Bioplastic beverage containers can be the bane of many a processing operation they look and feel just like PET bottles, making them difficult to differentiate for line pick employees. Can technology solve this issue? A multi-year study from CalRecycle answers the question.

BY RICHARD GERTMAN

SORTING OUT BIOPLASTICS

A multi-year research effort for development of an optical sorting system to test separation of bioplastics from other plastics, the Bioplastics Sorting Project resulted from a CalRecycle Market Development and Expansion Grant application submitted by Future 500. In addition to staff support by CalRecycle, key project support was also provided by Pellenc Selective Technologies USA who manufactured the optical scanning technology and Titus Services who constructed and operated the optical sorting machinery. Eight materials recovery facilities and three PET processors provided the materials to test the optical sorting machinery. Cascadia Consulting Group participated in the Optical Sorting Testing. A group of stakeholders reviewed and commented on the findings of the sorting.

The study was designed to answer four primary research questions:

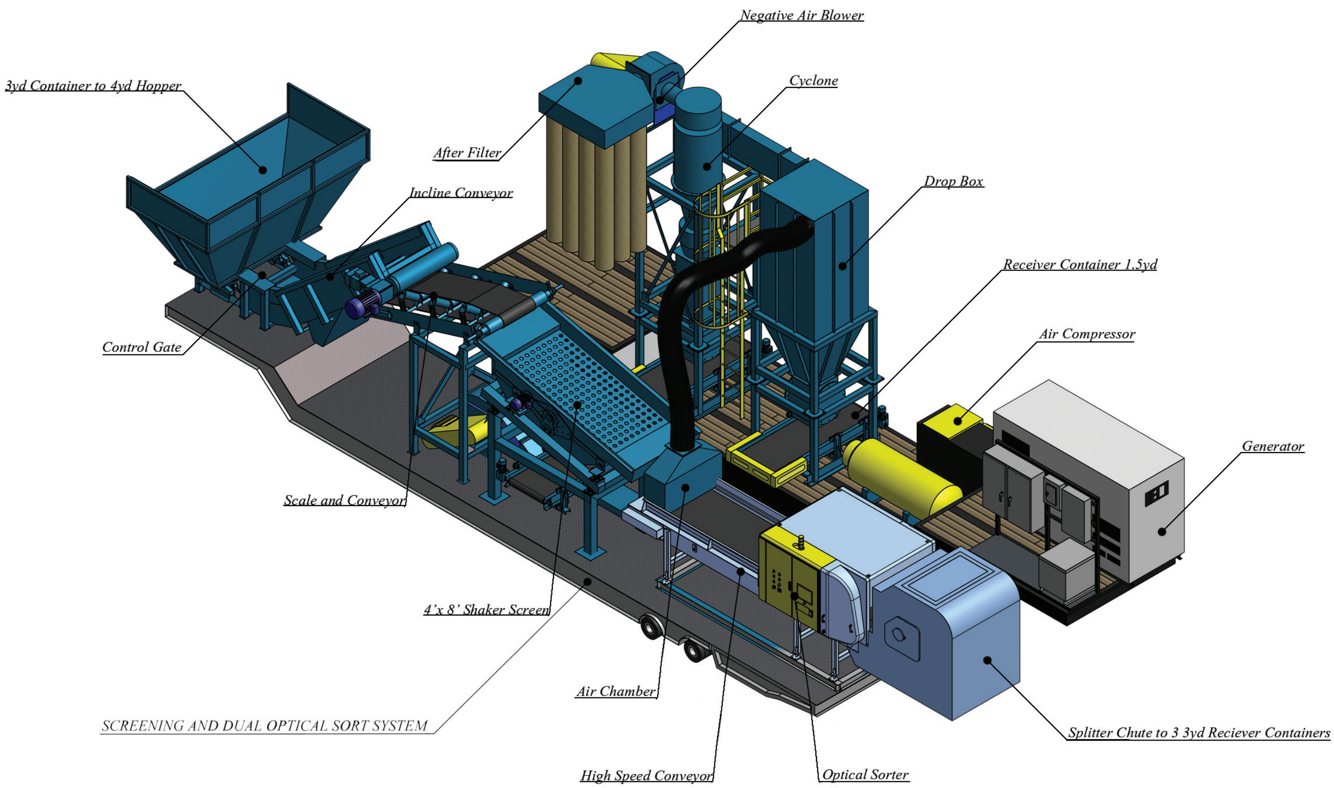
- Can the optical sorting system effectively separate PLA bottles from PET bottles, so that clean PET would continue to be available to PET reclaimers?
- Can the optical sorting system effectively separate PLA from other materials, so that PLA products could be recovered for recycling?
- Can the optical sorting system effectively separate other (non-bottle) PLA products, especially cups and food service items, from a mixed plastics stream?
- Can the optical sorting system effectively separate various other types of plastics from each other, from a pre-sorted mixed plastics stream?

