Beyond the Oven

How vision inspection technology can safeguard baking quality

BY **ANDREW MCGHIE**

Today's industrial bakery looks much different than it did 40 years ago. Baked goods that were once mixed, proofed, shaped, and decorated manually by the baker are now meticulously produced by automated machines. Several factors compel bakeries toward automation; a growing competitive landscape and diverse consumer demands are only part of the industry-wide drive to innovate and automate.

While much of the baking process is mechanized, most bakeries today still employ manual inspectors as their core line of defense to ensure top-quality baked products that are safe to consume. Despite these production innovations, quality assurance teams face the difficult task of accurately inspecting products for brand-specific traits and detecting unwanted foreign materials at full-line speeds.

Manual inspection was much more reasonable in the bakeries of the past, which produced products at smaller volumes than today's operations. Access to baking quality assurance experts was also different back then. Even so, relying solely on manual inspection presents more challenges than solutions for a modern industrial bakery.

Vision Inspection Technology

Many companies have started integrating vision inspection technologies to optimize product flow and help streamline final product assessment. Vision inspection systems incorporate high-speed cameras with imaging software and advanced algorithms to directly detect and measure food products for important visual traits on the production line.

Vision inspection technologies are commonly grouped into two inspection categories: final product inspection (FPI) systems and vision process control (VPC) systems.

Many early adopters of vision inspection technology used it to assess final products before packaging, helping them apply objective data to enhance their quality assurance programs. These types of vision inspection systems fall into the FPI category.

Next, bakeries began integrating automated rejection and recirculation capabilities into their FPI system to discard out-of-spec products based on programmed criteria. These criteria range from universal product traits such as overall product size, shape, and color to more detailed or brand-specific features like split height and length of a loaf of bread, topping coverage such as seeds, chocolate chips, and others.

More recently, as bakeries began adopting automated technologies to produce their products at higher volumes, processors began exploring different ways vision inspection could close the loop on their overall process control. While FPI applications could accurately assess product results, these processors needed more information to determine why their results occurred and how to correct them.

This data gap led to the introduction of VPC systems, which are typically installed at key production process stages at any point before packaging. Data visualization and real-time feedback, connected with process machinery, help enable a "smarter" manufacturing line, one in which bakers and operators can make data-driven decisions on process adjustments.

Combining VPC with FPI is how bakeries achieve 100% unbiased online inspection free from human interpretation. Through this integration, bakeries

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can wholly understand and control the processing capabilities of their production facility to align better with compliance standards.

How Vision Inspection Helps

While each bakery is unique, there are essential steps in the baking process where vision inspection has helped companies improve quality, consistency, and safety.

Pre-baking inspection. The dough-forming process, for instance, ensures products achieve an ideal final size and shape. Take hole doughnuts, for example, which should have a uniform diameter and center. Many doughnut manufacturers utilize automated shaping equipment to place dough onto a conveyor belt and into individual product lines. Over time, however, this application can run out of alignment. Using a VPC system directly after the shaper can help the production team monitor the uniformity of dough shapers across the belt. The system objectively detects the size and diameter of the overall product and center area. If the dough shape begins to drift outside specifications, the system can alert the operator to any changes in the consistency of the process.

Similar applications have been achieved after the proofing or dough-scoring process. Several outside variables can affect dough proofing, such as the external environment (temperature and humidity), dough hydration, the amount or quality of yeast used in ingredients, and mechanical factors. Again, installing VPC capabilities after the proofing and scoring can ensure this process is happening correctly.

Post-baking inspection. Many mass-produced baked products enter the oven in individual lanes. Within the oven and above these lanes are individual heating elements controlled by the production operator, who oversees whether products are baked uniformly across the entire belt width. Assuming dough forming and proofing processes maintain visual standards, which are managed by VPC systems, another vision inspection checkpoint at the oven exit can monitor the baked color of each unit exiting the oven.

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If the system detects a change in bake color over time—generally by evaluating the color of the outside crust of the final product—it can alert the production operator as to whether a specific lane or collection of lanes may need adjustment or repair. A manual alarm or automated control accomplishes this in an in-line rejection system. Additionally, because the FPI is analyzing products in real time, the operator can review the timeline of data to determine whether a protocol may be necessary to adjust their processes for routinely checking their oven performance.

> Many bakeries consider vision inspection technology a black box solution: install the equipment, apply a product code and, just like that, you have achieved 100% control of every aspect of your product line. Unfortunately, this is not the case.

Some baked goods have ingredients applied to the outside the product before or after baking. Examples include seeds, chocolate chips, glazes, colored seasonings, meats, vegetables, and many others, all of which come at a cost to the baking operation. As a result, ingredient and topping control is vital for managing operating costs.

Additionally, some products may have branded designs, logos, and other cosmetic features stamped onto the product at certain stages. Automated machines apply these features under tight constraints and require high repeatability. Over time and for various reasons, these applicator machines can clog, run out of alignment, or over-apply ingredients, resulting in an out-of-spec product.

Integrating a VPC system directly after applicators and product stampers can help operators keep tabs on the performance of these machines. This vision application can help companies avoid fatal errors in their process and control ingredient costs by capturing insights that may go unnoticed by human inspectors.

