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SULFUR-RECOVERY SOLUTIONS FOR SMALL-SCALE PETCHEM PROCESSING

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Ongoing concern about the sulfur content of natural gas and processed fuels is leading to tighter regulations and more stringent standards for sulfur emissions from processing facilities. In particular, small-scale processing facilities are seeking effective solutions that are also economical. Fortunately, advances in technology and manufacturing make it possible for small processing plants to meet regulatory demands without massive capital investment.

Sulfur recovery refers to the process of converting hydrogen sulfide (H_2S), a byproduct of natural gas processing and crude oil refining, into elemental sulfur. The Claus process typically recovers between 90% and 95% of the sulfur, and the remainder is removed with additional steps. In the US, the Environmental Protection Agency (EPA) typically requires processors to consider the total mass of emissions, sulfur dioxide (SO_2) recovery and stack effluent concentrations.

SRUs for small processors. Most small processors believe they are limited to caustic scrubbing, solid or liquid scavenger systems or liquid reagent systems that involve expensive, ongoing disposal and reagent costs. These operating costs are in addition to the original capital outlay and technology licensing fees.

These operators typically do not consider the use of standard Claus sulfur recovery units (SRUs) as an option because, historically, Claus units have been associated with plants that produce 15 metric tons per day or more of sulfur. Today, however, innovative engineering applications allow SRUs (FIG. 1) to operate at much lower capacities. The use of an SRU means that smaller processors do not need to flare acid gases, reduce production in anticipation of reaching SO_2 emissions limits or bear the high cost of reagents and scavengers.

For small-scale processors concerned about meeting additional regulations, a flexible sulfur-recovery solution is critical. Modularization is an innovative method that can provide a customized solution for a much lower cost than that of traditional SRU construction. The modular process minimizes the field construction, commissioning and total installed time to complete a project. This approach also minimizes impacts to existing onsite operations during unit upgrades.

In a modularized system, the SRUs are manufactured and tested in a fabrication facility and then shipped to the customer site for installation, final testing and startup. The advantages of modular manufacturing begin with the workforce. Whereas procuring the skilled labor required to construct a modern oil and gas processing facility can be difficult in remote locations where companies routinely explore for resources, a trained labor force is always available in the factory. This also means that fewer workers are needed at the plant site to construct and complete the project, which helps keep costs down and increases safety.

Manufacturing in an offsite shop environment compresses the typical construction schedule because the labor, equipment, materials and technical resources are immediately available, and there are

FIG. 1. A sulfur-recovery unit in the field.

minimal weather and plant-related delays. This means modular units typically can be completed in one-third to one-half the time of similar site-built equipment.

As part of the design process, the manufacturer should provide 3D modeling of the proposed units. This gives the customer an accurate visual reference of the SRU and facilitates modifications in the design. The 3D model also provides for a better understanding of how the modular unit will be incorporated into the existing equipment, and makes it easier to plan the final shipping and assembly processes.

Evaluating alternatives. Small processing plants have options for dealing with sulfur, so the evaluation of different strategies to find the best solution is important. Small SRUs allow novel engineering applications that are not available for larger SRUs.

For example, processors can use a heated sulfur tank instead of a concrete-lined sulfur pit to collect the liquid sulfur that is drained from the condensers. Typically, processors use sulfur pits to collect liquid sulfur and vent the pit gases to the sulfur unit incinerator. The drawback to this method is that any sulfur species in the vent gas contribute to the plant's overall emissions.

The use of a heated, aboveground storage tank is another option. The tank vapor space is swept with heated nitrogen and can then be routed to the tail gas treating unit (TGTU) and returned through the plant amine system to the SRU for reprocessing. By using this method, sulfur species in vent gases liberated during storage are removed but do not contribute to the plant's overall emissions.

