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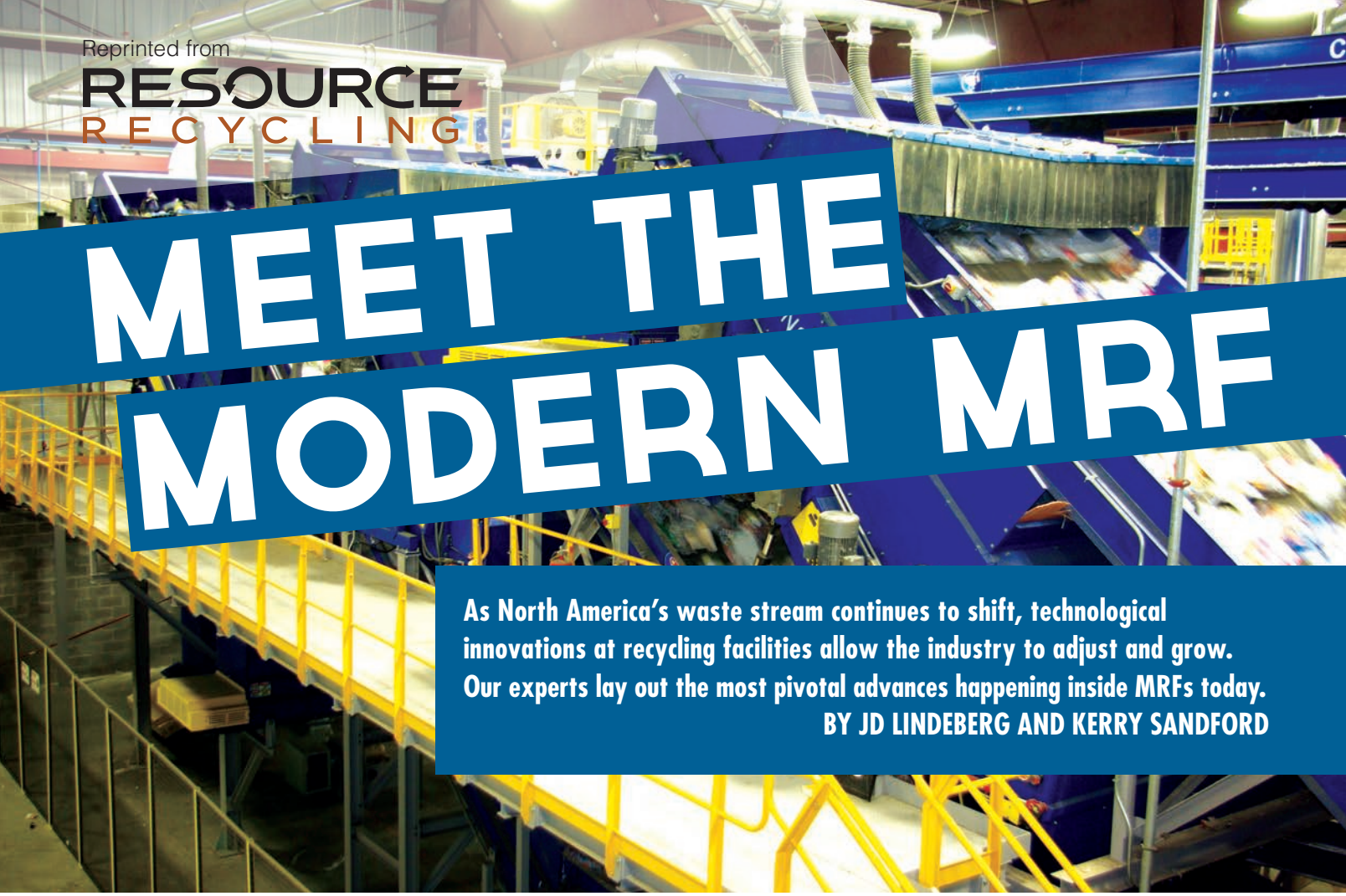


MEET THE MODERN MRF

As North America's waste stream continues to shift, technological innovations at recycling facilities allow the industry to adjust and grow. Our experts lay out the most pivotal advances happening inside MRFs today.

BY JD LINDEBERG AND KERRY SANDFORD

We've all heard the adage that the only constant is change itself. That's an excellent description of the current state of materials recovery facilities (MRFs), where alterations seem incessant.

Some of the change inside MRFs is truly innovative, while other attempts at "evolution" have been short-sighted and counter-productive. It's important to remember that, even in the best of circumstances, innovation can be messy and even disruptive to our collection, processing and marketplace systems.