Food safety efforts. As with most food production processes, bakeries are susceptible to unwanted foreign objects finding their way into their products at any point before packaging. Some companies employ foreign material detection equipment—primarily metal detection X-ray systems—to identify potentially hazardous items on or within products. These methods are great for identifying dense materials, but most low-density objects, such as paper, hair, films, and like-colored objects, tend to proceed unnoticed.

Hyperspectral imaging technology used for advanced foreign body detection and classification is one of the more recent innovations in vision inspection. Hyperspectral imaging acquires images of the products at different wavelengths

by incorporating spectroscopic measurement capabilities, thereby providing a better way to detect and classify foreign bodies on the outer surface of baked products. This advanced application benefits baked products with toppings, including muffins, cookies, snack cakes, frozen pizza, and others, where color inspection cannot provide the complete picture.

Artificial intelligence (AI) also has a growing role in inspection. AI models trained to identify typical defects and anomalies help companies expand their inspection capabilities while improving their ease of use. The automated learning of product features and specifications reduces complexity and promotes continuous operations, helping systems to function for longer periods of time and at pristine accuracy.

Implementing Vision Inspection

The vision implementation process at a baking operation may seem daunting at first, but the effort put forth in the beginning will help companies achieve a faster payback in the long run. It is essential to start the planning process simply, remain patient, and choose a dependable vision inspection expert who will work closely on your objectives, which will be the cornerstones to success.

Above all else, aligning the goals of your quality assurance (QA) and production teams is essential to a favorable outcome; however, despite working closely together in a baking operation, QC and production teams have different and, at times, contrasting performance metrics. The QC team is measured on their ability to implement processes to ensure high product quality standards that meet consumer expectations. On the other hand, the production team's focus is to maintain an efficient production process to create, package, and ship baked goods in the demanded volumes and time frames.

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The best route is to begin by considering the most critical individual traits of your products, the ones that matter most to your consumers. It may be the baked color of your cookie, the uniform diameter or height of your bagel, or the distribution of toast marks on your tortilla; those one or two features may be where to begin your journey. Again, input from your QC and production teams during this process is vitally important.

Remember, vision inspection technology aims to improve quality, not create waste. Setting standards too high will lead to too many rejected products, while standards that are too low will introduce too much variation in quality. Operating environments and ingredient quality can also affect the final product's appearance. Baking during the hot summer months may yield a vastly different product than during the winter, or a flour delivery from one harvest may produce a noticeably different product than the next. If you purchase ingredients from other suppliers, take samples from those formulations and determine where any differences may occur.

Collaboration is critical at every step of the vision system integration process. All stakeholders play an integral role in the process; however, selecting a trustworthy vendor who can set realistic expectations, offer guidance, ask the right questions, and promptly respond with answers to your questions while keeping to the negotiated budget and timeline is what makes success attainable. ■

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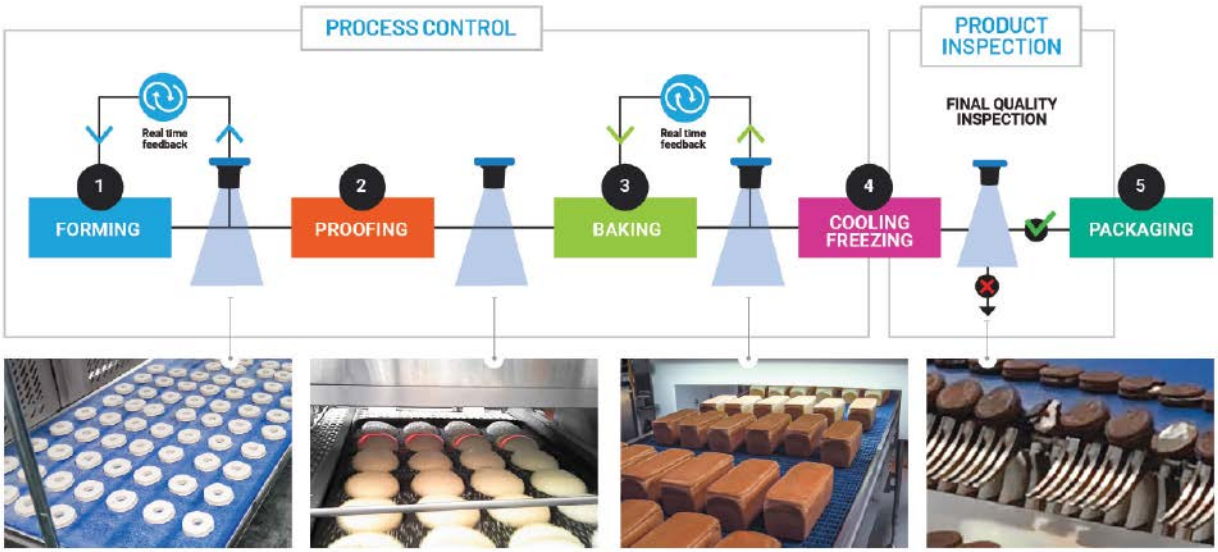

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More bakeries have discovered uses for vision inspection technology to monitor the quality of their process (Steps 1-4). This emerging technology falls into a category called vision process control.