Monitoring process performance

Process diagnostics technologies are facing greater challenges, higher expectation levels, and market demand for new and better services.

Unscheduled shutdowns can cost companies hundreds of millions of dollars a year in downtime and lost product. Many firms in the chemical process industries have taken a proactive stance in making sure that these types of situations are minimized by implementing state-of-the-art process-monitoring technology.

Many plant engineers are familiar with process investigation studies, which include process diagnostic services such as gamma scanning, radioactive tracing and neutron moderation. All are used to troubleshoot, optimize or monitor the online performance of both process equipment and entire process units. The key to these services is assessing *online performance*, since it is the capability of providing either real-time or time-tagged information under actual operating conditions that makes these services viable. Familiar examples of process diagnostic applications include scanning a distillation column to identify tray damage, or injecting a radioactive tracer into a suspect heat exchanger to confirm crossover between the shell and tube sides.

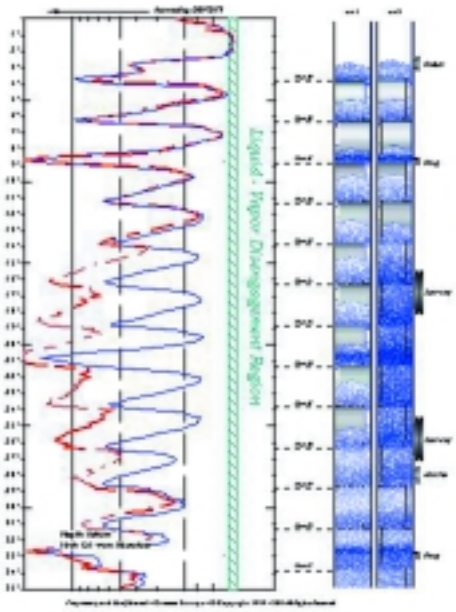
Process diagnostics has evolved over the course of the past 50 years. Continuing improvement in gamma detection, data acquisition and software development have made scanning and tracer results more sensitive, resolute and commercially viable. Dramatic improvement in timing and accuracy are attributed to the development of portable computers, as well as advances in scintillation detection. As with any new technology, the level of sophistication increases as each success or major breakthrough paves the way for another.

Today, process diagnostic companies are providing ammonia plant services, offshore technology services, and fluidized-catalytic cracker (FCC) diagnostics, focusing on the operation of an entire plant, as opposed to a single unit, such as a heat exchanger or distillation column. This approach diagnoses existing problems and identifies operating constraints by characterizing overall unit performance. As one ExxonMobil engineer noted, "We applied a wide variety of process diagnostic tools to troubleshoot FCC problems, as well as to increase our fundamental understanding of complex multiphase reaction systems. These tools allow improved correlations to be developed between the performance of pilot plants, computational fluid dynamics models and commercial units."

At present, a short list of key players provides these services. These include Tru-Tec Services (a Div. of Koch Industries), Synetix Services (formerly ICI Tracerco), Gamma Surveys, and Nuclear Scanning Services, Inc. (NSSI). Each company varies with respect to its size and technical emphasis.

Breaking new ground

As process diagnostics has gained acceptance throughout industry, its application envelope has been stretched to accommodate greater challenges, higher expectation level, and market demand for new and better services. For example, hybrid services have been developed to deal with formerly insurmountable measurement problems. One such example is provided by Tru-Tec's SpectScan service. This combines two different, applications — gamma scanning and radioactive tracing — to characterize liquid-phase distribution over fixed-catalyst-bed reactors (most notably, hydrotreaters). It does this by injecting a radioactive tracer into the feed immediately upstream of the reactor. As the mixture of radioactive tracer and reactor feed are introduced into the reactor, the tracer attaches itself to the catalyst bed, imprinting actual liquid distribution. The reactor is then gamma scanned to identify where the tracer is located as a function of elevation and radial geometry. Before the advent of this technology, attempts to characterize liquid distribution using conventional gamma scan and tracer methods had been futile. Another recent distillation application involves using a tracer and carefully placed scintillation detectors to track and characterize flow patterns on dual-flow trays.



Software from Gamma Surveys automatically analyzes tray conditions, giving the engineer various scenarios, such as the example above, for scan interpretation.