Following the award of the grant, Future 500 released a Request for Proposals (RFP) for the development of an optical sorting system. In addition to being able to separate PLA from whatever other materials were in the load being sorted, the RFP required that the sorting machinery be designed with capacity to process 3-5 tons per hour, and be mobile so that it could be moved from processing facility to processing facility. The plan was to test a wide range of materials over the range of conditions that would represent the range of materials processing.

The requirement for the system to be mobile resulted in three unanticipated constraints:

- The in-feed hopper and discharge bins were too small to allow

Figure 1 | The optical sorting equipment



the machine to be run at the capacity that would be expected in a commercial facility.
- It required two trailers to hold all of the equipment.
- The optical sorter had to be recalibrated every time the trailer was moved.

The only proposal received was from Pellenc Selective Technologies. After careful review, the Pellenc proposal was deemed to be fully responsive to the RFP. Pellenc provided the optical scanner, and Titus Services constructed the materials delivery system for the sorter (Figure 1).

Pellenc realized that it was important to remove small particles and lightweight materials before the containers were presented to the optical scanner, so the machine includes a two stage pre-sort system to screen out the fines (smaller than 2-inch particles), and vacuum off the lightweight fraction. The remaining materials continue on to the optical scanner.

The scanner reads the near-infrared signature of each container to identify its composition. The scanner reads the entire container to properly identify them even when they have attached labels or caps that are of different material types. A sensor in the scanning unit analyzes the material on the belt and inputs that information into a computer that determines how the material will be sorted (Figure 2).

Figure 2 | The optical scanner

Based on the scan, a computer sends a signal to a series of air jets. As each container comes off the end of the flat conveyor, it can be subjected to a blast of air pushing it up, blowing it down or it can be allowed to continue on unimpeded (Figure 3).

Pellenc claims three features are unique to its technology:
- It reads reflected light rather than transmitted light.
- It uses an advanced, patented spectrometer.
- The distance from the optical reading to the air jets is very short, so there is less chance for a round container to move before being sorted.

Problems may arise in sorting when materials are stacked on the belt so that the scanner does not have a clear view of each item.

Figure 3 | Air separations

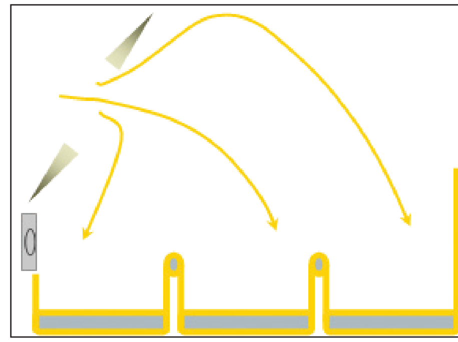


Table 1 | Sorted PET

Material	Pounds	Percent of total
<2 inches (shaker screen)	151.5	2.4%
Light paper (vacuum system)	30.3	0.5%
PET	5,780.1	91.4%
Metal and PLA	42.0	0.7%
Other plastics	202.7	3.2%
		98.1%*

* Table totals may not equal 100% due to rounding and yield loss in the sorting process.
Source:

Also, unflattened bottles behave differently to bursts of air than flattened bottles do, so when individual containers are blown up or down they may bump into other containers, resulting in inaccurate sorting. To achieve a higher degree of separation, processed materials may need to be run through the same equipment a second time, or through a second optical sorter.

The term “effectively separates” is used in both an economic and technical sense. In economic terms the question is whether the extra cost of operating the system can be recovered from the higher market revenues achieved. In technical terms, the question is whether an optical system can produce cleaner material for market. The answer to both questions can be yes, but there are many variables to consider.

One key element is the amount and composition of contaminant materials in the PET. Most contaminants can be easily distinguished from PET and easily removed. However, many PLA bottles are designed to look just like PET containers, so they cannot easily be identified visually by workers. Checking the resin code on each bottle would not be practical on an industrial scale.

Additionally, the cost effectiveness of the optical sorting system could be demonstrated if MRF operators are able to recover more of the high-value resins from materials that their systems sorted into the lower-value mixed plastics. The recovery of high value PET and HDPE from mixed plastics might be so cost effective, that reprocessing materials would pay for itself and additional materials would be available for use in manufacturing new products in California.

2011 Testing

The first of two sets of tests was conducted during 2011. In it, five streams of materials were tested from eight MRFs. The results are presented in aggregate.

