Industrial sensing instruments lead to ‘mass customization’

Rob Randelman and Rob Morris

Manufacturers today demand optical sensing instruments that are more versatile and adaptable than ever, challenging technology suppliers to provide rugged, reliable, and customized solutions.

Manufacturing has changed much over the past 25 years. A high percentage of goods are now made and distributed globally. The Internet is a major marketing tool, the age of the single-purpose factory or manufacturing line is almost over, and a new era of lean manufacturing and flexible, multi-purpose facilities is in sight. The age of mass customization is nearly upon us.1

Competition has never been more robust. As a result, industries are constantly looking for better ways to manage their supply chains, reduce waste production, increase manufacturing yields, and build value in their brands. Small savings or subtle improvements can make the difference between being successful and merely surviving. Analytical instruments that are rugged, reliable, and give better operating decision data can assist with this process and help to ensure success.

This idea is not new. Photometry, visual inspection, and even Fourier transform infrared spectroscopy (FTIR) have been employed in process control for a long time. There are, however, typically two major disadvantages with these techniques: cost and ‘rigidness of implementation’. Purchasing and maintaining such analytical instruments is costly, so only the most critical processes employ such systems. Furthermore, once the equipment is installed, it is often difficult and expensive to change the instrumentation or its uses as needs change. But both these problems can be overcome by utilizing miniature optical sensing technologies, especially fiber-optic spectroscopy.

The emergence of miniature spectrometers in the 1990s coincided with the development of low-cost computers and modular optical fibers, which meant that spectroscopy was no longer limited to the lab. Opportunities in field and process applications were now viable.

Miniature spectroscopy is particularly suited for process environments, where monitoring raw stock, processes, and finished goods is critical (see Figure 1). Flexibility in detectors, light sources, and sampling optics allows miniature spectrometers to be more deeply embedded in the process stream, making it much simpler to optimize setups.

Another consequence is that multiple-point sampling and redundant sensing are easily integrated into on-line applications. In fact, small-footprint modular systems can be rapidly configured for making a variety of absorbance, reflectance, and emission measurements. The potential applications for these systems are as varied as monitoring dye baths in carpeting, verifying the color and appearance of food and beverages, and analyzing chemical dissolution processes in pharmaceutical production.

This all means that industrial sensing instruments now need to meet a range of design criteria.

For example, they need to be rugged. The environments they operate in can be harsh, often experiencing extremes of temperature and humidity and the harmful effects of dust and vibration. Process-ready spectroscopic instruments, therefore, have

Figure 1. Small instrument size and flexibility make it much easier to measure raw stock. For citrus fruit, criteria such as maturation and sweetness can now be tested before the fruit is even harvested.

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few moving parts, can be configured to ensure thermal stability, and can be adapted to industrial or other shock-resistant enclosures. These properties have allowed miniature spectrometers to be carried into space, strapped to rockets and even used inside volcanoes without any problems.

They also need to be reliable. Improvements made to the reliability of sensing instruments have meant that predictive maintenance is now much easier to conduct, even as systems have become smaller, more flexible, and less expensive. One of the aims of Ocean Optics’ Jaz instrument is to ensure reliability by making the instrument ‘smart’ – capable of handling functions such as self-calibration, system health tests, reviews of spectral parameters, and using spectral data to warn of unusual events.

Optical sensing instruments for process environments need to be easily integrated into the process stream. But they also need to be versatile enough to work in a hand-held platform, especially at the beginning (raw stock) and end (finished goods) of the production process. Hand-held devices are ideal for gathering, storing and retrieving data. Adding another layer—designing the instrument as a series of modules with common electronics and communications—produces a device that can easily be adapted as an accessory to whatever architecture is required.

Despite all this enhanced functionality, operating costs have generally fallen. For example, multi-wavelength spectroscopic sensing—especially in the UV and visible ranges—has dramatically decreased in cost on a per-measurement basis (see Figure 2). Most miniature spectrometer systems can be configured for far less than $20,000 per instrument, and have sufficient flexibility that reworking them for different process needs is not a particularly expensive proposition.

Industrial sensing customers value ease of use, convenience, time savings, and a quality product. What distinguishes top industrial sensing system providers is the ability to rapidly develop application-specific measurement systems. Spectroscopy-based systems like the Jaz have all the advantages of spectroscopy, including multi-channel capability. But they can also feature: a microprocessor and onboard display that eliminate the need for a separate computer; stackable, autonomous instrument modules that make it simple to customize the system to changing application needs; and Ethernet connectivity for remote operation.

That is a lot of functionality built around one core spectroscopy technology, and that is just one instrument from a single manufacturer. Every day, optical designers are developing industrial sensing instruments that make mass customization possible.

This could lead to a future in which analytical instruments and smart sensors not only make commercial production processes more efficient, but can also alert operations staff to maintenance issues, process upsets, or ways to improve performance. Imagine instruments that can communicate with their ‘colleagues’ throughout the plant—and throughout the world—to report how they are doing and to highlight current process conditions. Imagine a future where analytical instruments could, in an hour, be completely reconfigured for another manufacturing process.

These breakthroughs hold the potential to radically change how we think of process automation. Instrumentation for this application used to be expensive, difficult to manage, and designed for a particular use that only the largest operations can afford; now it is becoming a flexible, easy-to-implement and use, cost-effective solution that is suitable for even the smallest operations.

The future holds a number of bright possibilities and Ocean Optics and other instrument providers are working on making those possibilities a reality.

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Figure 2. For smaller, more hands-on process operations like this micro-brewery, low-cost optical sensing instruments can reduce measurement barriers.
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References
1. http://en.wikipedia.org/wiki/Mass_customization Mass customization is a term coined in the early 2000s to describe the notion of producing ‘the many of the few’ – goods or services that are singular in scope, but manufactured with mass-volume economies of scale. Accessed 13 March 2008.