Expand Sulfur Recovery Unit Capacity With Oxygen Enrichment

As environmental legislation mandates stricter sulfur dioxide emission standards and products with lower sulfur contents, sulfur recovery plant loadings are increasing. To meet this need, Air Products offers a range of oxygen-based technologies engineered to increase sulfur recovery unit (SRU) capacities by 10–150%, thereby often eliminating the need for building expensive new sulfur plants.

Benefits of SRU Oxygen Enrichment

Increased acid gas capacity—when an SRU is faced with hydraulic or residence time limitations, its capacity can be increased via oxygen enrichment of the combustion air. Oxygen enrichment allows use of the existing SRU while producing new, lower sulfur products that comply with today’s regulations or processing heavier, sour feedstock to maximize margins. Also, oxygen enrichment is a low-cost method of meeting regulatory agency mandates for redundant SRU capacity.

Capital savings—SRU oxygen enrichment is only 5–25% of the cost of building a new SRU, depending on the enrichment technology deployed. It is also economical for grassroots Claus plants as a result of smaller equipment for the same acid gas capacity.

Flexibility—oxygen enrichment provides a flexible method for SRU capacity expansion. The oxygen flow rate can be adjusted to meet the changing needs of a refinery. Unlike physical expansion, no penalty is incurred for operating at lower-than-maximum capacity, since the costs of oxygen enrichment are essentially variable.

Quick implementation—the time required to modify an SRU for oxygen-based operation is relatively short. For low-level enrichment (21–28% oxygen), the oxygen supply can be “hot-tapped” into the combustion air main while the SRU is in operation. This completely avoids downtime and associated production loss.

Improved conversion and reduced emissions—the reduction of nitrogen diluent leads to higher conversions in the SRU. Also, less nitrogen entering the Tail Gas Cleanup Unit (TGCU) results in higher hydrogen sulfide partial pressure in the amine absorber, yielding better absorption and lower sulfur emissions.

Sulfur recovery units have increased capacity through oxygen enrichment by deploying Air Products’ Kirkpatrick and Brian C. Davis Refining Technology award-winning sulfur recovery technologies.
Air Products' SRU Oxygen Enrichment Technologies

SRU capacity is normally limited by hydraulic pressure drop through the unit. As combustion air is replaced with oxygen, inert nitrogen contained in the air is reduced, decreasing the SRU pressure drop and allowing more acid gas or sour water stripper gas to be processed. Air Products offers three distinct oxygen enrichment technologies for the SRU. The SRU capacity expansion needed will determine which technology is most suitable.

Figure 1 illustrates the potential SRU capacity increase for various acid gas stream concentrations and oxygen enrichment levels. Overlaid on Figure 1 are the three Air Products SRU technologies with ranges applicable for a rich acid gas stream:

**Low-level oxygen enrichment technology (LLE)**—this entails injection of oxygen into the combustion air main through a custom designed oxygen diffuser. Oxygen compatibility, affected by the air piping metallurgy and cleanliness, generally limits this technology to about 28% oxygen. LLE yields about a 10–30% SRU capacity increase with minimal plant modification and investment cost and can be implemented with zero downtime. The capacity increase from deploying this technology can often help postpone a significant capital investment in a new sulfur plant.

**COPE™ technologies**—the COPE (Claus Oxygen-based Process Expansion) process is a technology developed and jointly patented by Air Products and Chemicals, Inc. and Goar, Allison & Associates Engineered Systems, Inc. The process is a modification to the conventional Claus SRU that allows operation at oxygen enrichment levels beyond 28%, thus providing SRU capacity increases beyond those achievable with LLE. Higher enrichment levels require overcoming two hurdles: oxygen compatibility and potentially excessive reaction furnace temperatures. The COPE technology comprises COPE Phase I, which tackles the problem of oxygen compatibility with a proprietary burner, and COPE Phase II, which adds gas recycle to moderate furnace temperature. These technologies can be implemented in two phases, depending on the timing of the required capacity increase.

