Mixed Waste Materials Recovery Facilities

A current review of key performance aspects and technologies

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While sustainable technologies such as anaerobic digesters are capturing the limelight in the solid waste industry lately, another sustainable facility, called a mixed material recovery facility (MRF), is playing a workhorse role largely behind the scenes. At the heart of the mixed MRF is a sophisticated, semi-automated system that typically receives municipal mixed solid waste (meaning recyclable and non-recyclable materials, unseparated), which is sorted to separate recyclable material that is then sent offsite to become an ingredient in a new product.

In the US, the history of mixed waste processing began in the 1970s with the advent of refuse-derived fuel (RDF) facilities, and the need to prepare a fuel from solid waste that could be burned in specially designed boilers or with coal as supplemental fuel. Although some experiences were problematic, the variety of mixed waste, then heavy on steel and glass, was not ideally compatible with the machinery and led to excessive downtime. The lessons learned were key in evolving the technology and high reliability machines of today.

In the late '80s and early '90s another generation of mixed MRFs came online in response to accelerated municipal recycling goals. Since then, some of these facilities have been upgraded with newer technology to meet the ever increasing demand of higher capture rates of recyclable commodities and, more recently, the capturing of organics (i.e., food scraps). Although the highly automated systems in these facilities have proven over the last 15–20 years to do what they were designed to do—separate complex material mixtures accurately and efficiently—and have done it well, some facilities have had problems.

This article will provide a brief overview of the equipment in a mixed MRF, which communities have adopted these technologies, and commentary on key performance aspects.

Mixed MRF Processing Technologies

A mixed MRF is typically an aggregation of specific purpose machinery designed and situated to work in a sequential manner. The processes usually are integral with some manual labor, to segregate and sort mixtures of different materials as they flow through a facility into multiple, specific material streams, which include the desirable material streams and the undesirable (the residue or "contaminant") streams(s). Contaminants could include, but not be limited to, common items such as drywall, rocks, dirt, rubber products, food waste (unless organics are being separated), and many other materials.

Although food waste are increasingly targeted for separation and reuse, they may be considered contaminants when, for example, they come in contact and soil what may otherwise be clean fiber materials, or even plastics. Mixed MRFs are not specifically equipped or designed to "clean" materials, in the sense that they do not, unlike a home washing machine, remove dirt or food residue from materials that were originally clean. Some of the more common pieces of machinery used in a mixed MRF are briefly discussed in the following paragraphs.

The demand for higher diversion rates from the landfill in many states, the need to maximize revenue from recyclable materials, and the increasing cost of labor has driven the development of highly specialized pieces of sorting equipment that are found in the newest mixed MRFs. Although the need for some manual labor is still there, these specialized pieces of equipment actually make the manual separation part of the process more efficient by performing one or more preseparation activities before the material flows gets to the manual picking stations.

For example, three dimensional plastic containers and fiber containers because of their bulk can obscure smaller plastic or fiber items so the smaller items are removed with an automated machine, which allows the downstream manual sorters to focus on the larger items. The result is that valuable materials that may have been covered over in the flow and either not seen or too difficult to retrieve are now visible to the sorter and can easily be removed from the flow. Some older MRFs that have been retrofitted with some of the specialized pieces of equipment have experienced dramatic increases in volume of captured recyclable materials, previously left as residue for landfilling.

No reasonable technology exists for a mixed MRF that the authors know of that can distinguish a clean plastic container from a soiled one, or clean paper from soiled paper. If these materials come in dirty or are inadvertently mixed with other dirty materials in the MRF, they will likely exit the facility in a similar condition. Because of the sorting action as a material moves through a highly mechanized MRF, some plastics for example, may emerge somewhat cleaner, but nevertheless still be soiled.

Some pieces of equipment, such as bag breakers, trommels, and eddy current sorters have evolved and continue to be utilized in mixed MRFs today. However, the advances in the application of air classification and optical sorting technologies have been especially useful considering the many types of plastics in the wastestream to be sorted, some of which, but not all, are currently recycled. These are discussed further below.

