HOW LOW CAN IT GO?

The Shell Claus offgas treating (SCOT) process has been developed to remove sulfur compounds from Claus tail gas to comply with ever more stringent air emission regulations. The standard SCOT process is able to easily meet less than 250 ppmv total sulfur in the SCOT offgas, which corresponds to an overall sulfur recovery efficiency of 99.9% on intake.

Conventional SCOT type tail gas units operate with inlet gas temperatures to the reduction reactor of 280 - 300 ˚C in order to achieve a full conversion of the sulfur species to H_2S. In most cases this temperature requires the use of an inline burner since typical steam

GERRIT BLOEMENDAL, FRANK SCHEEL AND DALLIE HOETMER , JACOBS, THE NETHERLANDS, PRESENT THE LATEST DEVELOPMENTS IN SHELL'S CLAUS OFFGAS TREATING PROCESS.

conditions in refineries and gas plants are not high enough to raise the temperature of the gas to this level.

Jacobs Comprimo® SulfurSolutions (CSS) recognised that the ability to operate at a lower temperature offered the potential to reduce energy costs, reduce equipment sizes and eliminate the high maintenance burner from the tail gas treating plant. A catalyst was developed by catalyst manufacturers that could achieve high levels of sulfur species reduction at lower temperatures, specifically below 240 ˚C. This temperature would allow steam heating to replace the inline burner.

Description

The low temperature SCOT (LT-SCOT) process essentially consists of a reduction section and

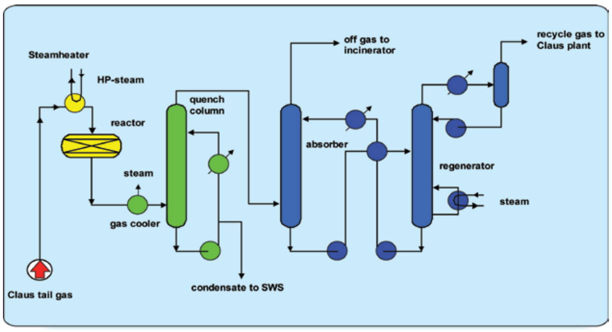

Figure 1. Low temperature tail gas treating with steam reheater.

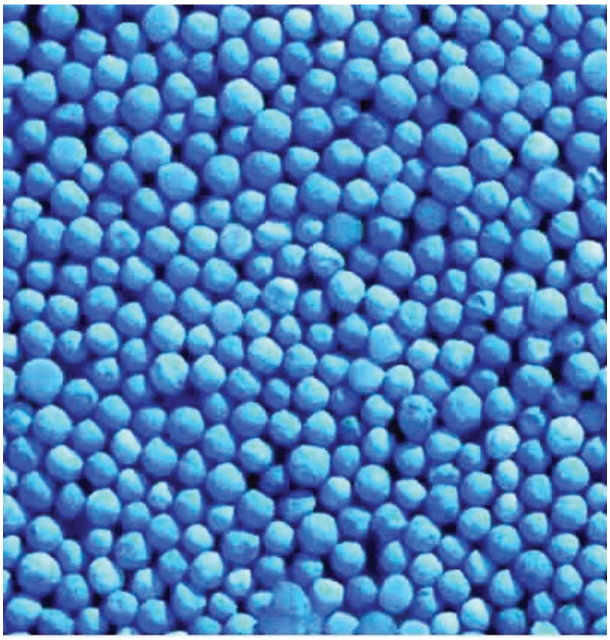

Figure 2. TG-107 is supplied as 2 - 4 mm spheres.

an ADIP absorption section of special design. In the reduction section all the sulfur compounds (other than H_2S) present in the Claus tail gas (SO_2, COS, CS_2 and elemental S) are completely converted into H_2S over a cobalt/molybdenum catalyst at 220 ˚C in the presence of reducing gas components such as H_2 and CO. The Claus tail gas feed to the SCOT process is heated to 220 ˚C with heat exchanger and optionally H_2 or a mix of H_2/CO added. If reducing gas, H_2 or CO, is unavailable, an inline burner (RGG) is required to produce reducing gas. The heated gases then flow through a catalyst bed where sulfur compounds, including CS_2 and COS, are reduced to H_2S. Water vapour in the process gas is condensed in a quench column by direct contact cooling with water and the condensate is sent to a sour water stripper. The cooled gas, which normally contains up to 3 vol.% H_2S and up to 20 vol.% CO_2 or more is counter currently washed with a selective alkanolamine solvent in an absorption column designed to absorb almost all H_2S but relatively little CO_2. The treated gas from the absorption column contains only traces of H_2S and is burned in a standard Claus incinerator. The concentrated H_2S is recovered from the rich solvent in a conventional stripper and is recycled to the Claus unit. The LT-SCOT units are designed for minimum pressure drop so that they can be easily added to existing Claus units. If insufficient pressure is available, a gas booster can be installed, preferably between the cooling tower and the absorption tower.

LT-SCOT versus regular SCOT

- It may be obvious from the above that for new units an inline burner is no longer mandatory in a SCOT unit: a simple 40 bar steam reheater can provide sufficient temperature for this catalyst. For new units this 40 bar steam is typically generated in the Claus WHB.
- Indirect savings occur from eliminating the combustion air, thus saving blower energy, and from the fact that the SCOT unit has a lower backpressure due to the lower total gas flow. The reduced gas flow subsequently also reduces the quench water and the amine circulation requirements; a 5% reduction of amine flow is achieved. This decreases the TIC of the LT-SCOT with about 10 - 15% compared to a conventional SCOT.
- Integration with the amine treater upstream of the Claus plant can lead to considerable equipment savings. The add on LT-SCOT in Figure 1 has a complete independent solvent system.

