition, just as for brownfield applications, it enables exacting emission regulations to be met even when organic sulfur is present.

Meanwhile, in refining, many sites are keen to exploit the use of cheaper, opportunity crudes. However, these are often higher in sulfur, so some refineries would need to increase their sulfur handling capacity. For this scenario, debottlenecking the existing SCOT unit could require extensive hardware modifications. In contrast, the new SCOT ULTRA process offers a far more cost effective opportunity to increase capacity without hardware changes.

In some cases, TGT unit operation can influence the reliability of the upstream sulfur recovery unit (SRU). A common cause of this is a low flame temperature, which may result from high CO_2 in the recycle to the SRU and can lead to fouling in the condensers. The SCOT ULTRA process, however, is designed to minimise the absorption of CO_2, which helps to maximise the flame temperature and, therefore, improve contaminant destruction and reliability. This issue is discussed in case study 1.

Case study 1: meeting stringent H_2S targets

A recent evaluation of the SCOT ULTRA process at a Shell refinery demonstrates that this simple solution can have a major impact on performance. The site had suffered several trips in its SRU caused by a buildup of high pressure, owing to the deposition of ammonium salts on the condenser tubes. Generally, operators target a flame temperature of at least 1250°C in the main burner to ensure sufficient destruction of ammonia and to prevent the buildup of these salts. However, in this case, the flame temperature was consistently below this target by 100°C or more.

The site technologists identified the root cause and, similar to all SCOT systems, this unit uses a recycle (Figure 1). However, the solvent has high levels of CO_2 co-absorption and recycling this back to the SRU quenches the flame temperature, which was what the site technologists observed.

To resolve this, the team evaluated various potential solutions. Short-term solutions, such as co-firing fuel gas, are possible but they come with negative consequences such as soot buildup and reduced throughput. Shell Global Solutions compared the current solvent, DIPA, with MDEA, which is the standard solvent for these applications, and with the highly selective JEFFTREAT ULTRA family of solvents used in the SCOT ULTRA process.

As shown in Figure 2, of the three solvents, only the solvent used in the SCOT ULTRA process could meet the H_2S target within the specific parameters. Figure 2 also shows that the lowest solvent circulation rate would be with the SCOT ULTRA process; this is an important parameter, as it determines the system's energy requirements. Key to this was the SCOT ULTRA process's enhanced CO_2 slip performance while maintaining high H_2S removal (Figure 3).

A more detailed look at the comparative evaluations (Table 1) shows that the site has to overcirculate the DIPA dramatically in order to manage

Table 1. The overall results of the comparative evaluation

	DIPA (current operation)	MDEA (at design flow)	SCOT ULTRA (at reduced flow)
H_2S in treated gas (% relative to current operation base case)[1]	100	218	39
Solvent circulation rate (% relative to current operation base case)	100	81	57
Recycle gas flow (% relative to current operation base case)	100	41	39
H_2S in recycle gas flow (% relative to current operation base case)	100	216	235
CO_2 slip, %	47	84	88
SRU 7 flame temperature, °C	1180	1255	1265

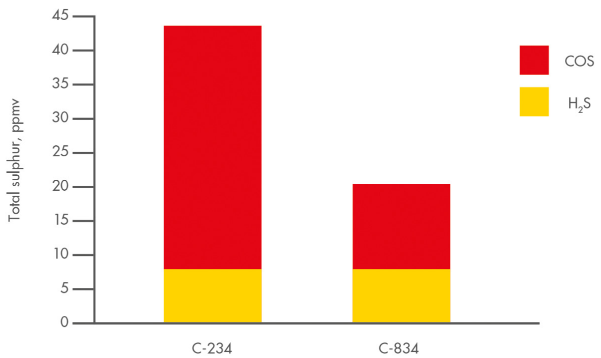


Figure 4. How total sulfur emissions in SCOT offgas vary according to the catalyst used. C-234 (L) catalyst is used in the conventional process, whereas a step change reduction (R) is achieved with C-834.

the H_2S emissions (Column 1). This is due to the solvent's high co-absorption and means running the system too close to its hydraulic limit.