In smaller processing plants, it is possible to combine functions and eliminate some steps and equipment in the sulfur-recovery process without compromising emission reductions or processing capacity. For example, in the quench section of a TGTU, hot tail gas from the reactor enters the quench tower to be cooled by water circulated in a loop. This process requires the circulation of quench water through a cooler and back to the quench tower. For small TGTUs, the quench tower and cooler can be combined into one small exchanger, reducing the cost and footprint required for the unit.

Maintaining a proper feed temperature is crucial for operation of the Claus and tail gas reactors, and this is another area where alternatives are available for small processors. Large facilities use steam or hot oil when available, but these can be expensive options for small processors, requiring additional infrastructure and operations. For smaller units, however, an electric reheater may be applied to perform this task. These reheaters are effective, inexpensive to install and simple to control.

Implementing a combustion control strategy is critical to optimal SRU operation and sulfur recovery. A properly instrumented and configured control strategy can play a key role in stable SRU operation. An effective control strategy, based on specific unit feeds and requirements, will provide operators with a clear picture of the unit parameters and the ability to adjust the controls for optimum recovery. This strategy can include the integration of critical online analytical results in addition to key flowmetering results.

FIG. 2. Tail gas diverter valves prior to installation.

A specially designed tail gas diverter valve system (FIG. 2)—one that addresses the need to keep elemental sulfur molten at all times in the valve area and during the recovery process—enables operators to be confident that the valves will work when needed. Real-time temperature monitoring of the valve body internals and thermal modeling through finite element analysis are available. By continuously monitoring the internal body temperature, plant operators can ensure that liquid sulfur will not solidify and cause the valve to freeze in position.

A temperature-monitoring system can measure the temperature at critical points in the body and report to unit operators if the temperature fluctuates outside of preset parameters. Equipped with temperature monitoring and designed to withstand the high temperatures, these valves seal tightly to prevent sulfur compounds from leaking into downstream equipment. Leakage into the incinerator can cause unexpected environmental emissions, and leaks into a non-operating TGTU can cause safety or corrosion problems.

Looking ahead. Sulfur recovery is a necessary operation in the petrochemical industry in the US and throughout the world. While the SRU equipment does not earn a profit for the operator, it does keep the processor from losing money due to reduced operations or plant shutdowns. The need for sulfur-recovery systems will continue to grow as environmental regulation of sulfur increases around the world. Refiners are processing more sour crude oils, and gas suppliers are exploring more sour fields. Smaller processors will be particularly affected by these trends, which will force them to seek economical solutions.

Since the efficiency of SRUs with tail gas treating routinely exceeds 99.9%, regulators are turning their attention to other sources of sulfur emissions at refineries and plants. Among these are the vent streams from sulfur pits, storage tanks and loading facilities, which traditionally have been either incinerated or routed directly to the atmosphere without treatment. Processors must be prepared to address this issue in the near future.

Regulators are also considering the sulfur content of refined products. Reducing the sulfur content in gasoline enables advanced mobile emissions controls and reduces air pollution. The EPA-proposed Tier 3 motor vehicle emissions standards would lower the sulfur content of gasoline beginning in 2017. The proposed standards are intended to reduce tailpipe emissions from most passenger cars and trucks. The goal of this new gasoline sulfur standard is to enable more stringent vehicle emissions standards and make emissions-control systems more effective.

Another looming regulatory change is a requirement for redundant sulfur-recovery capacity for smaller processors. While the specifics of this regulation are not available, there may be options for meeting this demand that will not require a doubling of every sulfur-recovery component at a plant. For example, since TGTUs are generally reliable, it may be possible to connect two SRUs, which are more prone to operational problems, to one TGTU and one incinerator to achieve proper duplication, while controlling the cost of modification. Refiners and processors must follow developments in this regulation as they make plans for the future.

With the prospect of tighter regulation on sulfur content in fuels, smaller processors are squeezed to find ways to recover more sulfur. In addition, countries around the world continue to implement more restrictive standards for sulfur emissions from petrochemical processors. **Result:** It is absolutely necessary for processors of all sizes to implement the most effective and cost-efficient technologies and practices to reduce sulfur and maintain compliance. HP

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