

# Improving polyethylene plant 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 polyethylene plant in a refinery.

Polyethylene is the most widely used plastic in the world with a number of modifications that have developed over the years to meet different market requirements. One of the biggest differences between the various processes is the density of the polymer. High Density Polyethylene (HDPE) is the crystalline form of the plastic and would be used where stiffness is an important quality like plastic pipe and household cleaner bottles. Low Density Polyethylene (LDPE) is the powder form of the plastic and is used for applications where flexibility is important like cling wrap and dry cleaner bags.

This application note describes the slurry-based HDPE process, but the basic concepts of analyzer use would also apply to the equivalent locations in a LDPE design.

## The polyethylene plant

The manufacture of polyethylene involves reacting many ethylene molecules with each other in the presence of a catalyst to form long chains of polymer. As part of the chemical reaction, a second compound, called a “comonomer” is added. This might be a chemical like hexene, butene-1 or propylene. Depending how much of which type is added, these chemicals affect the polymer’s final properties such as stiffness. Hydrogen

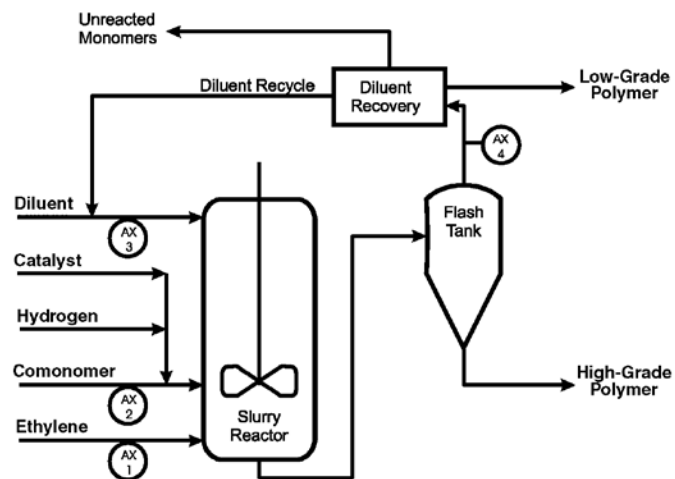


Figure 1 - Flow diagram of a typical HDPE polyethylene plant

is added to the reaction mixture to terminate the polymer chain length to control the polymer’s melting point. The reaction components are continuously fed into a reactor that is constantly being stirred (see Figure 1). To keep everything as a slurry, an inert diluent compound such as hexane or butane is also added to the reactor. The diluent also helps absorb the heat that is generated in the reaction.

The formed polymer, along with the diluent and any unreacted components, exits the reactor and enters a flash tank. Due to the flash tank’s lower pressure, any unreacted monomers and the diluent vaporize and leave the top of the vessel. The polymer settles out the bottom to be extruded into plastic sheets or pellets.

The vapors leaving the top of the flash tank enter a diluent recovery system to separate the diluent from any unreacted monomers as well as to filter out any polymer dust that

might have carried over. The diluent is recycled back to the feed of the reactor. The unreacted monomers are sent to other processes to be reprocessed and purified.

**Improving unit performance with process gas chromatographs**

Due to the extremely competitive nature of a commodity like polyethylene, it is critical that the quality of the plastic be high and consistent. To insure this high quality, it is important that the ingredients into the polymer reactor be tightly controlled. A number of process gas chromatographs are used to provide live feedback on the quality of the feed streams.

The first two process gas chromatographs (AX #1 and #2 in Figure 1) monitor the ethylene and comonomer for common impurities such as CO<sub>2</sub>, C<sub>1</sub>, C<sub>2</sub> and acetylene. The diluent recycle is also monitored (AX #3 in Figure 1) for the presence of H<sub>2</sub>, C<sub>2</sub><sup>=</sup> and comonomer impurities.

To provide feedback to the control system regarding reaction progress in the reactor, it is common to measure the flash tank off-gases. Measurement of the amounts of unreacted ethylene as well as the comonomer and hydrogen can indicate the quality of reactions occurring. However, this can be a difficult point to sample due to the high concentration of polymer dust. Special sample probes are used to filter out the polymer and to self-clean the filters to minimize plugging. 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 polyethylene industry. Emerson's process gas chromatographs have set the standard for online process measurement by supplying analyzers that are both robust and capable of handling the analytical requirements.

Analyzer #	Stream	Components Measured	Measurement Objective
1	Ethylene feed	CO <sub>2</sub> , C <sub>1</sub> , C <sub>2</sub> , acetylene	Ethylene feed purity
2	Comonomer feed	CO <sub>2</sub> , C <sub>1</sub> , C <sub>2</sub> , acetylene	Comonomer feed purity
3	Diluent feed	H <sub>2</sub> , C <sub>2</sub> <sup>=</sup> , comonomer	Monitor impurities recycled with the diluent
4	Flash tank off-gas	H <sub>2</sub> , C <sub>2</sub> <sup>=</sup> , comonomer	Feedback on reaction kinetics

**Figure 2 - Summary of process gas chromatograph applications in a typical HDPE polyethylene plant**

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