Press release/ Expert Paper

The Application Of Improved Sensing Technologies To Protect Product Quality In Polyethylene

Polyethylene are thermoplastic resins obtained by polymerizing the gas ethylene [C2H4]. Because of its exceptional application flexibility, polyethylene's rise in popularity for both consumer and industrial uses means that today it is the largest volume plastic in the world.

Low density polyethylene (LDPE) are polymerized at very high pressures and temperatures, and the high-density types (HDPE) at relatively low temperatures and pressures. Another type called linear low-density polyethylene (LLDPE) is manufactured through a variety of processes, of which gas phase is the most common. This most widely used Polyethylene process yields both HDPE and LLDPE with a wide range of copolymers.

The simplicity of the process accounts for its popularity: A high efficiency catalyst system aids in the polymerization of ethylene and allows for lower temperatures and pressures than those required in making conventional low-density polyethylene. In addition, it accommodates a broad range of interesting property combinations used in both HDPE and LLDPE markets. The gas phase process requires the production of a high-quality product while maintaining high standards of process safety. Traditionally production has depended on the use of gas chromatograph technologies to measure for hydrocarbon impurities in the process, and electrochemical fuel cell technologies to measure for ppm levels of performance. While able to make the requisite measurements, GC technologies have long been criticized for their relative expense to run and slow rate of response – problematic when protecting yield quality; while electrochemical oxygen sensors by their nature deplete and require regular calibration and replacement, resulting in ongoing cost and unnecessary system downtime.

In both cases, Servomex have adapted the latest advances in light hydrocarbon and O2 analysis technologies to provide measurable performance advantages over traditional techniques. Combined, Servomex offers a next-generation analyzer solution for polyethylene improves yield, ensures product purity and guarantees safety.

As product quality is paramount throughout the process, the ethylene feed requires measurement for any residual light hydrocarbon present from the fractionation process. This type of measurement is also required later in the process, as any residual ethylene recovered in the degassing tower and recycled together with the ethylene from the top of the reactor. In this recycle loop a hydrocarbon measurement is required to control the recycle process more efficiently.

The analysis of light hydrocarbons in polyethylene production has traditionally been carried out using gas chromatographs (GC), in particular process gas chromatographs (PGC). It works by physically separating the hydrocarbon compounds through a long column as the stationary phase and a carrier gas as the mobile phase. The different hydrocarbon compounds exit the column at different times, which are then detected by a detector. Measurement time for a C1-C5 analysis varies between 90 seconds to 5 minutes, depending on the type of instrumentation and configuration used. A continuous flow of dry, high-purity carrier gas, generally helium, is needed.

An optical hydrocarbon gas analyzer based on infrared absorption techniques has long been envisioned to enable a far quicker speciation and quantification of the individual hydrocarbon components in multi-component matrices of alkanes, alkynes and alkenes. Servomex's SERVOTOUGH SpectraScan 2400 light hydrocarbon analyzer utilizes revolutionary new Tunable Filter Spectroscopy optical sensor technology for on-line hydrocarbon gas composition analysis – a measurement uniquely developed for applications where a real-time analysis is necessary for optimal process control. Faster and less complex to use than existing Gas Chromatograph (GC) analysis techniques, breakthrough real-time readings for light hydrocarbons C1-C6 are available almost instantly – taking seconds rather than minutes. In addition, an optical analyzer does not need a carrier gas, which reduces the infrastructure requirements and operating costs.

A widely used optical gas analyzer technology used in process monitoring is non-dispersive infrared (NDIR), where one or a few discrete wavelength bands are used to measure the concentration of the sample gas through the absorption characteristics in those wavelength bands.

In general, a single beam multi wavelength (SBMW) or the more conventional sample and reference beam units (multi-beam, single wavelength MBSW) represent the methodologies of most Process IR analyzers, giving fast component concentration updates (in seconds) outside the response time of sample conditioning systems. They are not however reliable in differentiating or spectating similar chemical entities, such as the different compounds of hydrocarbons.

The SpectraScan incorporates a powerful improvement of the SBMW method where, rather than using discrete optical filters with limited amount of wavelength bands selected to correspond to required measurements, a tunability element is introduced to enable a degree of continuous spectral coverage which leads to a capability to deconvolute complex spectra.

