Process Analyzers — A Key Control Tool

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Process analyzer is short-hand for process analytical instrument, a device that provides chemical composition data on process streams in real-time, or as close to this ideal as the measurement technique permits. Chemical composition is almost the name of our profession, so these instruments run to the very heart of the chemical engineering psyche.

Process analyzers first appeared in the late 1930s in the Ludwigshafen research laboratory of I.G. Farbenindustrie with the development of the non-dispersive infrared (NDIR) analyzer for process gas streams by Dr. Karl Luft. A few years later, his colleague Dr. Erwin Lehrer developed an oxygen analyzer based of this molecule's paramagnetic properties. According to British Intelligence Operations Subcommittee (BIOS) Report #1007, dated June 12, 1946, the German chemical industry had deployed 400 NDIR analyzers and 12 paramagnetic oxygen analyzers during WWII. Many of Germany's most highly instrumented facilities, moreover, were under Soviet occupation and not available to the BIOS investigators.

In the late 1940s and 1950s, U.S. refineries and chemical plants began to adopt process analyzer technologies derived from both the earlier work in Germany, as well as domestic innovations in process photometry, process chromatography and other techniques. As with NDIR, new technologies tend to originate in end-user organizations, although there are exceptions to this rule. Dr. Arnold O. Beckman developed the pH meter (patent filed Oct. 12, 1934 and granted Oct. 27, 1936) on behalf of the California Citrus Growers Association. Beckman Instruments, founded to commercialize this development, expanded into photometry and chromatography, pushing this technology forward in the post-war period.

Process (UV) photometry was pioneered by DuPont in the context of a new process for the production of pigment-grade TiO_2 by the oxidation of $TiCl_4$. Process gas chromatography (GC) was pioneered at Union Carbide in South Charleston, WV, and Phillips Petroleum in Bartlesville, OK. Beckman, working with Mobil Oil and others, was a third early leader in process GC. Exxon Research & Engineering and Dow Chemical were also early leaders in process analyzer technology and application development.

In the 1960s and 1970s, the emergence of the mini-computer and the integrated-circuit microprocessor allowed more sophisticated and computation-intensive analytical technologies, particularly Fourier transform infrared (FTIR) and near infrared (NIR), to be deployed for onstream assays. The microprocessor also enabled internal diagnostic procedures to be incorporated into all process analyzers, increasing the reliability and credibility of these measurements.

Today, virtually any laboratory analytical method can be, and has been, deployed for onstream usage. Process applications of mass spectrometers are routine. This technology was developed for use in NASA's Mars landings in the 1970s, and Dow installed it in an ethylene oxide reactor only a few years later. Now, even more precise, ion cyclotron resonance (ICR) mass spectrometers, which can reliably separate isotopic species, are available for onstream use.

The process industries have always considered their applications to be among the most demanding in terms of ruggedness and durability. Many are, but other environments can be equally demanding. Optical data transmission is a worldwide reality, and these systems must operate unattended for significant periods in highly stressed environments. Could these components be useful for industrial spectroscopy? With the telecommunications industry in an over-capacity slump earlier in this decade, producers began to seriously explore the industrial market for applications of their optical technology. This, in turn, made available to process engineers additional options for fast, noncontact, nondestructive assays.

Another current driver of analyzer technology is the requirement for extremely low-level, trace component measurements in microelectronics fabrication, pharmaceuticals manufacturing and other high-precision applications. Detection limits are often in the low parts per billion (ppb) into the parts per trillion (ppt) region. This may seem remote to much of the chemical process industry, but if it can be measured, it can be mandated.

Licensed from Princeton University, continuous-wave cavity ring-down spectroscopy (CW CRDS) is said to be so precise that if it were a population counter pointed at the U.S., the accuracy of the result would be within one person. The licensee of this technology is Tiger Optics, LLC (www.tigeroptics.com). Over the last five years, more than 300 of these instruments have been installed at over 80 companies. In chemicals manufacturing, the fact that CRDS assays are absolute, requiring neither calibration nor costly calibration gases, together with its speed of response, is an important benefit.

Process analyzer technology has been evolving for more than 70 years and at an accelerating rate to meet increasingly demanding requirements. To stay abreast of these developments, two annual gatherings are recommended — the International Forum on Process Analytical Chemistry (IFPAC; www.ifpac.org) and the ISA Analysis Div. Symposium (ISA AD; www.isa.org/analysissymp). These two meetings offer high-quality technical programs and, perhaps, most importantly, the movers and shakers of this specialty, from both the end-user and the supplier sides, are generally well-represented.