Improving Refinery Catalytic Reformer 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 catalytic reformer unit in a refinery.

A number of high-octane alternative processes were developed as refineries attempted to remove lead from gasoline as an octane booster. Within this process, a catalytic reforming unit is used to run naptha streams through reactors that chemically restructure (or reform) the molecules into higher octane compounds.

Specifically, C_6 - C_8+ paraffin compounds are reshaped into a benzene, toluene and mixed xylene (BTX) rich stream. Other reactions occur but the production of a BTX-based reformate is the primary goal.

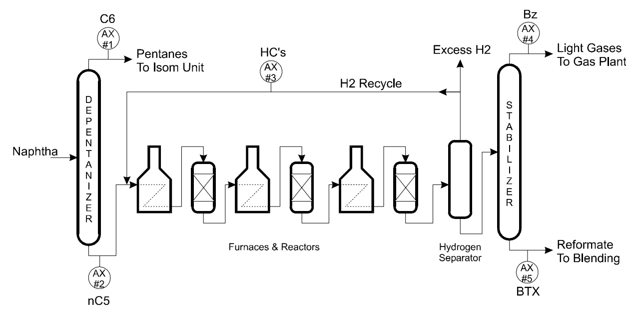

Figure 1 - Flow Diagram of a Typical Catalytic Reformer in a Refinery

The Catalytic Reforming Unit

The feed to the catalytic reforming unit in a refinery is typically a naphtha stream. The naphtha may come from a number of sources in the refinery, but typically comes from one of the side cuts from the crude unit. Before entering the reformer unit, the naphtha is first processed through a hydrotreating unit to remove compounds that are harmful to the catalyst in the reactors such as ammonia, sulfurs and metals.

As shown in Figure 1, the treated feed stream typically enters a depentanizer tower to remove the C_5 and lighter compounds from the naphtha. This is done for two reasons; light compounds cannot be reformed into an aromatic, and running them through the reactors accomplishes nothing other than adding a burden to them. In addition, light compounds tend to decompose in the reactor creating carbon formations on the catalyst.

After the light hydrocarbons are removed, hydrogen is added to the naphtha before it is run through a series of heaters and reactors. The chemical reactions are endothermic, and the heaters provide temperatures high enough to sustain the reactions.

After the last reactor, the stream enters a hydrogen separator to strip out the H_2 (and other light gases) from the stream. During the reactions, a net surplus of H_2 is created. Some of it is recycled back to the beginning of the process with the remainder sent to other processes that need H_2 such as hydrotreaters and hydrocrackers.

After the removal of the H_2, the stream enters a stabilizer tower (also called a debutanizer) that removes the butanes and lighter compounds from the reactor product. The reformate that remains leaves the bottom of the tower and is used by the gasoline blending system to make higher-octane gasoline. The reformate is sometimes sent to chemical processing plants to extract the BTX aromatics for the manufacture of other chemicals.

Improving Catalytic Reformer Unit Performance With Process Gas Chromatographs

A number of opportunities exist to use process gas chromatographs to improve the reformer unit performance. The first opportunity for using process gas chromatographs is to monitor the overhead and bottom streams of the depentanizer tower. Monitoring the overhead stream (AX #1 in Figure 1) for C_6 content can help minimize the loss of the C_6+ paraffins that are needed to feed the reactors. Monitoring the nC_5 in the bottom stream (AX #2 in Figure 1) helps control the amount of C_5 compounds and lighter that enter the reactor series.

The next analysis point (AX #3 in Figure 1) measures the hydrogen recycle stream for H_2 purity. A number of light hydro-carbons remain with the hydrogen and need to be monitored for their negative impact on the reactor catalyst. In some installations, a thermal conductivity analyzer can be used rather than a gas chromatograph if the levels of hydrocarbons do not vary significantly.

The last two common measurement points are the overhead and bottom streams of the stabilizer tower. Analyzer #4 monitors the overhead stream to minimize losses of the valuable aromatics and Analyzer #5 monitors the aromatics content of the reformate stream as it is sent to other process units.

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's process gas chromatographs have 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	Depentanizer overhead	C_6	Minimize losses of C_6 + paraffins
2	Depentanizer bottoms	nC_5	Minimize light paraffin content in the reactor feed
3	Hydrogen recycle	CO, CO_2, C_1 - C_5	Track hydrocarbon impurities in the H_2 recycle stream
4	Stabilizer overhead	BZ	Minimize losses of the aromatics in the overhead stream
5	Stabilizer bottoms	Aromatics (BTX)	Monitor aromatics (BTX) in the product stream

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

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