KEY TECHNOLOGY

A DURAVANT COMPANY

White Paper

Industry Report: Sorting Fresh-Cut Produce

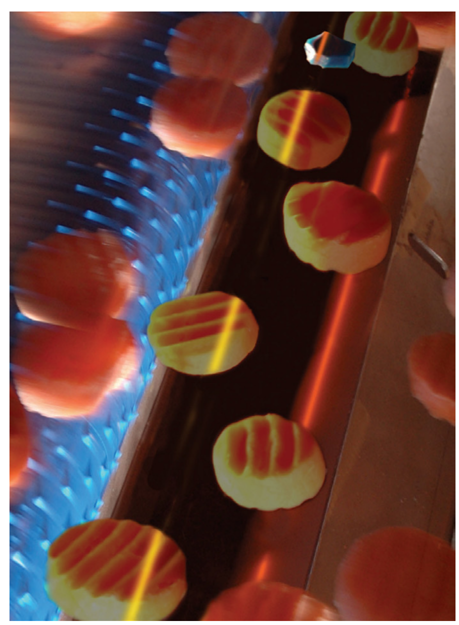
Until recently, processors of fresh-cut produce have relied on labor-intensive manual inspection to remove foreign material (FM) and defective products. But tightening restrictions on pesticide use and the growth of organic products are making defects more common while the scarcity and cost of labor and consumers' scrutiny of fresh-cut product quality is rising. Given these market dynamics, processors are looking for methods to improve inspection.

Advancing technology and experience in other food segments have ushered in a new set of solutions. Automated optical inspection systems (also called digital sorters), which have been widely adopted for decades in the potato processing and processed vegetable industries, have also been developed for fresh-cut produce. Compared to manual inspection, which is inconsistent and subjective, digital sorters are able to ensure product quality and food safety by more effectively identifying and removing FM and defect products, while at the same time reducing labor costs and improving operating efficiencies.

In this white paper, we will explore the technology being used to sort leafy greens, carrots, green beans and other fresh-cut produce. The objective is to help fresh-cut processors understand what tools can be leveraged to maximize product quality and identify the criteria they should consider when selecting the ideal sorter for their applications.

Sorting Basics

A variety of sorting systems such as freefall, chute-fed, on-belt and belt-fed in-air are available in different sizes to satisfy the requirements of virtually any fresh-cut processor. The highest volume sorters typically handle in excess of 8 metric tons per hour when sorting leafy greens and up to approximately 20 metric tons per hour when sorting cut vegetables. Some sorters rely on cameras for inspection, others on lasers, and some combine cameras and laser scanners to view product from the top only or both top and bottom of the product stream. Some sorters inspect only an object's color, others inspect an object's color, size, shape and structural properties, including differing levels of chlorophyll. The processor's products and business objectives determine the ideal mechanical platform, sensor types, sensor positions, lighting, ejection system, product handling subsystems and software features.



Regardless of configuration, every digital sorter contains similar basic elements. The conveyor that feeds the sorter and the sorter's mechanical platform work together to separate and singulate the mass flow of product into discrete objects for presentation to the sensors. The sensors capture object data, which is analyzed by the image-processing system. FM and defective products, as defined by the food processor, are either ejected by mechanical paddles or air jets. Two-way sorters separate the stream into good product that makes grade and 'rejects' that include FM and defective products. Three-way sorters can be programmed to separate good product into two grades, while removing FM and defects into a reject stream.

Although sorters are designed for continuous in-line product inspection at full production speeds, they can also be used in a batch-feed mode.

