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Food inspection

Ensuring food safety
Advanced product inspection technologies in the food industry

Author
David Prieto, Applications Specialist
Thermo Fisher Scientific

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Introduction

Product inspection in the food industry utilizes advanced technologies to support in the identification of foreign objects in the product or weight inconsistencies that the product has during and after the manufacturing and packaging steps. Metal detectors identify metal contaminants, X-ray systems identify a wide range of foreign materials, both metallic and non-metallic, including glass, stone, and bone, and checkweighers verify product weight for consistency and regulatory compliance. These processes are crucial for protecting consumer health, maintaining brand reputation, and enhancing operational efficiency by preventing foreign contaminants or defective products from reaching the market. Effective product inspection eliminates the cost of recalls and ensures compliance with regulatory requirements, thereby supporting consumer trust and the integrity of the food supply chain. Overall, the detection of contaminants and precise weight control form essential components of a comprehensive food safety and quality assurance program.

Product inspection technologies
Metal detectors

Metal detectors, capable of identifying ferrous, non-ferrous, and stainless-steel foreign objects, are an ideal solution for inspecting a wide range of food products, including frozen meals and packaged snacks. Metal detectors measure the magnetic and conductive properties of the packaged food being inspected. Each inspected product has intrinsic magnetic and conductive signals, known as product effect, which varies based on the type of product and packaging—for example, dry products like cereal have a low product effect, whereas wet foods like canned soups show significantly higher product effect due to their moisture and salt content. A successful metal detector measurement disregards the product effect and responds only to signals from contaminants. When a contaminant is detected by the metal detector, it alters the magnetic and conductive signal of the product, triggering the detection system to activate a reject mechanism or halt the production line, depending on operational preferences.

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In food manufacturing, the typical process includes incoming ingredient processing, blending, cooking, molding, packaging, and storage. Contaminants such as debris from aging blending blades or loose bolts and nuts can be accidentally introduced at any stage. Therefore, to minimize contamination risk and meet Hazard Analysis and Critical Control Point (HACCP) objectives for food safety compliance, metal detectors can be deployed at multiple points in the process, from inspection of incoming raw materials all the way to final packaging.

However, metal detectors are not suitable for metalized film packaging due to the "package effect." Packages with metalized film pouches or metal containers can trigger false alarms and interfere with the detection of contaminants, as the signal generated by these packages overshadows the signal of smaller metal fragments. Therefore, X-ray inspection is better suited for metalized film packaging. Additionally, environmental factors can affect the performance of metal detectors in product inspection. Magnetic fields from nearby equipment, electrical interference from other machinery, and fluctuations in power supply can all disrupt the detector's sensitivity and accuracy. Finally, temperature variations and humidity levels can impact the stability of the metal detector's electronic components, leading to inconsistent results. To mitigate these issues, it is essential to install metal detectors in controlled environments, shield them from external electromagnetic interference, and regularly calibrate the equipment to ensure reliable performance.

X-ray inspection systems

X-ray inspection equipment generates an image of each package's contents, enabling the detection of both metallic and non-metallic contaminants, such as glass and rubber, as well as identify broken food pieces and missing components. Unlike metal detectors, X-ray inspection is not affected by product effect or package effect, making it suitable for a broader range of products and packaging materials, including those made from metalized film or aluminum foil trays.

Food inspection systems.

X-ray inspection systems can be utilized at various stages of the production process, from the incoming ingredients phase to the final case packing stage. Given that different food products are designed to offer a complete nutritional solution, they often contain a variety of nutrients and vitamins that increase the potential for diverse contaminants to be introduced at any point, from raw ingredients to final processing. For instance,

incoming meats may contain metal shavings from previous processing steps performed by the supplier, and vegetable harvesting might inadvertently include stones and metal pieces that could be overlooked before processing.

X-ray systems can support multiple applications, but it is important to be aware that it also has its limitations. A common limitation is the density and thickness of the product, which can obstruct the X-rays and hinder the detection of very low-density contaminants, such as thin glass, small glass shards, wood fragments, and thin plastics to name a few. An example is that if there is a product that has a similar density to a small piece of broken glass, the X-ray system may not be able to detect the glass contaminant.