Case history

In 2003 Jacobs Netherlands was approached by Ruhr Oel Gmbh (ROG) represented by BP Gelsenkirchen - Horst refinery to assist in the upgrade of the sulfur recovery units to meet the more stringent future emission requirements.

At that moment, the refinery had three sulfur plants, two units from the early eighties provided with a common subdewpoint stage, and one unit from the early nineties consisting of a two stage Claus section and a conventional SCOT unit.

In line with the ROG BP strategy, an appraise stage was started, and several options were evaluated. All options pointed towards replacement of the subdewpoint system, either partially by adding a SCOT type process to the existing old sulfur plants or completely by installing a new, integrated Claus and SCOT unit.

To minimise investment cost, options were evaluated to provide amine solvent to the new SCOT section using the existing equipment in the refinery.

The refinery, at that point in time, used DIPA as a solvent for both the refinery absorbers and the existing SCOT absorber. After an extensive study a scenario was developed in which an existing regenerator could be made available to provide the solvent for the two SCOT units. As a side effect, this opened the possibility to change the solvent for the SCOT units from DIPA to MDEA, thus increasing the selectivity and minimising the CO_2 recycle. However, the capacity of the regenerator was still limited, making it mandatory to minimise the Claus offgas flow.

More or less parallel to these studies, Jacobs gained awareness of the fact that Axens had developed a new type of catalyst for tailgas treatment, the TG-107, which could operate at temperatures below 240 ˚C rather than at 280 ˚C. However, Axens at that point in time did not have much commercial/practical experience with this new TG-107.

Since the catalyst in the existing SCOT unit had been in operation for more than 10 years, it was considered an operational risk to continue operation with this aged catalyst for another 5 year cycle, and budget had already been allocated to replace the catalyst. Since it was known that for the new sulfur plant the refinery was running short of solvent regeneration capacity, the decision was made to replace the aged catalyst with TG-107, opening up the potential for low temperature operation and minimal sing tail gas flow. As the old unit was provided with an inline burner, the escape in case of non functioning of the TG-107 was to operate the catalyst at 'conventional' temperatures making it a unique opportunity to test the TG-107.

The new catalyst was loaded in the SCOT unit, and the unit was started by presulfiding the catalyst on June 16th, 2004. The presulfiding was done at reactor inlet temperatures below 240 ˚C (Figure 5), gaining evidence that this 240 ˚C is indeed the maximum temperature needed under all circumstances thus proving that future units can be built using a 40 bar steam heater rather than an inline burner.

The unit was left under presulfiding conditions overnight, and the next morning the tail gas from the Claus unit was introduced. After the complete Claus and SCOT unit had stabilised, checks were made for SO_2 slip from the reactor, and no SO_2 slip was found. The reactor inlet temperature was slowly but gradually reduced to find the operational limits.

An extensive survey programme was started after startup, and the catalyst performance was monitored for one and a half years, taking samples and analysing them paying special attention to COS slip and CO conversion. Initially the samples were taken on a weekly basis, later on a bi-weekly basis, and the last year on a monthly basis.

In parallel to this test programme, the new sulfur plant was planned and engineered. Although provisions were planned for future conversion to an inline burner in case the catalyst performance would decrease, the client operational staff was rapidly convinced that this new catalyst performs well, and the fall back provisions were deleted.

In 2006, the new sulfur plant was built on the plot of one of the old units. The new unit was mechanically complete in January 2007, and was brought successfully onstream. Shortly after the Claus section had been taken in operation on acid gas, the tail gas was routed into the SCOT section.

The new unit has been in operation now for more than a year and has proven to be very robust and reliable. The use of steam heaters, especially, makes operation flawless, and a continuous high recovery is obtained over a wide range of feed conditions.

In the meantime, the positive experience in the test plant has convinced several other companies to use this technology, and at this moment the TG-107 is installed in 12 units, mainly in Western Europe, and some 10 more units are under construction with capacities ranging up to 1200 tpd sulfur plant capacity, making this technology accepted in the refining industry, setting the new standard for best available technology.

Figure 3. The new sulfur plant in Gelsenleirchen-Horst refinery with two Claus reactors and an LT-SCOT reactor in one shell.

Figure 4. From left to right: Claus reheater, Claus reheater and LT-SCOT reheater.

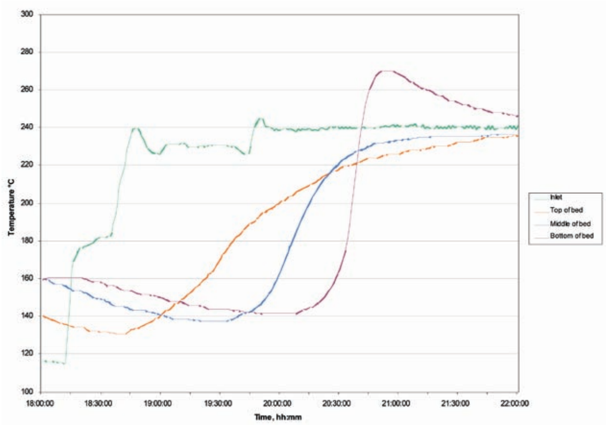

Figure 5. SCOT-reactor temperature profiles during in-situ presulfiding process.

Conclusion

More than 185 SCOT units for the treatment of tail gas from Claus plants, ranging in capacity from 3 tpd up to 4000 tpd sulfur production, are in operation throughout the world, demonstrating the reliability and flexibility of the process.

Over the last three years 20 LT-SCOT units have been designed and that number is growing rapidly both in revamp situations as in new unit designs, making this technology the new standard for sulfur recovery units.