Technology Notebook

Solid-state backscatter technology boosts film-gauging performance

Editor's note: David W. Pond is chief operating officer of Automation and Control Technology, and Fred A. Ferraro is engineering manager at eV Products.

To minimize raw material waste and improve product consistency, manufacturers of plastic products made of blown film and cast sheet/film, such as garbage bags and plastic sheets, use backscatter gauges to measure the thickness of product as it is being manufactured. Nucleonic backscatter gauges, while useful, sometimes fall short in performance, ease of use, and cost of ownership. This is largely because these gauges use radioactive materials, and their use requires compliance with government regulations. However, new solid-state backscatter gauges, using cold-cathode X-ray sources and cadmium zinc telluride (CZT) detectors, promise to measure the thickness of film and cast sheet products more accurately, safely, and economically.

Measuring Thickness

In blown-film production, where measuring instruments can't be positioned on both sides of the product, a single-sided setup must be used to measure material thickness. A probe beam of X rays, gamma particles, or beta particles is aimed at the surface of the material, and the fraction of the beam that is reflected is measured (see Figure 2).

Until recently, backscatter gauges were isotope-based devices, employing gamma or beta particles generated by radioactive (nucleonic) materials. These gauges have several drawbacks. Regulation compliance specifically has to do with nuclear safety and disposal. Second, nucleonic gauges detect backscattered particles using either scintillation tubes, which can be fragile, or ion chambers, which lose gas pressure. Finally, because nucleonic gauges use only a single detector, their speed of response and measurement accuracy are limited.

Solid-State Advantage

Backscatter gauge systems (see Figure 3) employ current technology to create the probe beam and detect backscatter. These solid-state gauges use nanotechnology-based cold-cathodes to generate X rays for probing materials and solid-state CZT detectors to measure backscatter.

By using cold-cathode-generated X rays, instead of nuclear-generated gamma or beta particles, solid-state gauge systems avoid the numerous regulatory issues associated with nucleonic gauges. This shift away from using nucleonic materials makes solid-state backscatter gauges more convenient and cost-effective to use. For example, end-users can replace sensors on the production line without waiting for field service—thereby eliminating long downtimes and increasing productivity.

A further advantage of cold-cathodes is that they can be turned on and off instantaneously via software control. This capability provides excellent control of the probe beam. More importantly, when power is turned off, no radiation is emitted. Nucleonic gauges constantly emit radiation, even when power is turned off.

The detectors used to measure backscatter are just as important as the technology used to generate the probe beam. Solid-state CZT detectors are ruggedly constructed devices with an open-ended service life. CZT is well suited for backscatter applications because it can be manufactured in almost any shape and size (see Figure 1). Consequently, solid-state gauge systems employ multiple, closely

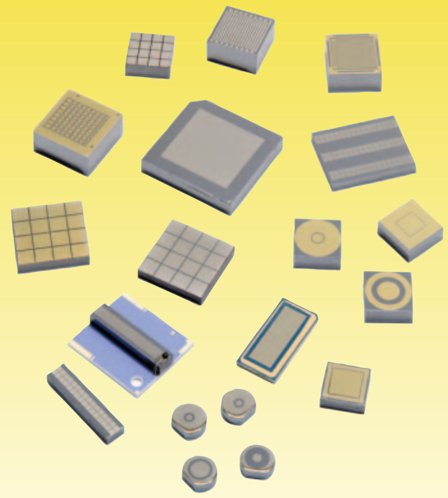

Figure 1. Solid-state cadmium zinc telluride (CZT) detectors can be manufactured in almost any shape and size.