Additionally, inconsistencies in packaging shape can affect the sensitivity and accuracy of the detection process. For example, in a snack bag, the distribution of the product can shift inside, creating false rejects due to the variety in the package shape. High-speed production lines can also impact the resolution and accuracy of X-ray inspection due to reduced exposure time and motion blur affecting the image. Therefore, the same product could have different detection results if there is enough variation in conveyor speed. Understanding these limitations is crucial when considering X-ray solutions for product inspection.

Checkweighers

Checkweighing, a complementary food quality technology to foreign object detection, ensures that the weight indicated on the product label matches the actual weight of each package. This prevents food processors from underfilling packages, which can lead to hefty fines from regulatory bodies, or overfilling, which results in unnecessary product giveaway. Checkweighers are typically positioned after the portioning and packaging stages, with a final weight check often occurring after case packing to verify the appropriate weight and packages were dispensed.

Some checkweighers also provide feedback to operators about the filling process. For example, a manufacturer sets a specific fill level or amount for a package, but over time, the filler may deviate from this set point, causing overfill or underfill. A checkweigher's ability to analyze data trends, showing how closely each fill aligns with the target weight, and provide real-time feedback to the filling machine, helps control production costs. This capability enhances efficiency in an automated manner while proactively ensuring consistent product weight over time.

Potential limitations to be aware of for checkweigher systems are environmental factors and product build up in the system. Checkweighers can be sensitive to environmental conditions such as vibrations, temperature changes, humidity, and airflow, affecting the accuracy of weight measurements and mitigation solutions may be required. Furthermore, debris or product build-up on the weighing platform can affect the accuracy of weight measurements, but with a cleaning procedure will reduce this limitations effects.

Quality assurance and regulatory compliance

The food industry is crucial worldwide, necessitating effective regulation. Each country or region has its own regulatory bodies to ensure proper food safety procedures and public safety. Here, we will mention a few of these entities to highlight their importance. The United States has the Food & Drug Administration (FDA), Europe has European Food Safety Authority (EFSA), among others. These entities focus on safety and enforce protocols that manufacturers must follow to operate in those regions.

Additionally, some regulations that are worth mentioning are the International Organization for Standardization (ISO), of which one of the important standards that it has is the ISO 22000: Food Safety Management System. This specifies the requirements for a food safety management system where an organization in the food chain needs to demonstrate its ability to control food safety hazards to ensure that food is safe at the time of human consumption.[1] And the Hazard Analysis and Critical Control Point (HACCP) is a systematic approach in the food industry to identify, evaluate, and control potential food safety hazards.[2] These methods ensure food products are safe for consumption and uphold manufacturing standards. Product inspection technologies support the food industry by offering solutions to ensure product safety and brand protection. Additionally, product inspection can facilitate record-keeping of both short-term and long-term data, supporting businesses during audits, and for tracking history.

Future trends and innovations

Product inspection continually improves its systems to support industry and public safety. A notable future trend is the integration of X-ray technology with Artificial Intelligence (AI) for complex applications. Combining AI with X-ray systems involves using advanced algorithms and machine learning techniques to enhance the detection and analysis of defects and inconsistencies in food products, assisting with complex calculations, and facilitating image analysis. Some applications include identifying the correct orientation of a product within its packaging or categorizing/sorting various parts of a product.

Additionally, advancements in X-ray image inspection are being enhanced to not only identify discrepancies in images but also assess segmented areas within a package for improved analysis. Expanding the use of gray scales in visual tools has also been further explored, such as for quality evaluation of products in a stacked format.

Conclusion

Product inspection technologies, including metal detectors, X-ray systems, and checkweighers, are crucial for ensuring the safety and quality of food products. Each plays a vital role in identifying contaminants, verifying product weight, and enhancing overall quality assurance. These technologies support regulatory compliance and consumer trust by maintaining high safety standards.

References:
1. ISO 22000:2018—Food safety management systems—Requirements for any organization in the food chain
2. HACCP Principles & Application Guidelines | FDA

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