To help readers get a clear grasp on how modern MRFs are moving forward and what to expect in upcoming operational shifts, we'll outline the equipment and structural shifts having the biggest impact on sortation and materials recovery today. The goal is to show how smart use of technology and design can help the MRF world continue to make changes for the better.

Keeping up with the Joneses' discards

Before getting into the specific innovations occurring at MRFs, it's worth asking why shifts are necessary to begin with. Perhaps the largest factor pushing the rate of change is the shifting waste stream. Dramatic changes from around 1990 to the present impose new challenges on the recovery infrastructure. The twin trends of smaller quantities of newsprint and the increase in plastic bottles and other packaging continue, unabated (see chart on page 18). Already the impact is being felt on older facilities where tip floors no longer have sufficient space to contain the less dense plastics, while the loading docks formerly occupied by newsprint trailers take on less and less importance.

Other, more subtle trends abound. While glass, a dense and relatively straightforward product to physically recycle, has declined in prevalence, exotic plastic packaging – blister packs, different formulations of PET, films, etc. – have increased substantially. In short, packaging is getting less dense, more exotic and harder to recycle in sufficient quantities to create meaningful economic impact.

Ultimately, MRF design must focus on lowering the cost of sorting a stream that's becoming increasingly complex. While early single-stream MRFs often required 1.5 to 2.0 manual sorter hours per ton processed, some of the newer large MRFs are approaching 0.5 to 0.75 manual sorter hours per ton processed. While these more automated MRFs cost more to build, the ability to run them with less labor has the potential to reduce overall processing costs while producing better and more consistent products. Technological innovations may be the key to cost-effective, increased quality throughput. What follows is a rundown of the equipment categories where much of that innovation is taking place.

The new generation of balers

While the basic function of compacting materials into bales has not changed, the operational features of balers continue to advance,

Glass cleanup equipment at the Delaware Solid Waste Authority MRF

The process used for overhead suction of plastic film at a facility operated by the Rhode Island Resource Recovery Corporation

showing better handling of various materials, increases in speed and throughput, improved efficiencies in cost and energy, and reductions in cross-contamination.

A new generation of auto-load back-fed downstroke vertical balers allows for a safe and cost-effective approach to accumulating low-density bulky materials, such as plastic film. The addition of pre-compression chambers or precompression doors to horizontal balers enables low-density materials to be baled with fewer ram strokes, and higher density materials can now at times be baled in just one ram stroke, greatly improving throughput.

While the size of bales produced has not changed significantly in recent years, the rate at which consistent high-density bales can be produced continues to increase. In larger MRFs, a two-ram baler is often dedicated to baling containers and a single-ram baler is dedicated to baling fiber. In recent large MRF designs, shuttle conveyors are often integrated to allow all materials to be baled even if one baler is not operational.

In addition, balers featuring variable displacement hydraulic pumps (that maximize throughput for a given motor size) are reducing energy requirements.

Also notable is the fact that sophisticated controls improve cycle rates, optimize fill of the bale chamber and greatly reduce the potential of plugging two-ram balers.

The addition of bale doors to two-ram balers speeds up the process of baling cans, plastics and other free-flowing materials while reducing the potential of bales being cross-contaminated when switching materials to be baled.

Screen plays

The primary operational difference between dual-stream and single-stream MRFs is the ability of the single-stream MRFs to separate two-dimensional fiber from three-dimensional containers. And the primary workhorse of this process over the last 20 years has been the disc screen.

Disc screens consist of a series of rotating shafts with discs spaced along them. They force three-dimensional material to roll down the sloped face while carrying the flat material over the top. Many screens also allow smaller materials to drop between discs.

Designs of the screens vary greatly by manufacturer and function. Variations can be found in the size and shape of discs, disc spacing, shaft rotation speed and incline of screen. Most modern screens have adjustable shaft speed and adjustable incline angle, which can be controlled while the system is in operation. Many screens also allow the disc spacing to be changed manually to accommodate a changing stream.

While the ability of the disc screen to separate fiber from containers continues to improve with new designs, other technologies are both augmenting and competing with screens in this separation process.

Shaker screens and finger screens, for instance, pre-date disc screens but are still used to remove fines and size materials in a number of MRFs. They are relatively low cost and have few moving parts to maintain. Airflow can also be applied to various screen designs (disc and shaker) to aid in separation of light materials, especially to separate small paper from containers.