The MDEA solvent (Column 2) is a weaker base, and, although it would achieve improvements in CO_2 slip, recycle flow and flame temperature, the H_2S levels would remain very high.

The SCOT ULTRA process would achieve a substantial decrease in H_2S levels (Column 3) because its more powerful solvent can maintain superior CO_2 slip. In fact, as shown, significant solvent reductions could be made and the site could still achieve superior H_2S absorption and CO_2 slip.

Case study 2: controlling H_2S, destroying COS

A gas plant needed to meet extremely stringent emissions limits; its target was 35 mg/Nm^3 of SO_2 emissions, which equates to approximately 20 ppmv of total sulfur components from the SCOT absorber overhead.

To help achieve these stringent specifications, Shell Global Solutions proposed Shell's high pressure degassing technology, to recycle the vent gas to the front of the SRU. In addition, because the tail gas to the SCOT unit was highly contaminated with high levels of carbonyl sulfide, it also deployed the SCOT ULTRA process.

Criterion's C-834 catalyst therefore played an essential role in meeting its targeted emissions limits. Figure 4 shows the total sulfur emissions. Although both cases use the JEFFTREAT ULTRA family of solvents to bring the H_2S levels down to an extremely low level, the C-834 catalyst also destroys the carbonyl sulfide to a sufficient level to achieve the specifications.

Conclusion

As the industry continues to develop natural gas reserves that contain organic sulfur and the limits for SO_2 emissions continue to tighten, gas plant operators face major challenges in meeting environmental mandates cost effectively and without compromising on reliability. The same is true for refiners, many of whom are bringing more sulfur into the facility by using crude oils containing elevated sulfur levels.

Fortunately, technology developers, such as Shell Global Solutions, have continued to push the boundaries of what is achievable in order to help operators achieve their objectives. Whereas conventional SCOT achieves sulfur recovery levels of up to 99.98%, SCOT ULTRA is demonstrating a significantly higher capability. For instance, in case study 1, the evaluations show that the refiner could achieve a sulfur recovery level of 99.99%.

It can be concluded, therefore, that the SCOT ULTRA process provides TGT unit operators with an inexpensive solution for meeting stringent emission regulations, including World Bank standards.

With the SCOT ULTRA process, Shell has unlocked a step change in conventional SCOT performance. It can help operators to meet stringent emission regulations, even with highly challenging and highly contaminated feeds. In most situations, no hardware changes are necessary. This is a low cost solution requiring only a solvent swap and/or a new catalyst in the reactor – even a water wash is unnecessary. This technology is de-risked, and it is an improvement of an existing process, already being deployed commercially. HE

References

1. Shell Global Solutions SCOT factsheet.
2. Aligned with Huntsman marketing materials, eg: http://www.huntsman.com/performance_products/Media%20Library/global/files/jefftreat_ms300_solvent.pdf.

Notes

- * - SCOT is trademark owned by the Shell group of companies.
- ** - JEFFTREAT is a registered trademark of Huntsman Corp. or an affiliate thereof in one or more, but not all countries.
- *** - Criterion Catalysts & Technologies LP (Criterion) is a wholly owned affiliate of CRI/Criterion Inc. and an affiliate of the Shell Global Solutions network of companies.

Benefits of JEFFTREAT® ULTRA solvent

Jointly developed by Huntsman and Shell, this next generation solvent exhibits ultra-high selectivity towards H_2S.

- Existing plants can treat to a deeper level
- Operates well in hot climates at high absorber temperatures
- Can eliminate the need for an inlet gas chiller
- Lowers required solvent circulation rates by up to 30% compared to generic MDEA
- Reduces steam, cooling, and power (utility costs)
- Minimizes the absorber height required for your process
- Saves capital costs for new plants
- Maintains treating capability during times of high H_2S spikes
- Reduces CO_2 co-absorption by up to 50%
- Increases the hydraulic capacity of co-operated sulfur recovery units

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