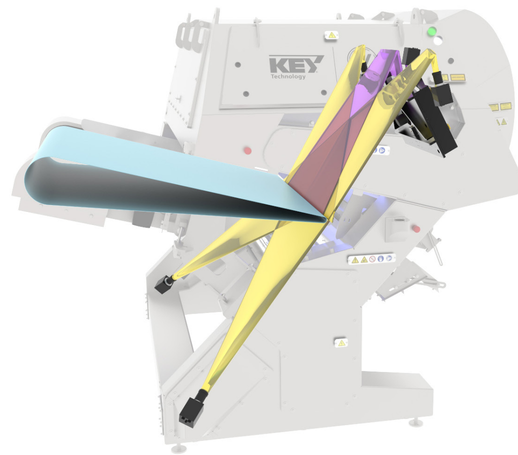
Sensors and Wavelengths

The ideal sorter for any given application combines the lights, cameras, laser scanners and image processing software that most effectively differentiate good product from defects and FM. To maximize that differentiation, it is important to identify the wavelengths that produce unique 'signatures' for each object of interest. The sorter manufacturer might use a spectrophotometer on the customer's products, defects and FM to see how each of these objects respond to different wavelengths. Armed with this information, the manufacturer will identify the ideal wavelengths or sets of wavelengths for the application – spanning from the visible color spectrum to near infrared (NIR) – and recommend the most appropriate technology to achieve the desired results.

The simplest systems that rely only on monochromatic (black and white) cameras detect differences in color (if only on the gray scale) to distinguish good product from defects and FM. But most sorters are capable of much more. Modern 4-channel color cameras are capable of detecting millions of subtle color differences within the visible range (red, green and blue) and NIR or UV spectrums. All cameras capture product information based primarily on material reflectance and, depending on the sorter's image processing software, can be harnessed to recognize defects and FM based on color, size and shape.

Sorting systems can also use laser scanners to inspect the product stream. Lasers are used primarily to inspect a material's structural properties, which make them ideal for detecting a wide range of FM and some product defects. Like cameras, lasers can be designed to inspect across a broad range of light frequencies.

Powerful multi-spectral sorters feature cameras and laser scanners on one platform and combine input from these multiple sensors at the pixel level to more clearly differentiate FM and defects from good product. This 'Pixel Fusion' capability enables a sorter to remove the most difficult-to-detect FM and defects without false rejects. It can also identify specific FM types, which enables the system to send smart alarms that alert operators if a critical quality problem occurs, so quick corrective action can be taken.



Beyond sensor types and wavelengths, cameras and laser scanners can differ in their resolution and image processing systems differ in their sophistication to impact a sorter's capabilities. Today's cameras and laser scanners offer twice the resolution of previous generation sensors to detect sub-millimeter defects and FM. Advanced image processing software offers 'object-based recognition' that enables a sorter to analyze objects based on size and shape as well as the location of the defect on the product. Some sorters also allow the user to define a defective product based on the total defective surface area of any given object. These object-based selection considerations put more power into the processor's hands to produce optimal product quality.