Disc Screens. A disc screen is essentially composed of multiple rows of closely spaced shafts placed 90 degrees to the material flow

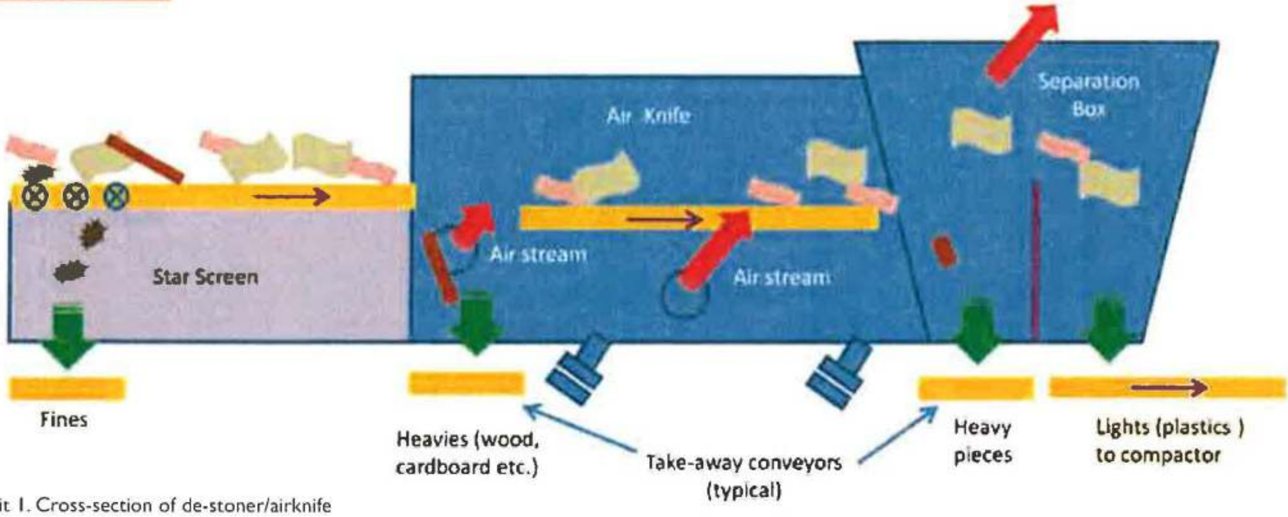

Exhibit 1. Cross-section of de-stoner/airknife

on which are mounted steel discs. The discs are closely spaced across the width of the shaft and rotate as the shaft is turned by a motor. Incoming material is propelled forward by the rotation and rides over the top of the discs. Separation of material occurs as the smaller fraction falls through the openings between the discs, and larger materials are carried through and out the unit to the next separation station.

The disc size, spacing, and arrangement on the shaft produce a specific opening configuration and size that allows a precise sorting of certain materials. As compared to the trommel, the rotating discs help keep the unit cleaner and experience less plugging, and the flat sorting plane without the aerial agitation found in trommels, tends to expose more material to the sorting action and a more uniform flow across the sorting openings. Overall, these characteristics generally make a screen more efficient than a trommel.

Screening technology has rapidly evolved to where there are now disc screens specifically for different materials and sorting requirements, including screens for removing fine fiber, newspaper, old corrugated cartons (OCC), and glass.

One item of note is the use of "water-based" primary separation technology. This is a very different approach than using the "dry" type mechanical equipment described above. A water-based separator uses the principle of the specific gravity of the different materials in a moving mass of water to affect separation. For example, plastics are lighter than water and float, organics (including paper) remain suspended in the water column and inorganics such as metals and glass sink to the bottom. At the end of the process each wastestream can then be intercepted for further processing. Is the water-based method comparable in effectiveness to the dry method? That is a discussion for another article. Suffice to say that both types of methods have the advantages and drawbacks.

Air Classifiers. Separation of light, "two-dimensional" materials such as paper, textile plastic film, aluminum, and pieces of cardboard, from heavier, bulkier materials can be accomplished in an automated device called a de-stoner/air knife. Exhibit 1 shows a schematic cross section through a unit with two air knifes. This unit uses directional air currents and a vibratory motion to stratify and separate lighter material from heavier material. The unit is mounted on heavy coil springs to reduce the transmission of vibration to the ground.

Following along on this exhibit, the waste is fed in from a star gear screen and immediately encounters a gap in the air knife through which high velocity but low-pressure air is flowing. The air flow is provided by a standard centrifugal blower. This flow of air blows the lighter and two-dimensional materials up and towards the downstream conveyor. The heavier and bulkier materials, including small stones and pieces of glass and metal, are unaffected by the air current, and fall through the gap onto a take-away conveyor. Thus, the designation as a "de-stoner."