1. Sorted PET

The first materials tested were loads of PET bottles that had been positively sorted from all other materials on a MRF container sort line (i.e., bottles sorted into a dedicated PET bin). This stream was reprocessed by the optical sorter to remove non-PET materials, especially PLA, that had inadvertently been separated into the PET bin at the MRF. As shown in Table 1, an average of less than 92 percent of the materials sorted to be PET were actually PET. Of the remaining materials, 3 percent was fines and lightweight paper and film plastics which were removed in the pre-sort and 4 percent was other plastic and metal. Of the 6,207 pounds of materials sorted, only 19 PLA bottles (less than 3 pounds) were recovered.

2. Sorted HDPE

The second stream was material that had been positively sorted to be HDPE. These materials were reprocessed to remove paper, recover any PLA, and to separate other material types that had been inadvertently sorted into the HDPE. As shown in Table 2, only 90 percent of the material processed to be HDPE was actually HDPE. About 1.5 percent was fines and lightweight materials, and about 7 percent was other plastic. Only two PLA bottles were identified in the 5,710 pounds of materials that had been sorted as HDPE.

3. Sorted mixed plastics

The third stream was material sorted to be mixed plastics (resin codes Nos. 3-7) at the MRFs. These materials were reprocessed to remove loose paper, and to recover any PET and HDPE that had been missed when the materials were initially sorted. As shown in Table 3 (see page 26), over 40 percent of the materials in these samples were PET and HDPE (although the breakdown between PET and HDPE was not recorded), less than 30 percent of the total materials sorted were actually other plastics, and about 25 percent was trash. In the 2,646 pounds sorted as mixed plastics, the optical sorter found 31 PLA bottles (about 4 pounds).

4. Unsorted mixed containers

The fourth stream was mixed containers that had been separated from the fiber in the early stages of processing at the MRFs and would otherwise be sent to the mixed container sort line. As shown in Table 4 (see page 27), almost half of the materials in the mixed container stream were fines, and only 5 percent of the materials on that line were PET and HDPE containers. A total of 10 PLA containers were identified from the unsorted mixed container line and they all came from one MRF. Of all plastics in these samples, the optical scanner identified 36 percent as PET, 30 percent as

Table 2 | Sorted HDPE

Material	Pounds	Percent of total
<2 inches (shaker screen)	66	1.2%
Light paper (vacuum system)	16	0.3%
HDPE	5,131	89.9%
Metal and PLA	26	0.5%
Other plastics	414	7.3%
		99.0%*

* Table totals may not equal 100% due to rounding and yield loss in the sorting process.
Source:

HDPE, and 34 percent as other plastic containers.

5. MRF processing residuals
MRF residuals were run through the optical sorting machinery to recover any PET, PLA, and HDPE that had been missed in processing. The total amount of plastic and metal containers in the MRF residuals was less than 10 percent by weight. From 13,452 pounds of MRF residuals, only 18 PLA bottles (less than 3 pounds) were recovered.

Table 3 | Sorted mixed plastics

Material	Pounds	Percent of total
<2 inches (shaker screen)	53	2.0%
Light paper (vacuum system)	18	0.7%
PET & HDPE	1,092	41.3%
Other plastics	767	28.9%
Metal and PLA	13	0.5%
Trash	653	24.7%
		98.0%*

* Table totals may not equal 100% due to rounding and yield loss in the sorting process.
Source:

Need for additional testing

When the grant funds were originally awarded to Future 500, the number of PLA bottles entering the California marketplace was growing. The initial testing was designed on the assumption there would be sufficient numbers of PLA containers in the samples to confirm the ability of the optical sorting machinery to separate PLA from PET and other plastics. However, the testing revealed insufficient PLA to statistically verify the system capabilities.

The PLA bottles that were successfully separated from the processed materials by the sorter were noted. The sensor records from this first set of tests show that almost no PLA passed under the scanner, indicating that the optical sorter did not fail to separate the PLA, but materials sorted into the "Other" materials categories were not examined to confirm that they were free of PLA.

Additional samples were tested in June and July 2012. These samples were "seeded" with marked PLA bottles, clamshells and cups before they were sorted by the optical scanner, and the recovery marked containers was tracked. The Cascadia Consulting Group monitored the testing and reported the results. The full results of this segment of testing can be found at http://tinyurl.com/PLASort.

2012 testing notes

The optical scanner successfully identified PLA in the mix of plastics. Under the most favorable operating conditions, a sorting accuracy rate of 99.6 percent was achieved. Less favorable results were achieved when the materials were sorted into three categories, than when they are sorted two ways.

Although it was not reviewed as part of

the testing protocols, it seems likely that, if the materials recovered as PET in many of the samples had been run through the scanner again, most, if not all, of the PLA would have been correctly separated from the PET.

