Polyethylene Polypropylene

APPLICATION NOTE

Polymer plants continue to seek ways to increase production and efficiency without compromising safety.

Process gas analysis is integral to the control and optimization of the polyethylene and polypropylene manufacturing process. The composition of the reactor gas streams provides the plant control system with an indication of production efficiency, and the information necessary to make adjustments to process variables. Due to the need for polymer manufacturers to vary product formulations, the speed of inlet gas analysis becomes particularly important during process transitions. To attain a real-time measurement, polyethylene reactor gas was monitored using a MAX300-IG, process control mass spectrometer. This data was compared to a simultaneous measurement performed using the traditional process gas chromatography (GC) approach. The GC data validated the accuracy of the MAX300-IG, while further comparison indicated that the mass spectrometer was faster, and able to provide a more complete analysis.

Typically, the production of polyethylene and polypropylene occurs via the polymerization of the gaseous monomer in the presence of strictly defined concentrations of the additives necessary to produce the desired density and branching within the final product. Manufacturing facilities are designed to generate different polymeric materials in response to market conditions.

These variations in the plant's mode of operation occur in a semi continuous process, with changes to the composition of the gas-phase reactants determining the final product. As a result, there is a transition period occurring between each "batch", as the reactor constituents change over from the initial formulation to the composition that will yield its replacement. A batch can run for hours or several days, generating material of significantly diminished value, considered “off-spec” product. Gas analysis of the reactor sample is typically used to automate process control based on production conditions. Specific gas mixtures are optimum for the generation of a given class of polymer. Closely monitoring these concentrations allows the manufacturer to adjust process variables if any deviation is detected from the ideal set point. In this way, the plant maintains maximum efficiency and is able to protect equipment from aberrant or uncontrolled reactions. Furthermore, because of the high frequency of transition events, the rapid detection of standard process conditions results in substantial gains in efficiency; it deceases the amount of material that must be sold as "off-spec". For maximum safety, efficiency, and product yields, the polymer plant is reliant on fast, accurate gas analysis during stable process conditions and formula transitions.

Real-time Analysis in Polymer Production

A MAX300-IG, process gas analyzer, was used to monitor production at a polyethylene plant in parallel to a process GC. The mass spectrometer analyzed all of the gases in the process stream, while the GC measured hydrogen, ethane, and ethylene. The analysis rate of the MAX300 was 0.4 seconds per component. This allowed the analyzer to measure six streams at the facility at a rate of 10 seconds per stream, with a clearing delay. The fast data acquisition provided a high level of precision and accuracy when compared to the GC data (Fig. 1).

