Process Mass Spectrometry

A Tool for High Performance Gas Analysis

By Graham Lewis

Mass spectrometers (MS) have been providing fast, precise online gas analysis for industrial applications for more than 30 years and continue to provide valuable data for process control and environmental and safety monitoring. But one trend in particular — accessibility — has had a substantial impact on the recent growth of these instruments.

Traditionally regarded as a powerful but delicate laboratory tool relegated to the realm of highly-trained lab experts, gas analysis mass spectrometers have become more flexible in terms of analytical capabilities are defined in hard-wired components, whether they are analyzing solids, liquids, or gases.

Why Use MS for Gas Analysis?

Mass spectrometry has become one of the preferred methods for multi-component gas analysis because of its speed and range; gas analysis mass spectrometers can provide a quantitative analysis in seconds and are more flexible because their analytical capabilities are defined in software, compared to many other gas analyzers whose analytical capabilities are defined in hardware. This distinction is what allows an MS to analyze a wide range of sample streams with widely different compositions. For example, in the chemical and iron-making industries, the MS can analyze natural gas with methane concentrations over 90 percent as a feedstock, then later in the process measure streams containing methane at less than 0.5 percent concentration.

How It Works

All mass spectrometers share the same five basic components, whether they are analyzing solids, liquids, or gases.

Sample selection: The two main types of sample selectors for gas analysis are continuous inlet and batch inlet. A continuous inlet is used when a relatively large amount of sample is available to flow to the MS. Sample selection is under software control, with rapid multi-stream samplers, rotary valves or banks of solenoid valves used to switch between gas samples. Because of the speed of MS, it is not uncommon to have up to 60 sample streams being analyzed by one MS. The batch inlet is used when a limited amount of sample is available, usually at low pressure. The sample is expanded into a fixed volume to reduce its pressure, and then into the MS.

Pressure reduction: In most applications it is preferable to ensure that the original sample composition at the original sample pressure (usually atmospheric or slightly above atmospheric) is maintained at the vacuum pressure in the MS; the pressure reduction system should not discriminate between lighter and heavier atoms and molecules. The most common inlet is a combined capillary and molecular leak, and an alternative is the membrane inlet.

Ionization: The most common technology for ionizing gas samples is electron impact (EI). In EI, streams of high energy electrons are emitted from a hot filament and focused to collide with the sample gas; these collisions eject electrons and produce positively charged ions, which are directed into the mass separator by electrodes. While EI is relatively simple and extremely well-proven, detection of trace components can be difficult.
The magnetic sector MS provides greater stability and precision (between two and 10 times better) than the quadrupole MS. Unlike the flat-topped peak generated by the magnetic sector, the quadrupole produces a Gaussian 'round top peak'. So it is 'fault sensitive' — any drift in the mass scale will produce an error in the peak height measurement. This has to be corrected by more frequent calibration.

The magnetic sector MS is also much more resistant to contamination than the quadrupole. The ions are accelerated into a vacuum, where they are separated by their mass to charge ratios in a magnetic field of variable strength. In a process MS, ions are separated by their mass to charge ratios in a magnetic field of variable strength. In a magnetic sector MS with high energy quadrupole — used for process gas analysis.

Detection: Most gas analysis applications are carried out using a Faraday cup detector, which has a very wide dynamic range. A secondary electron multiplier may be used when greater sensitivity is required. A modern gas-analysis MS may employ both detectors for high concentration and low concentration ion beams.

Conclusion
Smaller. Faster. More precise and intuitive. Technology has advanced dramatically and rapidly over the last two decades, including in the world of mass spectrometry. Scientists and researchers can evaluate more processes in the world of mass spectrometry. Scientists and researchers can evaluate more processes in the world of mass spectrometry. Scientists and researchers can evaluate more processes in the world of mass spectrometry.