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White Paper

Digital Sorting Solutions for Food Processing

Food processors around the world work hard to produce various types of fresh and processed products that are free of defects, foreign material (FM), extraneous vegetative matter (EVM), and Out-of-Specification (OOS) products to improve the quality and increase the value of their product. These quality objectives are easily achieved with today's sophisticated range of digital sorting systems that recognize color, size, shape, structural properties, and/or chemical composition to detect the widest range of visible and invisible defects and FM.

The latest advances in sorting help processors achieve optimal quality standards while safeguarding yield through reduced false rejects, rework, and product degradation. With so many effective quality-improving tools now available, the challenge becomes identifying the optimal sorter configuration or combination of sorters to best achieve each processors' objectives.

In this white paper, we will explore the various types of sorting systems that are available to food processors, including the latest state-of-the-art color sorters, smart laser sorters, and new hyperspectral technology. The goal is to help processors of various types of foods such as fresh cut, frozen and dried fruits and vegetables, potato products, nuts, snacks, and confections, select the perfect sorting solution for their specific application.

Laser and Laser/Camera Combo Sorters

Considered the "workhorse" in most food processing plants, laser and laser/camera combination sorters make effective multipurpose sorting solutions. Depending on the needs of each application, today's most advanced laser sorters can be designed with up to five lasers operating at different wavelengths to detect and remove a wide variety of defects and FM, which is an important contributor to global food safety. When combined with high resolution cameras for superior shape, size, and color determination, the result is a high quality product.

Laser sorters inspect the distinctive structural properties of each object to reliably identify and remove FM such as plastics, glass, and stones and EVM such as shells, sticks, and membrane, even when the material is the same color as

good product. A laser sorter is also capable of achieving color sorting, although advanced color cameras provide a more precise detection of very subtle distinctions in color shades.

If the sorter is equipped with a combination of lasers and advanced color cameras, fewer lasers can be used because color cameras take over the color sorting function from the lasers to enable a richer color contrast by recognizing millions of color differences. With the appropriate software and algorithms, laser/camera sorters can also sort by shape, if needed.

Shape Sorting

For nuts, green beans, and other select products, shape sorting can be an extremely important capability. With nuts, broken products sell for less money. With green beans, shape sorting differentiates beans from same-color stems. Advanced shape sorting can be accomplished with monochromatic or color cameras, coupled with powerful software algorithms. A sorter can be dedicated to shape sorting or configured to achieve shape sorting in addition to FM, EVM, and color sorting. Effective shape sorters must avoid shade effects while creating the images to maximize the contrast of the shape.

Three-Way Sorting

While most sorting challenges can be satisfied with two-way sorting (one accept stream and one reject stream), some applications benefit from sorters that feature two ejector systems and three outfeed streams that achieve three-way sorting. When a multipurpose laser/camera combination sorter is equipped with three-way sorting, higher quality is achieved in a single pass. Generally, three-way sorting separates the incoming stream into a FM and EVM reject stream, a lower grade product stream and a premium product stream. If the incoming defect load is high, the lower grade product stream may also be a rework stream that is either resorted via a return loop back to the sorter infeed, buffered and sorted later, or fed to another sorter.

Compared to running product through a two-way sorter multiple times, a three-way sorter achieves similar results while cutting the number of passes in half, which doubles throughput, reduces labor, and minimizes product degradation. Compared to leveraging two-way sorters in tandem, a single three-way sorter can achieve similar results while reducing capital equipment requirements.

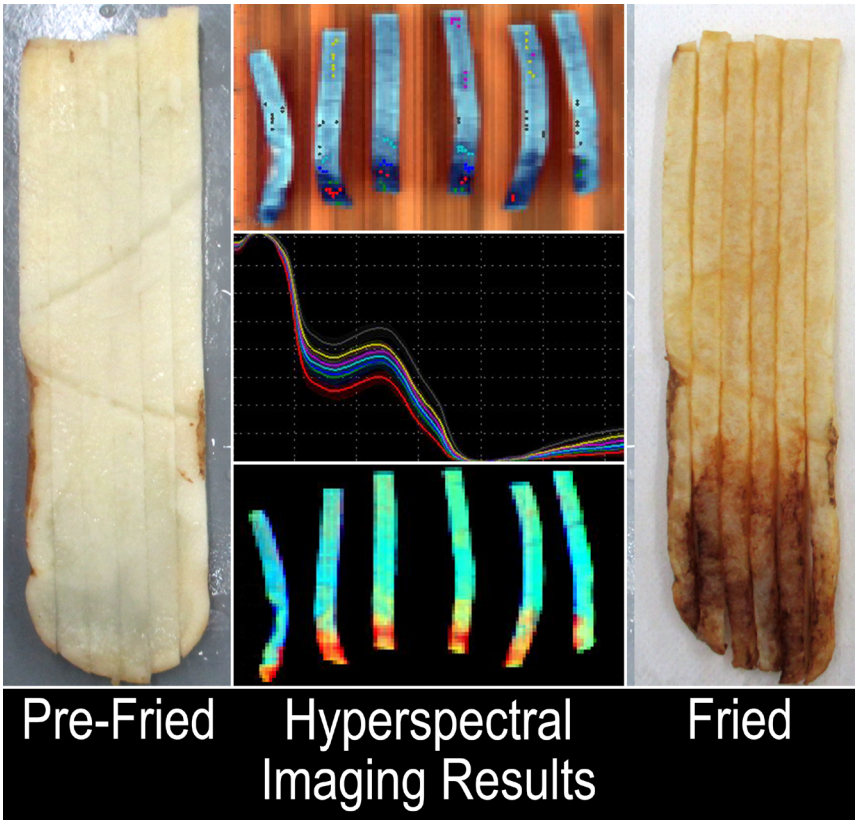
Hyperspectral Imaging

The newest sorting technology currently commercialized, primarily for nut and potato processing, uses hyperspectral imaging rather than lasers or traditional cameras. Hyperspectral imaging systems divide light into hundreds of narrow bands over a continuous range of wavelengths that cover a vast portion of the electromagnetic spectrum. Compared to the three data points collected by an RGB camera and the single data point from each laser sensor, a hyperspectral camera collects hundreds of data points.