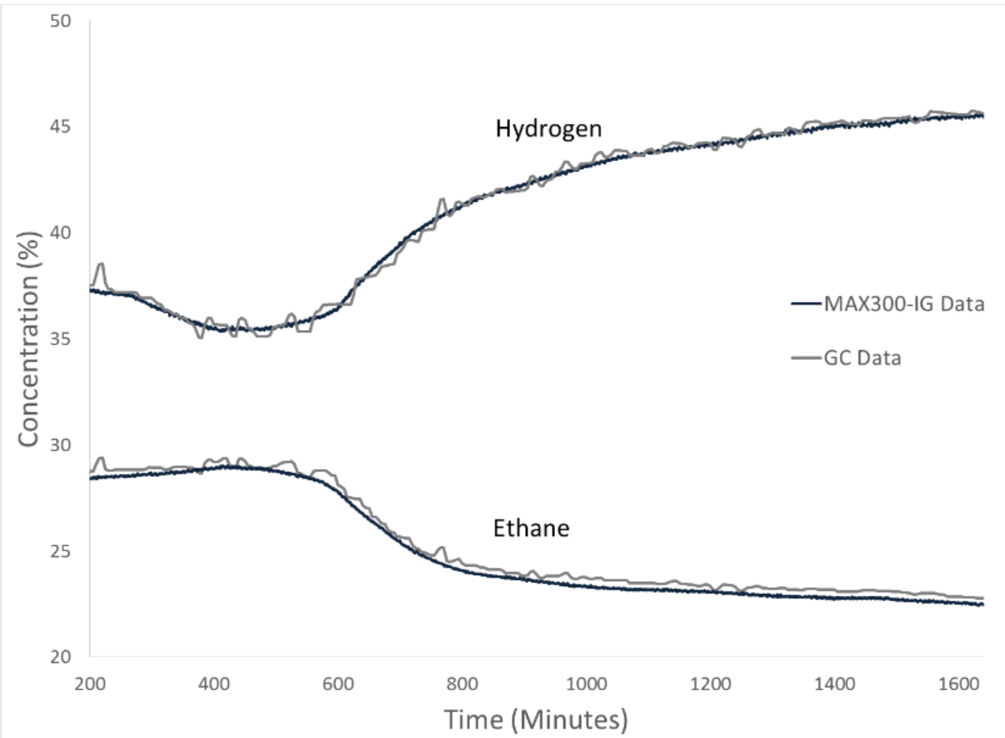

Figure 1. The MAX300-IG was used to monitor all components of the polyethylene process. Here, the hydrogen and the ethane trends from the mass spectrometer are shown along with 24 hours of GC data recorded on the same stream. Both instruments provide accurate measurements, while the real-time acquisition of the MAX300 yields a high-precision profile of the changing gas composition.

The rate of data reporting is particularly important to plant operations during the transition from one polymeric formulation to another. These transitions can occur multiple times per day and, if a manufacturer can recognize the end of the transition faster, they can sell more high-value product. The MAX300-IG was able to identify the endpoint of transition 5.3 minutes sooner than the GC at the test site (Fig. 2).