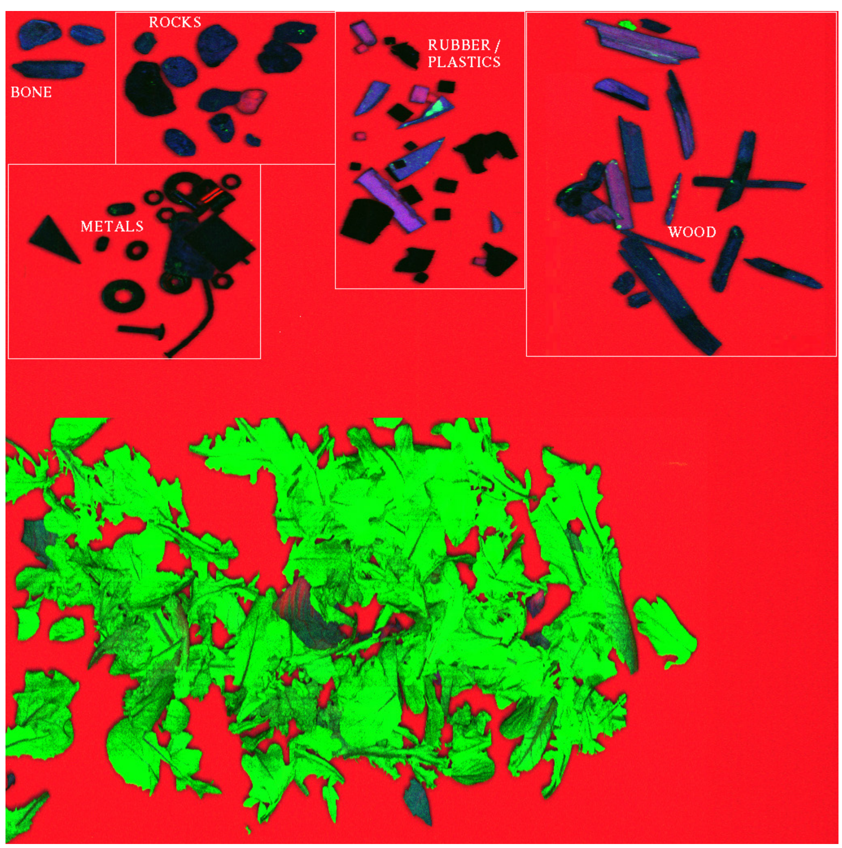
Fresh-Cut Applications

To maximize food safety, processors want to find and remove all FM from their product. Here, laser scanners, which recognize the structural properties of objects, including the presence or absence of chlorophyll, are best at finding insects and animal parts, paperboard, wood, rocks, plastics, glass and more.

To maximize product quality, processors also want to find and remove defective products. A wide range of defects can be identified by sorters equipped with color cameras. If the type of defect being targeted appears on multiple sides of the product, a sorter with only top-mounted cameras is effective. To detect and remove small, single-sided defects and in situations where product overlap can occur at higher capacities, sorters with top- and bottom-mounted cameras are often recommended to be able to spot a defect wherever it may appear on the object surface.

Defects associated with water exposure, sun exposure, chemical burn, insect damage, rodent damage, rot, disease, bacteria and fungus, as well as problems in the outer wrap of iceberg, romaine and cabbage due to bruise damage or wilt, can all be removed with color camera-based sorters. Typically, color cameras that inspect within the visible spectrum are most effective for detecting leaf defects in iceberg, romaine and cabbage. Vis/IR (a combination of visible and IR frequencies) cameras are usually effective for baby spinach and spring mix.

But much more is possible with color sorting. One processor that packs peach slices in glass jars learned that customers prefer the color of the slices to be consistent. Mix yellow and orange slices in one jar and customers who visually perceive the yellow slices as unripe may be dissuaded from purchasing the product. This processor used color sorting to separate the slices by color. The technology allowed them to pack jars with only yellow slices and jars with only orange slices. All the jars sold well and their sales increased.



Shape sorting has been used in the processed vegetable industry for years to differentiate green beans from same-color stems and knuckles. Extend this shape-sorting capability further and consider using the technology to separate straight green beans from curved ones. Such a separation would enable the processor to package straight beans in single serve packs and price them at a high mark-up while diverting curved beans to bulk product, thus increasing the overall total value of their green beans' processed volume.

Processors of leafy greens such as iceberg, romaine, leafy spinach, cabbage, arugula, frisée, escarole, radicchio, Belgian endive, mache greens, watercress and various salad mixes find sorting with a combination of cameras and lasers most effective. The cameras are trained to detect leaf defects and the lasers detect FM. Leafy greens can challenge sorters because leaves tend to overlap and clump as they are conveyed through the inspection process. Selecting the ideal infeed conveyor for the application helps separate leaves, and using a belt-fed sorter that inspects product entirely in-air with top and bottom sensors achieves the best results since it can find FM that may be sandwiched between layers of leaves or rest on the underside of a leaf.

Fluorescence-sensing laser sorters that detect differing levels of chlorophyll are also useful to many fresh-cut processors. This technology is so powerful, it can identify and remove leafy green product left over from the prior crop or previous production run as well as leaves from trees and other extraneous vegetable matter, even if it has similar color, texture and shape as good product. Carrot processors interested in identifying and removing carrot tops with stems remaining or embedded in the crown can achieve this objective with fluorescence-sensing lasers.