Advanced software on hyperspectral systems convert the data to create unique biological fingerprints for each object to enable detection based on chemical composition. The challenges of the technology are the speed required to process the enormous amount of data and the resolution of the images, which affects the size of the defects that can be detected. Currently, this technology is used on specialized sorters where it achieves unparalleled performance removing FM and EVM, even under high incoming defect loads, and detects invisible defects.

The effectiveness of chute-fed hyperspectral sorters is field-proven to maximize the removal of shells, membranes, husks, hulls, and other FM or EVM from walnuts, pecans, almonds, pistachios, peanuts, and other nuts. The technology increases FM and/or EVM removal, often achieving more than 99.5 percent efficiency with very low false reject rates. For nut processors that can afford multiple sorters, a sorter based on hyperspectral technology that is focused on removing FM is often the first sorting step, followed by a high-end laser/camera sorter. Hyperspectral sorters are also perfectly suited for a dedicated rework line that receives material rejected by mechanical equipment and other sorters to be reclaimed because it can handle high defect loads effectively.

For potato processors, hyperspectral technology can detect sugar end potatoes and zebra chips prior to frying where the conditions are invisible to traditional camera and laser sorters. This is especially important to potato strip processors because these defects are not visible until after frying, which is usually done by the processor's customer at the foodservice level, when the defects turn dark brown and reflect poorly on the supplier.



Reverse Sorting

Reverse sorting is a software-driven capability included on select laser, laser/camera, and hyperspectral sorters that enables the user to quickly switch the definitions of what is accepted and what is rejected. It is ideal for rework and when incoming defect loads are higher than 50 percent. Typically, sorters are programmed to reject FM and/or EVM but when running in reverse-sort mode, they are programmed to target good product. This approach uses less compressed air and, more importantly, it improves the results with a cleaner end-product when defect loads are high.

Many sorter suppliers claim a reverse sort capability but often, the adjustment requires a labor intensive recalibration, which may take more time than it is worth. On select sorters, the switch from a forward sort to a reverse sort is achieved in seconds via the touchscreen control panel, with no recalibration or mechanical adjustments required.

X-ray for Embedded Defects

Not as common as camera and lasers, x-ray technology can also be used for bulk sorting. While color, laser, and hyperspectral sorters currently focus on surface related defects, x-ray has the capability to "look" inside the product by focusing on density. In the food processing industry, this technology can detect FM such as metal, glass, and stones because these objects have a higher density than the food products. X-ray detection is typically found at the end of a processing line as the last quality check to remove any remaining FM. To ensure all FM is removed, some systems employ a push-rod ejection system that either opens a gate or pushes a scraper to remove the FM along with a significant amount of good product. Air ejection is also used, but requires very aggressive duration settings to ensure all FM is removed at this final step.

Sorting Platforms

In addition to the various types of sensors (laser sensors, traditional cameras, and new hyperspectral based technologies) and the proprietary algorithms that process and analyze the data to make accept/reject decisions, food sorters also differ in their mechanical embodiment. Waterfall, chute-fed, and belt-fed sorters are all capable of inspecting product in-air and are each suitable for specific products and applications, with varying degrees of success.

Waterfall sorters inspect product in-air during the free-fall. Chute-fed sorters stabilize product on the chute prior to in-air inspection. Belt sorters stabilize product on a belt, inspecting the product from the top while on the belt and then feeding the product off the end of the belt for optional inspection from the bottom, followed by in-air rejection. Stabilizing the product is critical to

the sorter's efficiency because it improves the predictability of the product trajectory in the air through the inspection and ejection zones. This enables the sorter to better focus on objects to identify small FM and defects and improves the accuracy of the ejection system, both of which help maximize the sorter's yield and defect removal performance.

The major advantages of chute-fed sorters, compared to belt sorters, are the smaller footprint and the absence of moving parts, which contributes to low maintenance requirements. The major advantages of belt sorters are high throughput and the improved ability to achieve an effective three-way sort. Regardless of the platform, food processors should look for sorters with low-impact infeed and discharge chutes that have been designed to minimize bounce and breakage for the gentlest product handling, so value isn't lost through product degradation.

Conclusion

With so many high performance sorting systems on the market and technology advancing at such a rapid pace, it can be difficult for food processors to identify the ideal solution for their application.

Working with a supplier that offers the widest variety of food sorting systems makes it easier to compare solutions and consider options. If the supplier offers mechanical grading systems in addition to digital sorting solutions, both aspects should be considered together to create the optimal combination. The supplier's food processing expertise should not be undervalued – it contributes to the design of superior sorting systems, helps guide the processor's selection process, and can be tapped into long after installation and start-up in the processor's quest to continuously improve operations and final product quality.

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