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Near Infrared (NIR) Sorting in the Plastics Recycling Process

1. ***Background:*** In modern single-stream MRFs and plastic reclaimers, the large volume of incoming material necessitates processing equipment able to move and sort material at high speed. At the same time, the highest value is obtained from the purest, least contaminated streams. To accomplish these somewhat contradictory goals, today's single stream MRFs and reclaimers employ automated equipment that sorts plastic packaging by NIR (near infrared) signature, either in transmission or reflection. NIR machines are both faster and more accurate than manual sorters. Automatic sorters interface NIR sensing with air nozzles to sort plastic items of various resin compositions, for example separating PET bottles from HDPE bottles.

   To obtain the highest material value, the equipment must sort the items effectively and accurately. Otherwise, the article is either directed to the waste stream or becomes a contaminant in another recyclable stream where it is likely to not be recycled.

   It is also common for some plastic reclaimers to use NIR equipment near the end of the processing line for final contaminant removal as well.

2. ***Sorting Technologies Used:*** Sorting technologies are used in combination with each other and multiple times throughout the recycling process to achieve the desired result.

   a. NIR: NIR uses the wavelength signature of specific resins to distinguish them from one another. It does not distinguish color. NIR sortation is employed at both MRFs and plastic reclaiming facilities.

   b. Visual Sensing: A visible light sorter uses visible light and a high-speed camera or other light sensor to distinguish different colored bottles. It does not distinguish plastics by resin composition.

   c. Manual sortation: Although not a technology, it's important to recognize that most plastics reclaimers use manual sorters to inspect the material and remove contaminants from the material stream.

3. Employing the technology:

NIR sortation at the MRF: Whole plastic bottles are sorted at MRFs using NIR sensors positioned above very high-speed conveyor belts after other recyclables have already been separated from the plastic stream. The bottles are ideally presented on a wide conveyor belt in a single layer as much as possible. Other materials may still be present as contaminants. The NIR machine detects the unique wavelength

signature of the desired polymers and air jets direct the polymers to their specific streams. Contaminants are rejected to waste or further processing.

Some MRFs may also employ color detection using visible light sensors or cameras. Color detection can be mounted on a separate machine or integrated alongside the NIR sensor in the NIR machine., However, MRFs generally do not need to sort polymers by color.

NIR sortation at the plastic reclaimer: At the plastic reclaimer, there are two major stages of the plastics recycling process - whole container processing and flake processing. A grinder or granulator sits between the two stages and creates flake from whole packages. Typically a plastic reclaimer specializes in one resin type, therefore NIR sortation during whole container processing is designed to eliminate contaminants and improve plastic quality in bale supplies. NIR sortation of flake provides a final quality control step by removing very fine contaminants.

a. Whole container processing: Bales of a particular plastic enter the plastics reclaimer. The first step is to remove the baling wire and break up the bale into independent bottles. This enables each bottle to be sorted on its own characteristics. A number of different technologies are then used to remove contaminants from the desired polymer, depending on the polymer. Automatic sorting using NIR and color sensors is often used following other technologies, especially at PET reclaimers.

b. Flake processing: NIR sortation can be used during flake processing to improve quality and remove contamination by unwanted polymer types. However, most polymer contamination is removed prior to NIR flake sortation by a variety of other technologies, particularly float/sink. Flake sorters normally integrate NIR, color and metal sensors into one machine to remove a variety of unwanted materials.

4. Issues with NIR sortation

Shrink sleeve labels: Some brands use full-wrap shrink sleeve labels to advertise their products. Full-wrap shrink sleeve labels cover the entire bottle with a label that might be a different polymer than the bottle itself. Depending on the particularities of the label, NIR machines may not be able to "see" through a label to identify the polymer beneath it. If the label is a different polymer the bottle will be directed to the wrong stream in a MRF, or to waste in a plastic reclaiming facility.

To address this issue, APR's Design® Guide for Plastics Recyclability recommends testing for sleeve labels that cover more than 75% of the bottle surface, to determine whether the label interferes with NIR polymer sortation. It is extremely important to follow APR label guidance when using these types of labels to ensure that the label does not render the bottle unsortable.

Black and dark colored items: NIR sortation cannot be considered reliable in detecting black colored plastic bottles or items. Most NIR sensors cannot "see" black items as the black colorant absorbs the light waves and provides no signature. Therefore, black items may be mis-sorted with and combined

with incompatible polymers, or they may be directed to waste. Some newer NIR machines claim to be able to identify black polymers but these machines are not yet widely implemented in the U.S.

To address this issue, APR's Design® Guide for Plastics Recyclability recommends testing for items with NIR reflectance less than or equal to 10 or an L value less than 40 to determine whether the color interferes with NIR polymer sortation. It is extremely important to follow APR color guidance when using black or dark colors to ensure that the color does not render the bottle unsortable.

5. ***The APR NIR Sorting Potential Test***

The APR has developed a test, "Evaluation of the Near Infrared (NIR) Sorting Potential of a Whole Plastic Article", that provides a means of evaluating whether a plastic article can be accurately identified and sorted on pilot scale NIR sortation equipment that performs similarly to that used in production facilities. Good results in this screening test indicate that a plastic article has the potential to be sorted well in production conditions. Poor results indicate that an improvement in plastic product design is desirable to promote recovery.

An optional, second part of this test method incorporates a means of determining whether the pilot equipment and software have the ability to be adjusted to correctly identify and sort this article and if so, to capture this adjustment in production facilities. The test involves establishing the baseline performance of a pilot NIR sorting machine by processing a known blend of material while targeting the polymer of the test article. Then, 20 samples of the test article are added and the mix is reprocessed. Sorting efficiency of the test articles is compared to the baseline efficiency. Five passes through the NIR unit are used to develop repeat values for the test articles

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