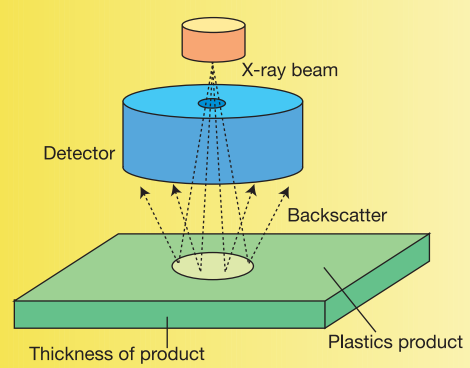

Figure 2. Principals of backscatter measurement: In a single-sided thickness-measuring configuration, the source and backscatter detector are positioned on the same side of the product being measured. The thickness of a product is determined by aiming a probe beam at its surface and measuring the fraction of the beam that is backscattered.

spaced detectors of several shapes and sizes to minimize dead space and increase backscatter collection-efficiency (see Figure 4). In contrast, nucleonic backscatter gauges use a single scintillation detector.

By using multiple detectors, solid-state systems increase data collection speed and accuracy. For example, when several backscattered X-ray photons simultaneously impinge on multiple CZT detectors, each photon is correctly counted as a unique backscatter event.

Speed of response, which improves measurement precision and repeatability, is increased in solid-state gauges by providing multiple digital signal processing paths inside the sensor head. These design features directly translate into higher performance. To provide flexibility to end-users, these systems can provide both digital and analog output signals.

Connecting Measurement, Control

Current solid-state backscatter gauges integrate measurement and control — providing flexible mounting configurations to match the end-user's process, easy-to-use software control, and efficient data management. Software control enables tuning of both the X-ray source and the detectors to match the characteristics of the product being measured.

Figure 3. The BXR-1 Backscatter Sensor from Automation and Control Technology Inc. uses multiple solid-state detectors and a cold-cathode X-ray source to measure thickness safely, accurately, and economically.

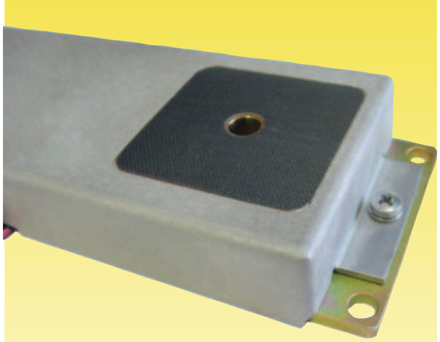

Figure 4. Solid-state backscatter gauges employ multiple, closely spaced CZT detectors of several shapes and sizes to minimize dead space and increase backscatter collection efficiency. In the BXR-1, the detectors are under the black area of the detector head.

When a plastics manufacturer switches from one product to another, the operator selects the appropriate recipe for the material, and through software, the system instantly tunes the characteristics of the sensor and detector. This capability allows changes to be made "on the fly" without having to shut down the line to make time-consuming hardware changes.

The combination of software control and rapid response enables users to acquire real-time dynamic feedback and factory management data to quickly and easily track and analyze changes in product quality. Data collection and report generation is accomplished through an integrated data collection and management system.

Solid-state Economics

Cost comparisons between various backscatter gauges must address the total cost of ownership (TCO) of a device. TCO includes the initial purchase price, direct costs such as replacement parts and service costs, as well as indirect costs such as maintenance downtime, cost of compliance with hazardous material regulations, and operator training.

The initial cost of a solid-state backscatter gauge is higher than that of a conventional gauge. However, the TCO of solid-state gauges is significantly lower. Because there are no scintillation tubes or ion chambers to replace, solid-state backscatter gauges are anticipated to have significantly lower operating costs than nucleonic gauges.

The development of nonnucleonic backscatter gauges that use cold-cathode X-ray sources and solid-state detectors has caused a shift in thinking about thickness measuring technology. By employing cold-cathode sources, these devices eliminate concerns associated with nucleonic gauges.

Furthermore, multiple reliable CZT detectors improve measurement accuracy and potentially reduce downtime and total cost of ownership. By taking advantage of the inherent benefits of solid-state and nanotechnology, backscatter gauge manufacturers are satisfying demands for safe, accurate, and affordable film-gauging instruments. PM&A

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