Sanitation and Ease of Use

While the ideal digital sorter for any given application depends on the products' characteristics and the processor's objectives, features that contribute to improving sanitation and ease of use are valued by every fresh-cut processor.

A mechanical platform that positions sensors, sensor windows, light source and sensor backgrounds away from product splatter and contamination zones helps minimize sanitation requirements and maintain sorting accuracy.

To ease use, smart sorters present a highly intuitive user interface (UI), offering different views to users of various levels, depending on their needs. Auto-learning and self-adjustment algorithms, predictive diagnostics and smart alarms enable the sorter to automatically adjust to normal changes in the product and the production environment to maximize the sorter's performance and eliminate the need for operator supervision during normal production. If and when operator intervention is needed, a sorter that can offer remote access further eases use. In combination, these smart features reduce operator qualifications and reduce training requirements while helping the sorter operate at peak performance.

For lines that process a variety of fresh-cut products, sorters that feature recipe-driven changeovers help maximize production flexibility and uptime while ensuring repeatable results and easing use. Even on lines that are dedicated to a single product, recipe-driven operation helps processors count on consistent performance from their sorter day in, day out, including when running the same product across multiple sorters on different lines.

Adding Value with Process Monitoring and Control

Today's powerful sorters do more than sort. Since they continually inspect 100 percent of what is flowing through the line, recognizing each object's color, size, shape and structural properties, they can easily be leveraged to monitor and control processes. A sorter's computer can process large volumes of information to collect data and generate reports about the sorting process and every product and object on the line, whether the data is used to perform the sorting function or not. The data can be harnessed to optimize processes upstream and downstream of the sorter, in addition to improving the sorter's own performance. This 'Information Analytics' capability enables the sorter to acquire data and share it for off-line analysis or exchange it directly with a customer's SCADA, MES or PLC network.

Sorter Selection Criteria

When searching for the perfect sorter for any given application, several variables should be considered beyond throughput and sensor configuration.

The value of the sorter manufacturer's experience cannot be underestimated. Their expertise helps identify the ideal wavelengths and sensors to achieve the customer's sorting objectives given the products and application requirements. Their expertise also guides them to consider custom-engineered product handling components that minimize product damage and sanitation features necessary to prevent contamination and keep the sorter operating at peak performance.

Of course, the effectiveness of the sorter relies not only on the hardware but also on software algorithms that manipulate raw data and categorize information based on the customer-defined accept/reject criteria. The art and science of image processing lies in developing computerized routines that improve the effectiveness of the operation while presenting a simple user-interface to the operator. Thus, the sorter manufacturer's expertise in developing high-performance algorithms to select for the customer's products affects both the sorter's performance and ease of use.

When comparing competitive systems, consider the resolution of the cameras and lasers because higher resolution allows the sorter to detect and remove smaller defects. Compare cameras and their ability to detect possibly millions of subtle color differences. Compare the illumination system (usually either fluorescent, LEDs, or HID), understanding that superior lighting leads to superior sorter performance.

Sorters are sophisticated pieces of equipment based on technology that advances at a rapid rate. As technology advances, the capabilities of sorters grow, which can be used to the processor's advantage. To continue to get the most from a sorter over time and maximize return on investment, look for a modular sorter that is designed to be easily upgraded or reconfigured in the field.

Last but not least, it is important to consider the level of service a supplier can provide in a specific region – from engineering to after-sales support.

The Bottom Line

With access to digital sorting technology that is developed specifically for fresh-cut produce, processors now have a highly effective tool for removing FM and product defects while reducing labor costs and improving operating efficiencies. Processors that select and install the ideal sorting system for their application are better able to consistently ensure their product quality and food safety. They are safeguarding their customers and protecting their brands.

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