

Improving Refinery Gas Processing Unit Performance With Process Gas Chromatographs

Process gas chromatographs have been used since the 1950s to provide real-time compositional data to process control systems. Today, there are tens of thousands of process gas chromatographs in use throughout the process industry making the gas chromatograph the analytical workhorse for on-line compositional measurements. One example of how process gas chromatographs are used for improving process operations can be found in the gas processing unit in a refinery.

In a refinery, the gas processing unit takes the light gases generated during the refining of crude oil and recovers any entrained heavier components. The light gases that remain are then blended and sent to the refinery fuel gas line to be used as fuel for heating the various boilers and processes. During the separation of light from heavy compounds, there are a number of opportunities to improve the unit's operation by using a process gas chromatograph to provide real-time chemical composition measurements to the plant's control system.

The Gas Processing Unit

The feed to the gas processing unit can come from a number of sources within the refinery since nearly all of

the process units generate some light gases during their operation. Typical feed streams to the gas processing unit include:

- Crude Unit
- Coker
- Fluidic Catalytic Cracking Unit
- Hydrocracker

The streams enter the unit where they are separated into low-value fuel gas streams, medium-value propane and butane streams and high-value gasoline and naphtha streams. Process gas chromatographs provide compositional data that assists the control system in ensuring that each component gets to the right product stream.

As shown in Figure 1, the feed streams first enter the absorber deethanizer unit near the bottom of the absorber unit. Entering the top of the absorber unit is an absorption oil that is being recycled from the naphtha splitter. As the absorption oil flows down the column, it interacts with the gases flowing to the top. The absorption oil strips out most of the heavier components where they eventually enter the Light Straight Run (LSR) gasoline and naphtha streams.

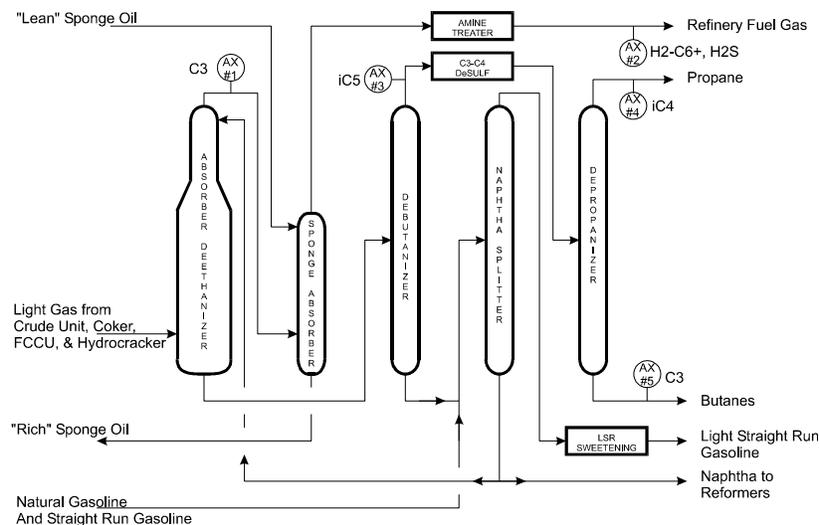


Figure 1 - Flow Diagram of a Typical Gas Processing Unit in a Refinery

A significant amount of the heavy components (C₇₊) are still present in the overhead stream of the absorber unit due to their vapor pressure volatility. To further recover the remaining heavy components, the light gases are run through a sponge absorber where a sponge oil is used to remove remaining heavy components. This "lean" sponge oil is typically a product from another processing unit like the coker or cat cracker. After the heavy components are removed, the new "rich" sponge oil is returned to the unit from which it was originally taken.

The stripped light gases leave the top of the sponge absorber and move to an amine unit for amine treatment before finally entering the refinery fuel gas system.

Back at the absorber deethanizer, the heavier components that leave the bottom of the absorber tower enter a series of fractionators that separate the mixture of heavier components into purified streams to be used by other processes.

The first step in this purification is a debutanizer that separates the C₃ and C₄ components from the rest. The C₃s and C₄s exit the overhead of the debutanizer where they are desulfurized before entering a depropanizer. At the depropanizer, the C₃s and C₄s are separated from one another into a propane stream and a butanes stream. Other refinery units then use the propane and butanes streams as needed.

After the heavy stream has left the bottom of the debutanizer, it is now ready for final purification by the naphtha splitter. In the naphtha splitter, the C₄-C₆ components are sent overhead to become light straight run gasoline used in gasoline blending or sometimes as feed to an isomerization unit. The naphtha (C₆-C₈+) leaving the bottom is sent to the refinery reforming unit with a small stream that is recycled back to the top of the absorber deethanizer.

Improving Unit Performance With Process Gas Chromatographs

With the amount of chemical separations in the gas processing unit, there are a number of opportunities for process gas chromatographs to improve the unit performance. The first opportunity to use a process gas chromatograph is monitoring the overhead stream of the absorber deethanizer. It's important that C₃ and heavier components not get lost in the overhead stream. Therefore, this chromatograph (Chromatograph 1) monitors the C₃ concentration in the overhead stream. By controlling the C₃ concentration, all of the other heavy components will automatically be minimized in the overhead stream.

The next opportunity for a process gas chromatograph (Chromatograph 2) is monitoring the BTU and H₂S content of the light gases leaving the sponge absorber.

The next three opportunities for process gas chromatographs is to improve the operation of the fractionators. Chromatograph 3 monitors the overhead stream of the debutanizer to minimize loss of valuable C₅+ components. Chromatographs 4 and 5 monitor the overhead and bottom of the depropanizer tower for performance optimization.

A summary of these applications can be seen in Figure 2.

The Emerson Solution

Emerson has a long history of providing process gas chromatographs for the refining industry. Emerson process gas chromatographs continue to set the standard for on-line process measurement by supplying analyzers that are both robust and capable of handling the analytical requirements.

Analyzer #	Stream	Components Measured	Measurement Objective
1	Absorber deethanizer overhead	C ₃	Maximize recovery of heavy components
2	Refinery fuel gas	H ₂ -C ₆ +, H ₂ S	BTU calculation and H ₂ S monitoring
3	Debutanizer overhead	iC ₅	Minimize losses of heavies in the overhead stream
4	Depropanizer overhead	iC ₄	Optimize tower operation
5	Depropanizer bottoms	C ₃	Optimize tower operation

Figure 2 - Summary of Process Gas Chromatograph Applications in a Typical Refinery Gas Processing Unit

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