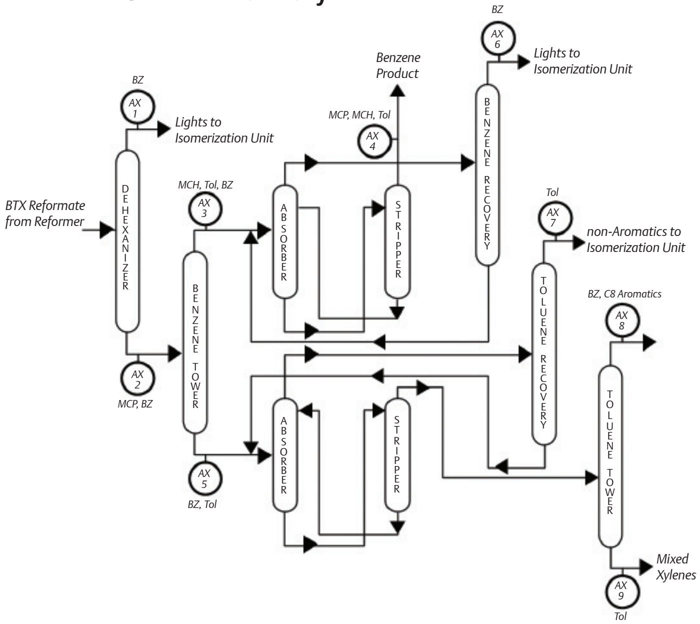
Improving Refinery Aromatics Separation Unit with Process Gas Chromatographs

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 aromatics separation unit in a refinery.

Many refineries take the reformate from the catalytic reformer and extract the aromatics rather than blend them into gasoline. This is done for two reasons. The first is to meet the high demand of benzene, toluene, xylenes and other aromatics by the chemical industry. The second is the strict limitations on how much aromatics gasoline can contain due to the U.S. Environmental Protection Agency's Clean Air Act requirements. For these two reasons, the current trend is to separate the various aromatics in the reformate as product streams rather than blend them into gasoline.

Figure 1 - Flow Diagram of a Typical Aromatics Separation Unit in a Refinery



The Aromatics Separation Unit

The reformate product stream from the catalytic reformer unit is the feed to the aromatics separation unit. As shown in Figure 1, reformate typically enters a dehexanizer tower that removes the light paraffin compounds in the reformate. The compounds that are removed are predominately C_5 and C_6 paraffins that are then sent to the isomerization unit for further processing. The bottom stream from the dehexanizer then goes to the benzene tower.

At the benzene tower, the benzene and lighter components are sent to an absorber-stripper section that separates the benzene from the lighter components. Any light compounds that leave the absorber are sent to a benzene recovery tower where one last attempt is made to recover benzene from the stream. The light compounds eventually leave the top of the benzene recovery tower and go to the isomerization unit. The benzene product stream exits the top of the stripper column.

While the benzene is being purified, the stream leaving the bottom of the benzene tower enters a different set of absorber-stripper columns to separate the non-aromatic compounds from the aromatics. The non-aromatics leave the top of the absorber where they enter a toluene recovery tower that makes a final attempt to recover any aromatics from the non-aromatics. The non-aromatics leave the top of the toluene recovery tower and move to the isomerization unit or other units as a light straight run gasoline stream. The aromatics enter the toluene tower where the toluene product is separated from the heavier aromatics such as xylene, ethyl-benzene and C_9^+ aromatics. In some facilities, the mixture of xylenes is further processed to separate them into purer products.

Improving Unit Performance with Process Gas Chromatographs

A number of opportunities exist to use process gas chromatographs to improve the aromatics separation unit performance. The first opportunity is optimizing the performance of the dehexanizer tower. On the overhead stream, a process gas chromatograph (AX #1 in Figure 1) monitors any benzene in the stream to minimize the loss of aromatics. A second process gas chromatograph (AX #2 in Figure 1) monitors the bottom stream for methylcyclopentane (MCP) and benzene. The control system calculates the MCP-to-benzene ratio to control the amount of MCP in the final benzene product.

A third process gas chromatograph (AX #3 in Figure 1) monitors the overhead streams in the benzene tower. This overhead stream is monitored for other impurities that could end up in the benzene product stream by measuring the methylcyclohexane (MCH), toluene and benzene. The MCH and toluene is ratiod to the benzene level to control how much of these impurities end up in the benzene product.

The final benzene product is monitored with a process gas chromatograph (AX #4 in Figure 1) to verify the product purity by measuring the MCP, MCH and toluene. To insure that the maximum amount of benzene is recovered as product, a process gas chromatograph (AX #5 in Figure 1) measures for benzene concentrations in the overhead streams of the benzene recovery tower.

The bottom streams of the benzene tower are monitored using a process gas chromatograph (AX #6 in Figure 1) for the benzene to toluene ratio to control the amount of benzene that would end up as impurity in the final toluene product stream. Another gas chromatograph (AX #7 in Figure 1) monitors the actual toluene product for common impurities such as benzene and C_8^+ aromatics. There is also a process gas chromatograph (AX #8) on the toluene recovery tower overhead to minimize the loss of toluene into the non-aromatics. Finally, there is often a gas chromatograph (AX #9 in Figure 1) on the mixed xylene stream to minimize the loss of toluene. A summary of these applications can be seen in Figure 2.

The Emerson Solution

Emerson has a long history of providing process gas chromatographs to 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.

Table 1 - Summary of Process Gas Chromatograph Applications in a Typical Refinery Aromatics Separation Unit

Analyzer #	Stream	Components Measured	Measurement Objective
1	Dehexanizer overhead	BZ	Minimize losses of benzene
2	Dehexanizer bottoms	MCP, BZ	Provide MCP-to-BZ ratio to control MCP in benzene product
3	Benzene tower overhead	MCH, BZ, Tol	Provide MCH^+ Tol to benzene ratio to control impuritiesin benzene product
4	Benzene product	MCP, MCH, Tol	Monitor benzene product quality
5	Benzene recovery overhead	BZ	Minimize losses of benzene
6	Benzene tower bottoms	BZ, C_8 Arom.	Provide BZ-to-Tol ratio to control BZ in toluene product
7	Toluene product	BZ, Tol	Monitor toluene product quality
8	Toluene recovery overhead	Tol	Minimize losses of toluene
9	Mixed xylenes product	Mixed Xylenes	Minimize losses of toluene

BZ = Benzene
Tol = Toluene
MCP = MethylCycloPentane
MCH = MethylCycloHexane
C_8 Arom = C_8 Aromatics

www.RosemountAnalytical.com
www.analyticexpert.com
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Emerson Process Management
Rosemount Analytical
Gas Chromatograph Center of Excellence
10241 West Little York, Suite 200
Houston, TX 77040 USA
Toll Free 866 422 3683
T +1 713 396 8880 (North America)
T +1 713 396 8759 (Latin America)
F +1 713 466 8175
gc.csc@emerson.com
www.RosemountAnalytical.com

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