Ballistic or inertial separators, meanwhile, can separate low-density materials from higher-density materials by tossing items across a series of gaps with an array of oscillating paddles – the more dense materials are carried forward and the less dense materials fall into the gaps. Ballistic separators are relatively low-cost, have few or no shafts for stringy materials to wrap upon, contain minimal wear parts and can be used in place of, or in addition to, disc screens.

Trommels continue to be used for removing fines as well as larger screening operations. In a number of MRFs, trommels do much of the work to separate containers from large fiber, allowing for the use of a smaller disc screen or the use of other separation technology or manual sorting to finish the process.

Finally, air drum separators are able to capture the small amounts of paper remain-

This disc screen employed at a Casella MRF in Massachusetts is of a type used in only a few U.S. facilities

ing in a container stream by causing the material to fall across one side of a perforated drum. Paper and plastic film are sucked against the drum by a vacuum within the drum. As the drum rotates, the paper and film are carried to the backside of the drum where these materials are blown off the drum, allowing recovery of small pieces of paper that most disc screens and ballistic separators miss. This technology is also used in some glass cleanup systems.

Looking into an optical future

Optical sorters have long been used to separate stones from beans and in a number of manufacturing inspection processes. With the refinement of near infrared (NIR) identification science and the development of ever-faster computer processors, it has become technically possible to optically identify and sort most residential recyclables.

A common example of optical sorting is separation of PET bottles from the container stream. Manual sorters can typically pick 40 to 60 bottles per minute, whereas large optical sorters can move hundreds of bottles per minute.

Features offered in current optical sorter designs include:

- NIR spectrum sorting
- Color sorting
- Wide spectrum sorting
- Metal detection and sorting
- Widths from 0.5 meter to 3.0 meters
- Up/down/dual eject
- Multi-lane sorting

Manual sorting polypropylene from polyethylene requires the reading of SPI codes on each container or being able to recognize the product label. Using NIR technology, optically sorting these materials can be done at high speed and with increased accuracy.

But the technology's use doesn't stop at containers. Specialized optical sorters have been developed for extracting plastic film from mixed recyclables and mixed waste. Some processors are even investigating using the method to sort flexible packaging. In Europe, plastic film is being recovered for recycling using optical sorters with a built-in system for holding the plastic film down to the acceleration belt.

Capital costs deter some MRFs from employing optical sorters. At $250,000 to $700,000 per unit, optical sorting is not easily justified in most small MRFs, and even in medium or large MRFs, optical sorting is not cost-effective for many materials. To be justified, each optical sorter must do the work of multiple manual sorters, unless manual labor is unavailable, very costly or not practical.

As sensors, lighting, air ejection and computer technologies improve, optical sorting will become more capable, faster and more accurate. The price optical sorters may eventually fall as breakthroughs in electronics are achieved.

The glass challenge

A single-stream MRF's glass handling system is key to production of high-quality bales. As collection has moved toward vehicles with increased compaction, much of the glass collected in many communities arrives at the MRF broken and mixed with other materials. The challenge has been to remove the glass and, to the extent practical, recover the glass as a recyclable commodity.

The most recently constructed single-stream MRFs have tended to install glass breakers that reduce glass to pieces 2 inches or smaller, and the systems then screen the broken glass and other fines from the stream as early as possible in the sorting sequence. Glass breaker designs have evolved to the point where nearly 100 percent of the glass can be removed from the stream at the glass breaker. By placing the glass breaker as early in the sorting sequence as practical – under the first stage of the OCC screen, for instance – an operator can minimize wear to sorting equipment.

Most glass markets demand the light fraction be removed from the glass. Some buyers want the fines (particles smaller than three-eighths of an inch) removed as well. The simplest glass cleanup system is an air knife that blows off light materials. That tool is enhanced if the glass is in free fall when it encounters the knife. More sophisticated glass cleanup systems use an air drum separator or similar technology to remove the plastic film, paper and other light materials. Removing the fines, usually with a trommel screen or shaker screen before removal of the light fraction, can greatly boost the effectiveness of the glass cleanup effort.

Do the robot

Unless the packaging industry, either voluntarily or through outside pressure, reduces the number of packaging types that MRFs must sort, both recovery facility costs and residual rates will continue to climb. However, a number of sorting technologies could eventually help out the MRF cause on this front.

Robot sorters are currently used for sorting food on many food processing lines. Using optical identification, a robot could sort one or multiple materials at a single station, or multiple robots using the same optical identification unit could sort multiple materials at multiple stations. We can expect to see some robots in MRFs over the next several years.