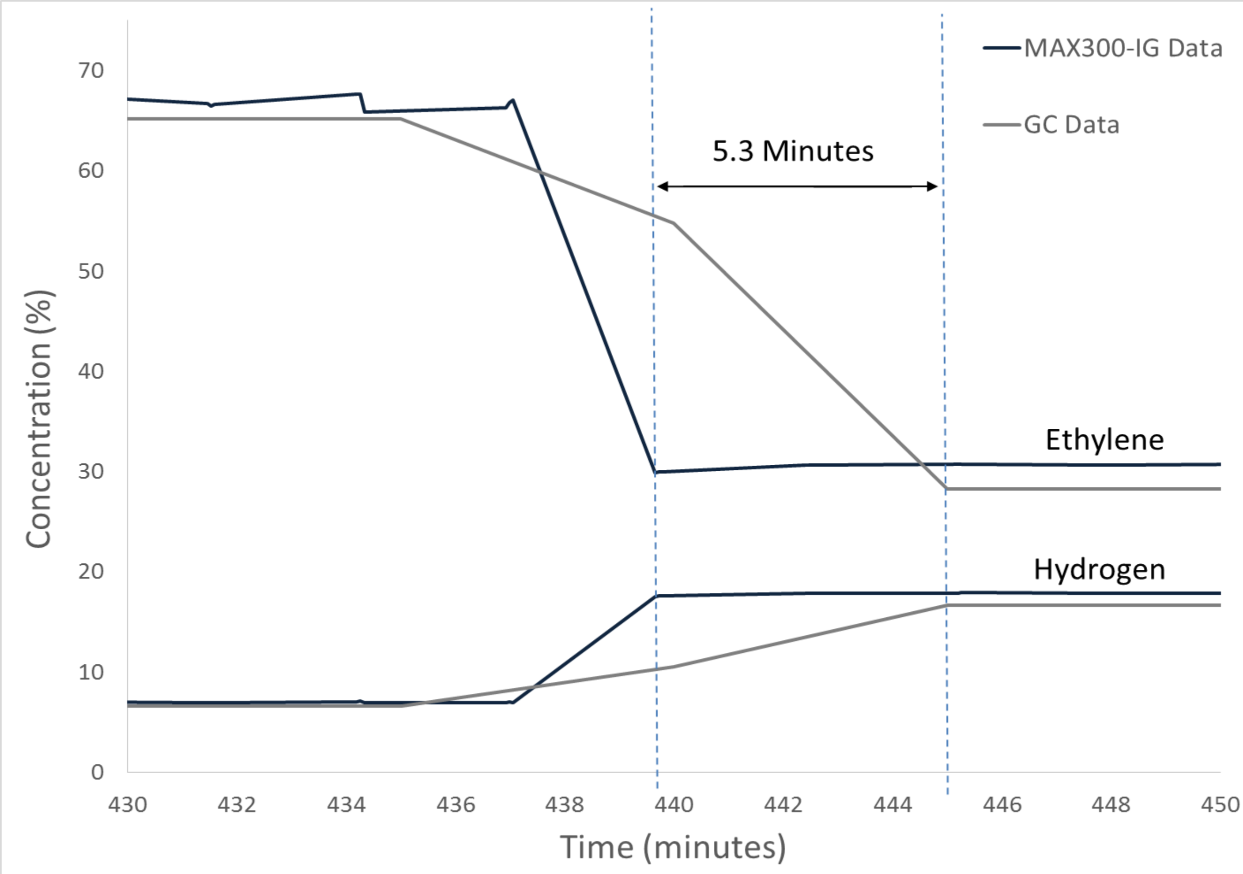

Figure 2. During product formula transition, the MAX300-IG identified the endpoint 5.3 minutes faster than the GC analyzing the same sample stream. The ability to quickly identify the onset of production conditions increased the volume of high-value product produced.

Pinpointing the conclusion of the transition is particularly important. For example, on a production line producing 5 tons of low density polyethylene (LDPE) per hour, 5.3 minutes represents 0.45 tons of product. The value of product manufactured during 5.3 minutes, at the same LDPE production line is $618*. The MAX300-IG has the speed to monitor multiple production lines at the same facility. At a site with 3 such production lines undergoing a transition every 2 days, the value of identifying the completion 5 minutes faster would be worth as much as $29,000 per month.

*At $1,400/metric ton of LDPE

The MAX300-IG

Mass spectrometry has been used for industrial process control for over 40 years. In polymer applications, the MAX300-IG (Fig. 3) provides the real-time measurement of alkane and alkenes as well as of hydrogen, nitrogen, and argon in the reactor sample streams (Table 1). The analyzer can measure all components at concentrations ranging from 100 % down to 10 ppb. This dynamic range, and the high linearity is particularly important during product transitions where component concentrations can change drastically in a relatively short period of time (Fig. 4).

The 19 mm quadrupole mass filter allows for increased sample throughput, generating high analysis repeatability and long term stability, with no loss of sensitivity at the high-mass range. The analyzer performs quantitative analysis at a rate of 0.4 seconds per component. Typical maintenance consists of replacing the plug-and-play ionizer unit and changing the pump oil biannually. The analyzer does not use a carrier gas.

Table 1. Standard polymer application measurements for the MAX300-IG, process gas analyzer.

Compound	Analysis m/z
NITROGEN	28
HYDROGEN	2
METHANE	16
PROPANE	29
PROPYLENE	41
ETHANE	30
ETHYLENE	26
1-BUTENE	39
OTHER BUTENES	56
N-BUTANE	58
ISOBUTANE	43
PENTANE	72
4M1P	84
4M2P	69
1-HEXENE	**55**
N-HEXANE	86
N-OCTANE	85
N-DECANE	142
ARGON	40