**COPE Phase I process**—in this process, oxygen is supplied to the reaction furnace via the proprietary COPE® burner, which is equipped with a separate oxygen port and center oxygen gun to safely handle pure oxygen. The oxygen and air streams are not premixed. This technology is utilized for oxygen enrichment beyond 28% O₂ and up to the reaction furnace temperature limit (normally 2700–2800°F). For rich acid gas streams and those SRUs processing sour water stripper gas, capacity increases of around 60% are typical. For lean acid gas feeds, increases of up to 100% may be possible. The only major equipment required for the implementation of the COPE Phase I process is the proprietary COPE burner. This burner has large turndown, high intensity mixing and excellent ammonia destruction capability. The capacity increase requirements of many sulfur recovery units can be met by using the COPE Phase I process.
COPE Phase II process—at high levels of oxygen enrichment, the temperature in the reaction furnace often reaches the refractory limit. The COPE Phase II process uses a recycle blower or steam eductor to moderate the combustion temperature by recycling a portion of the cooled process gas from the outlet of the first condenser back to the COPE burner. Cool acid gas recycle for temperature moderation is the major distinguishing feature of this technology. Figure 2 shows a Claus SRU modified using COPE Phase II. SRU capacity can more than double with this technology. Gas recycle does not increase the overall system pressure drop and is easy to operate.

The COPE burner safely handles the acid gas, combustion air (if any), oxygen, recycle gas and start-up fuel. The recycle blower has proven itself to be very reliable at many locations after over a decade of continuous service.

For safe and reliable operation, the recycle rate can be varied to provide reaction furnace temperature moderation over a wide range (2500-2800°F). The COPE Phase II process provides a high degree of operating flexibility. An SRU fitted with this process can operate at 100% O₂ as well as in the air-based mode or the COPE Phase I mode (oxygen enrichment without recycle), depending on the plant loading. Oxygen is used only when needed to achieve the desired sulfur processing capacity. Transition from air-based to oxygen-based operation and back is easily accomplished.

Special/Unique Features of COPE Technology

- Can operate at up to 100% oxygen enrichment levels to provide maximum possible capacity increase.
- Most cost-effective technology. Can be installed in most cases without the need for a new reaction furnace or waste heat boiler.
- Oxygen is added only in one location (through the COPE burner), thus providing maximum safety and reliable process control.
- All process gases go through the COPE burner. This provides the largest possible capacity increase with no temperature moderation and also ensures the complete destruction of contaminants.
- Provides state-of-the-art ammonia destruction; best among all oxygen enrichment technologies.
- A proven and extremely reliable technology with over 120 train years of operation and units onstream for over fourteen years. Figure 3 shows the SRU capacity expansion results for several COPE Phase I and Phase II installations.
Implementation

Oxygen for SRU oxygen enrichment can either be delivered to the refinery from Air Products' extensive gas supply network or generated on-site. We work closely with you from the project's outset to help determine the most cost-effective mode of supply. Some of the key factors affecting the choice are the anticipated oxygen volume, usage pattern, and the proximity to a delivery source.

Air Products employs a sophisticated Modified Claus Process Simulation Model to determine the optimal oxygen enrichment technology for your refinery. Based on the desired capacity increase, the model determines the oxygen requirement, furnace temperatures, pressure drops, heat exchange duties, residence times, and evaluates the SRU performance over the entire range of oxygen-based operation. We also provide operator safety training, participation in Process Hazard Reviews, start-up assistance and ongoing technical support.

Safety is the number one priority at Air Products, and we have one of the best safety records in the industry. Air Products provides oxygen flow control skids and process control panels which meet national and local safety codes. The process controls include many safety interlocks designed for the safe use of oxygen in the SRU. In the case of low level enrichment projects, Air Products also provides a custom-designed oxygen diffuser. Over the years, oxygen enrichment of sulfur plants has demonstrated an excellent safety record.

To Find Out More...

Air Products and Chemicals, Inc. is a major international company with over 17,000 employees operating in over 30 countries. Air Products' experience in the Refining and Petrochemicals Industries includes Claus SRU oxygen enrichment, Fluid Catalytic Cracker oxygen enrichment, Sulfuric Acid Regeneration oxygen enrichment, partial oxidation processes and oxygen technology for wastewater treatment. Air Products has offered the industry SRU debottlenecking solutions since 1985, with over 120 train years of mid and high level oxygen enrichment COPE process experience, and many other low level oxygen enrichment SRU programs.

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