While not formally part of this project, CalRecycle supplied the team with some prototype bottles made from a polymer in the polyhydroxyalkanoate (PHA) family to test whether the optical system could separately distinguish PHA. The team introduced the bottles into the system for one run in 2012. This bioplastic exhibits a scanner "signature" similar, but not identical to PLA. It appears the Pellenc system is able to separate this bioplastic as well.

Table 4 | Unsorted mixed containers

Material	Pounds	Percent of total
<2 inches (shaker screen)	5961	44.3%
Light paper (vacuum system)	550	4.1%
PET & HDPE	669	5.0%
Other plastics	650	4.8%
Metal and PLA	3276	24.4%
Trash	2258	16.8%
		99.3%*

* Table totals may not equal 100% due to rounding and yield loss in the sorting process.
Source:

PET reclaimer residuals

In addition to the testing of samples provided by MRFs from around the state, Pellenc and Titus tested the sorter on samples provided by three PET reclaimers. The tests were run to determine whether contaminants could be removed from the PET that the reclaimers had purchased, and to determine if additional PET could be recovered from the reclaimers' residuals stream. PLA and other contaminants (including HDPE) were successfully separated from the PET and some additional recyclable materials were recovered from the reclaimer residuals.

Optical sorting effectiveness

Four questions were answered as part of this research project.

1. *Can the optical sorting system effectively separate PLA bottles from PET bottles, so that clean PET would continue to be available to PET reclaimers?*

The primary purpose of the Future 500 Bioplastics Testing Project was to determine if optical sorting could be expected to provide some certainty that, if PLA bottles were introduced into the marketplace in significant quantities, MRF operators would still be able to produce clean PET for recycling. The optical sorter was able to remove non-PET materials, including PLA, from the samples.

2. *Can the optical sorting system effectively separate PLA from other materials, so that PLA products could be recovered for recycling?*

One sample from the 2012 study showed that when the machinery is set to separate only PLA from all "other" materials, it can achieve a 99.6 percent recovery rate. The optical system is capable of separating PLA bottles, cups, and clamshells from other mixed containers at a MRF. Separating PLA from other materials would allow it to be recycled into new PLA products.

3. *Can the optical sorting system effectively separate other (non-bottle) PLA products, especially cups and food service items, from a mixed plastics stream?*

Three samples demonstrated that the sorter can successfully separate PLA from non-PLA materials, including PET.

4. *Can the optical sorting system effectively separate various types of plastics from each other, from a pre-sorted mixed plastics stream?*

Three samples demonstrated that the sorter can successfully separate PET and HDPE from loads of mixed plastics.

Summary and conclusions

The testing of the optical sorting system has demonstrated that it is capable of improving the quality of materials shipped to market from MRFs.

Being able to separate a mix of PLA products from mixed containers showed that the optical sorter can identify PLA when it is present in any of the product forms tested, and separate it from other products.

The optical sorter was used to recover higher value PET and HDPE from mixed plastics that were inadequately sorted in standard MRF operations. Over 40 percent of the materials in these sorted mixed plastics loads were PET and HDPE. More of these materials may be used in manufacturing new products in California if the materials are processed to a higher level of quality.

Reprocessing incompletely sorted mixed plastics through optical scanners can provide additional revenue to MRF operators. The additional revenue from the sale of the extra PET and HDPE may more than cover the cost of additional processing at some MRFs.

The bioplastics sorting project demonstrated the Pellenc/Titus mobile optical sorting system can add value to recovered plastics by removing contaminants from PET, and redirecting recovered materials to their appropriate markets.

The optical sorting system is capable of removing many types of contaminants and increasing the quality of marketed PET. Over 8 percent of the materials in loads sorted by the MRFs as "clean" PET bottles were found to be other plastics.

The optical sorting system is capable of separating PLA bottles, cups and clamshells from all other mixed containers at a MRF. Separating PLA will allow it to be recovered for manufacture into new PLA products.

The results from one sample showed that when the machinery is set to separate only PLA from "Other" materials, it can achieve a 99.6 percent recovery rate.

Findings

Overall recovery rates for PET and HDPE would be increased by efficient use of this technology. A system of this type also could be used to positively sort PLA for recycling, addressing a major challenge as bioplastic packaging grows in market share.

Reprocessing sorted mixed plastics through optical scanners can make more PET and HDPE available to high-value markets, and provide additional revenue to MRF operators.

Overall recovery rates can be increased by running materials through the sorting system more than once, or by running loads through a second sorting machine.

Realistically, sorting more than once is not likely to happen at most MRFs due to throughput and economic constraints. Intermediate processing facilities can be used to provide higher value materials to reclaimers.

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