Accordingly, Tunable Filter Spectroscopy (TFS technology successfully and rapidly speciates light hydrocarbons and enables fast and reliable caloric value measurement.

Consisting of a light spectrometer, a flowthrough sample cell, a single-element photo-detector and electronics, the SpectraScan's all-optical sensor platform uses a unique tunable Fabry-Perot assembly that provides wavelength scanning with high etendue, enabling high-throughput and high-precision wavelength scanning in preselected region. The physical separation of the compounds as performed in chromatography is not required - instead the analyzer achieves speciation and quantification of the individual hydrocarbon components in multicomponent matrices of alkanes, alkynes, alkenes and/or alcohols.

The SpectraScan's measurements include:
 Methane (50-100%, C1),
Ethane (0-20% C2);
Propane (0-10%C3);
Iso-Butane (0-5% iC4);
N-butane (0-5%)
l Pentanes (0-2% C5 lumped); and
n-Hexane (0-2%, nC6), plus a measurement for Carbon Dioxide (0-20% CO2).

Using the absorption of infrared light as it passes through the volume of gas, the absorption spectrum of each compound acts as unique "fingerprints" for identification or speciation analysis. In addition, the magnitude of the absorption is a function of the number of molecules of the gas, and in certain conditions a linear relationship according to Beer- Lambert law. With a known path length, pressure and temperature, the magnitude of the absorption spectra is used to compute volumetric concentrations. An advanced spectral processing and chemo metric algorithm provides highly accurate and robust speciation performance, compensating for various spectral nonlinearities due to pressure, flow and temperature variations. Unlike Fourier-Transform infrared spectrometers (FTIR), the TFS design is mechanically simple and does not require high-precision optical alignment, and thus insensitive to shock and vibration, while providing equal or better signal-to-noise performance. Compared to grating base spectrometers such as diode array based spectrographs, the TFS provides much greater optical throughput or Etendue which results in better quality spectra which are important for quantitative measurements. The TFS allows for a continuous wavelength scanning within a predetermined wavelength window or a set of wavelength windows, enabling "true" absorption spectra to be measured at very near spectral point spacing.

The stability of the analyzer is of great importance as it affects the maintenancerequirements and operational costs. The SpectraScan is specified to have a permanent span calibration/ accuracy and < 0.2% of full scale of baseline drift per month. The span accuracy is permanently maintained as it is based on "first principle" of direct absorption measurement where the measurement signal is solely dependent on the molar concentration, pressure and temperature.

Pressure is continuously measured in real time and corrected, and sample temperature is maintained at 60°C through the use of a heated gas cell and an integrated pre-heat line. The spectral processing algorithm removes any baseline noise and drifts to the extent that light source drifts/degradation and contaminated windows, two common sources of drifts, are minimized or eliminated. TFS analyzers have run for months without the need for re-zeroing.

The TFS based hydrocarbon composition analyzer's performance is characterized in a number of laboratory tests to demonstrate its accuracy, linearity, calibration robustness, selectivity and stability. The accuracy is defined in terms of root mean squared error of prediction (RMSEP), where measured concentrations are less than 0.2%. C1 to C4 saturated alkanes are measured with equal to or better than 0.05% accuracy; propene and ethane have slightly lower prediction accuracy (RMSEP 0.15% and 0.18% respectively) which is mainly due to concentration over ranging.

Robustness of the calibration model is proved by over-ranging ethane and ethane to 32% outside their calibration limits of 25% and 10% respectively, where accuracy is not affected in the presence of hydrogen, an un-modeled background. Overall repeatability of the measurements is within a highly acceptable 0.02%.

The result is a breakthrough measurement for light hydrocarbon analysis, which eliminate the slow performance and cost-of-ownership issues posed by GC technologies by providing unattended, real-time and consumable-free analysis ideally suited for the polyethylene manufacturing process.

Servomex is locally represented by Elemental Analytics in Johannesburg. With the use of their extensive experience doing **turnkey projects**, they offer a full extended product portfolio with related sample systems. They are committed to exploring the **import replacement market** and serve the industry with products of high quality and reliability

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About Elemental Analytics:

Elemental Analytics (Pty) Ltd is a company based in Boksburg, South Africa, specializing in analytical applications. The company has effectively marketed and maintained instruments in Africafor the past 25 years.

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