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 (SO₂) 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 SO₂ 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 achieve deep decreases in hydrogen sulfide (H₂S) emissions and improved selectivity for H₂S over carbon dioxide (CO₂).

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 H₂S removal specifications. In case study 1, the H₂S 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 SO₂ emission regulations, including World Bank standards (150 mg/Nm³), or those that require deep removal of carbonyl sulfide and mercaptans. While the highly selective JEFFTREAT ULTRA family of solvents bring H₂S 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 CO₂ 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 CO₂, 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 H₂S 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 CO₂ 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 H₂S 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 CO₂ slip performance while maintaining high H₂S 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>
<thead>
<tr>
<th>Table 1. The overall results of the comparative evaluation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
<tr>
<td>H₂S in treated gas (% relative to current operation base case)</td>
</tr>
<tr>
<td>Solvent circulation rate (% relative to current operation base case)</td>
</tr>
<tr>
<td>Recycle gas flow (% relative to current operation base case)</td>
</tr>
<tr>
<td>H₂S in recycle gas flow (% relative to current operation base case)</td>
</tr>
<tr>
<td>CO₂ slip, %</td>
</tr>
<tr>
<td>SRU 7 flame temperature, °C</td>
</tr>
</tbody>
</table>

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 H₂S 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 CO₂ slip, recycle flow and flame temperature, the H₂S levels would remain very high.

The SCOT ULTRA process would achieve a substantial decrease in H₂S levels (Column 3) because its more powerful solvent can maintain superior CO₂ slip. In fact, as shown, significant solvent reductions could be made and the site could still achieve superior H₂S absorption and CO₂ slip.

**Case study 2: controlling H₂S, destroying COS**

A gas plant needed to meet extremely stringent emissions limits; its target was 35 mg/Nm³ of SO₂ 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 H₂S 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 SO₂ 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.

**References**

1. Shell Global Solutions SCOT factsheet.

**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.
Introducing JEFFTREAT® ULTRA solvent

- the only solvent used in Shell’s new SCOT® ULTRA process

Benefits of JEFFTREAT® ULTRA solvent

Jointly developed by Huntsman and Shell, this next generation solvent exhibits ultra-high selectivity towards H₂S.

- 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 H₂S spikes
- Reduces CO₂ co-absorption by up to 50%
- Increases the hydraulic capacity of co-operated sulfur recovery units

Global Headquarters
Huntsman Corporation
10003 Woodloch Forest Drive
The Woodlands, Texas, 77380
USA
Tel: +1-281-719-6000
Fax: +1-281-719-6055

Asia Pacific
Huntsman Performance Products
No. 455 Wenjing Road
Minhang Economic & Technological Development Zone
Shanghai 200245, P. R. China
Tel: +86-21-3357-6588
Fax: +86-21-3357-6543

Europe, Middle East and Africa
Huntsman Performance Products
Everslaan 45
B-3078
Everberg
Belgium
Tel: +32-2-758-9544
Fax: +32-2-758-9946

WWW.HUNTSMAN.COM

© Copyright 2017. Huntsman Corporation. All rights reserved. SCOT® is a registered Shell trademark. JEFFTREAT® is a registered trademark of Huntsman Corporation or an affiliate thereof in one or more, but not all, countries.