In the early 1990s, Tru-Tec developed its CAT-Scan service to generate a cross-sectional density profile of reactor risers or packed beds for distribution evaluation purposes. Instead of taking relative density measurements vs. elevation (*i.e.*, a gamma scan), the measurements are made by modifying chord length and angular orientation to provide a density difference as a function of radial geometry. A CAT-Scan can be thought of as a gamma scan performed at a fixed elevation. The data are then input into a linear regression algorithm that is similar to the one used by CATscan technology within the medical profession.

The technology has taken nearly 10 years to achieve the same standards of reliability and repeatability of the more-established gamma scan and tracing technologies. Today, CAT-Scan technology is the only viable means for detecting annular maldistribution, a condition whereby severe liquid/vapor channeling exist in coaxial flow about the geometric center of a packed bed.

Meanwhile, Synetix has concentrated its efforts on offshore technologies. The firm was the first to use radioactive tracing, gamma scanning and neutron moderation for process investigation studies on a commercial level. The firm has also produced nucleonic instrumentation as an offshoot of its core service businesses.

One new application is the Tracerco Profiler. This measures stratification of foreign materials that lay down inside horizontal multiphase settlers. At present, oil/water/gas (OWG) separators and certain reactors have already benefited from this new technology. The Profiler is a permanently installed density/level detection instrument that measures phase-to-phase dispersion, as well as the quality of the interface between phases. It accomplishes this by providing a real-time fluid density profile in 1-in. increments. The equipment requires no maintenance, and interfaces directly with plant control systems, allowing continuous process control of phase, emulsion and foam levels. Commissioned systems on OWG separators have resulted in increased throughput due to improved process control, and significant savings due to reduced chemical additive (*e.g.*, foam inhibitor) consumption. According to Mike Bonner, Chevron operations team leader, "This system has created a major step change in the way we run our [offshore platform] operations… We have reduced our production losses due to process upsets, increased production rates and improved our environmental performance."

Another recent innovation is Synetix's Tracerco Diagnostic Catalyst Maximizer. This uses extremely sensitive gamma-forward-scatter technology to provide absolute density measurements of reactor catalysts. It can identify the conversion of zinc oxide into zinc sulfide in sulfur purification reactors. This particular measurement allows for an online determination of remnant catalyst bed life. Developments such as Tru-Tec's Spect Scan and the Tracerco Diagnostics Catalyst Maximizer are particularly appropriate in reactor applications where large vessel diameters, thick walls and dense catalyst beds preclude conventional gamma transmission measurements.

Taking a different tack on the market is Larry Baker, founder and president of Gamma Surveys, an independent services company, presently focusing on gamma scan and related technologies. According to Baker, "We have taken a heuristic approach to interpreting and presenting scan data." Baker has written software that automatically analyzes tray conditions, presenting the engineer with various probability scenarios that could explain the scan data (figure). This is useful for training young engineers, and for providing the customer with a more uniform methodology for scan interpretation.

Combination packages

New technologies aside, other changes are underfoot. One trend is the tendency toward large project work involving a medley of different services. This exists in stark contrast to what has been the mainstay of the business for the last 20 years, using one (or two at best) service(s) to identify a singular problem involving one major piece of operating equipment. The focus is now shifting to using process diagnostics to characterize overall unit performance by applying many tests and test methods. What is unique and noteworthy is not that large-scale projects are happening, but that they are happening on a regular basis.

Furthermore, each project often consists of several different test methods, each approaching the problem from a different angle. For example, an FCC reactor riser study could involve one tracer test to determine vapor velocity and distribution; a second to determine catalyst velocity and distribution; a CATscan to determine the density profile of the reactor riser at a critical elevation; and, finally, an infrared image of the riser to concur all test results. The data from the litany of tests are then analyzed qualitatively and quantitatively to determine the catalyst slip factor and other measures used to optimize performance. On the distillation side of the business, gamma scans are being used to help plan turnarounds by identifying the scope of tray or packing repairs, months in advance of the targeted shutdown date. Gamma scans are also being used during startup to document baseline performance.

Once again, using scan results predictively is not a new concept. The fact that it is happening on more than an occasional basis is noteworthy, since the practice involves crossing over party lines that exist between chemical and mechanical engineers, and maintenance vs. operations. Tru-Tec now provides site reliability specialists, in which an engineer(s) or technician(s) is permanently assigned to a customer's site. The approach combines technology and experience with an intimate knowledge of the plant environment, including its critical equipment, key players and common operating problems. The concept has been tested at Koch Industries' Pine Bend and Corpus Christi refineries with positive results thus far.

— John Bowman