Figure 3. The MAX300-IG, Process Control Mass Spectrometer

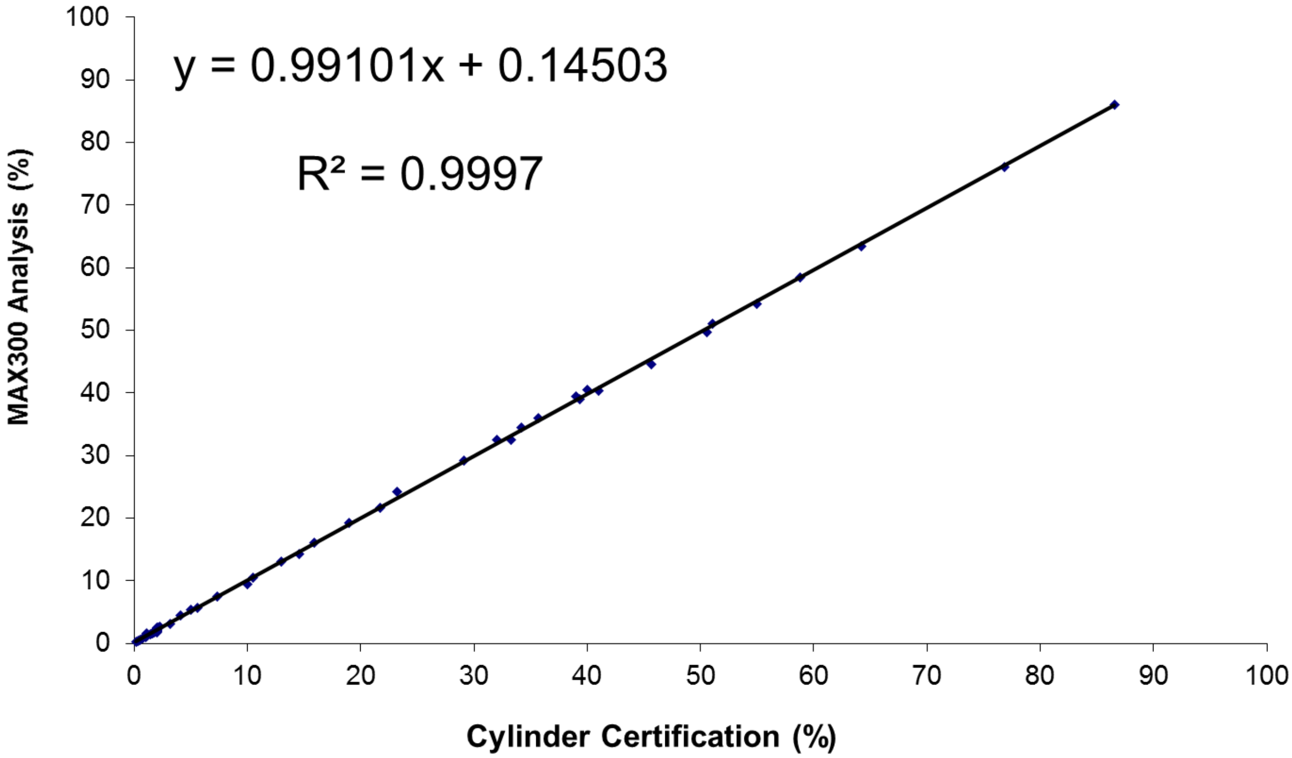

Figure 4. The linearity of the MAX300-IG is demonstrated by the analysis of certified gas bottles. This dataset includes readings of propane, propylene, ethane, ethylene and hydrogen. Calibration for instrument response is obtained from a single standard and the analyzer is linear from 100% down to the low detection limit.

Conclusion

The MAX300-IG, process gas analyzer is an effective tool for polymer process control. The analyzer requires limited maintenance and calibration support, and provides a real-time, quantitative measurement of all compounds in the inlet and effluent streams of multiple reactors at a manufacturing facility. The analysis rate updates the control system at 10 seconds per sample stream. This real-time analysis is important for maintaining high-precision production control. Controlling the reactors as close to optimum conditions as possible increases product yield, and maintains equipment with minimum adjustment, reducing turnover. Endpoint detection is particularly important during formula transition. The fast analysis of the MAX300-IG yields significant economic increases compared to the slower analysis approaches.

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