Similar to what the industry has seen on disc screen designs, ballistic separators will likely evolve and differentiate to better sort a wide range of materials. We can expect augmentation with airflow as well as multi-stage designs that achieve specific separations.

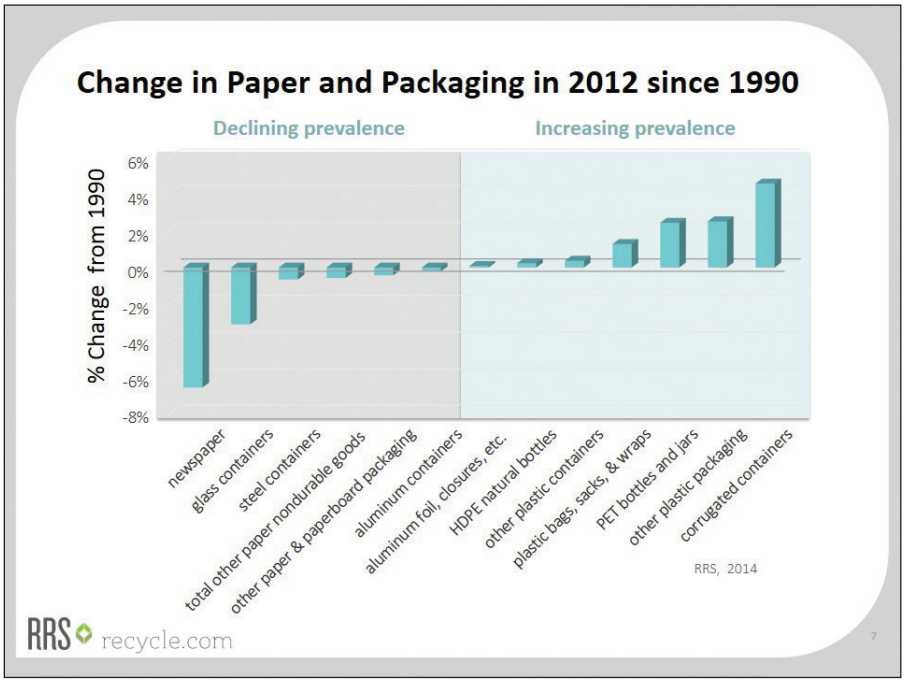
The industry evolution could also move beyond equipment advances. The wider appearance of PETe, PETg, PLA, clear polystyrene and clear polypropylene in commonly used packages can confound even the most expert of human sorters, whether at the home or in the MRF. However, these materials need to be accommodated somewhere in the recycling industry if they are to be successfully recovered. One approach that is developing in some parts of the

country is creating a mixed resin product for shipment to a more specialized MRF, a plastics recovery facility (PRF). These PRFs can serve the MRFs in a region by accumulating sufficient volume of difficult-to-sort plastics to allow sophisticated optical sorting, wash lines and flake and pelletizing lines.

A "dirty" fight ahead?

Policymakers, politicians, industry experts and experienced marketplace observers recognize that recycling rates have stagnated nationwide. While most big cities have made the move toward a separate single-stream recycling infrastructure, a few are exploring the options presented by so-called "dirty" MRFs. These facilities can differ widely in their capability, but they are essentially built on the same underlying assumption: collect and process only one stream of waste, using one set of trucks, or curb cart, and most importantly, deliver all materials to one facility. Although the cities considering this approach are relatively few in number, the resurgence in interest in this approach suggests frustration with the other currently available solutions.

Recyclable streams, whether dirty or separated, will continue to have more materials and therefore more contaminants. Case-by-case cost analyses of these streams on a material-by-material basis determine limits of contamination. Concepts like "highest and best use" remain important to end markets both because the higher value materials are already scarce in their virgin forms and because contamination removal (sorting) at the end market is often the most expensive approach. Innovations in technology may not only help to improve our recovery numbers – they also may improve material qualities that end up back in products on store shelves.



The push for greater innovation at the MRF level should be aided by the fact that material recovery is firmly embedded in the economy. The public's environmental motivations that created the recycling movement in the 1970s and 1980s have given way to industrial dependence on the recovered material supply chain to create cost-effective raw material streams for resins, aluminum, steel and fiber. Along with this industrial growth has come a proportionate growth in the economic activity and jobs based on the recovery industries. Economic growth and job arguments have replaced more "tree hugging" perspectives as important program justifications.

As the nation continues to recognize the economic upsides that strong recycling systems can spawn, the motivation will likely be there among policymakers and investors to find more efficient and cost-effective methods to handle the ever-evolving waste stream. Change, it seems, is set to continue. RR

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