As the lighter materials are conveyed to the end of the air knife there is another high-velocity, low-pressure air stream directed through the conveyor. This final current of air separates the very light material (mostly plastics and light paper) from other denser bulkier material. The lighter material with a relatively large cross sectional area is carried to the far end of the collection bin, while the denser, more compact material does not travel as far and drops into the bin directly at the end of the conveyor. All air is exhausted out the top of the air box. If a hood is not used over the final air discharge to capture the light product, then a grate or similar screen is used to deflect light material into the air box end bin.

Exhaust air can be captured and rerouted back to the blowers to increase efficiency and reduce discharge of dust to the environment to near. This feature is recommended when the unit is used inside a building and outside where migrating dust could pose a nuisance to other operations or adjacent businesses.

Optical Sorter. The use of automated machinery employing "electronic eyes" to assist in separating materials has become increasingly popular. In many cases, the increased efficiency and higher purity targeted material provides a positive benefit/cost ratio as compared to traditional manual methods. The function of the equipment is based on the principle that all solid materials have a unique surface "signature," that reflects and absorbs light rays in varying amounts.

Following along on this exhibit, as the waste material enters from the conveyor and passes under the control unit, a bright light illuminates the materials. A sophisticated instrument called a spectrometer imbedded in these machines "reads" the reflected light from the materials and through a computerized interface tuned to see wood product, actuates a compressed air device which sends a blast of air that is channeled by the computer program to specific multiple ports positioned across the end of the conveyor belt. As the materials pass over the ports, the ports that have been activated will discharge a blast of air under the material. The air ejects larger wood pieces to a receiving hopper on the far end of the machine, while non-wood material simply rolls off the end of the conveyor belt into a separate hopper.

A vibrating pan feed conveyor is often used to feed the optical sorter. This type of conveyor will increase the effectiveness of the optical sorter by flattening out and separating the materials before they enter the electronic eye detection zone of the sorter.

Currently, two types of optical sorting technologies are used to sort plastics by resin and by color. In sorters using spectroscopy, light waves are emitted whereby each type of plastic on the sorting line reflects back a unique wavelength (Exhibit 3). A sensor installed on the equipment then decides how to classify the plastic into a separate category. In comparison, sorters using X-ray technology identify the elemental form of the plastic resin. In the color separation technology, a variety of different camera equipment is used to differentiate slight variations in the color of the plastic to help separate the plastic streams.

One of the most common types of optical sorting technology used for glass separation is light spectro-photometry (LSP), which can distinguish between various colors of glass and ceramics. This equipment uses the wavelengths of the different colors to trigger a near-infrared (NIR) sensor and tell the sensor what color the glass is that is passing by. This in turn helps trigger an air blower that shoots a stream of air at the glass pushing it into the appropriate sorting bin. Manufacturers of these types of equipment claim sorting efficiency of 90–95%.

This equipment is manufactured typically by specialty companies that work closely with the lead MRF processing system vendor to ensure it design and function is properly integrated in the facility.

Recent Adopters

The last few years has seen the construction and operation of several new MRFs, and retrofits of older mixed MRF facilities across the United States. A few, but certainly not all of the most notable projects are briefly discussed below.

San Jose, CA. The City of San Jose has been a leader in recycling nationwide being one of the first to develop a Zero Waste Plan. Despite its success in achieving a high diversion rate for the residential wastestream, multifamily residents posed a challenging problem for the City. To enhance the diversion rate for these residents, the City embarked upon a program to process this stream through a MRF facility whole at the same time encouraging these residents to source separate their recyclables. As such, the MRF is viewed as an adjunct method for recyclables diversion.

The Green Waste MRF was originally constructed in 1999 to process recyclable materials, yard waste, and C&D debris. In 2008, the facility underwent a reconstruct ion to allow side by side processing of source-separated recyclables and another line for mixed waste processing. The current processing capacity of the facility is 2,000 tons per day of mixed and single stream recyclables.

The MRF line can process up to 30 tons per hour and includes pre-sort stations, a bag breaker, a trommel screen, a drum separator, a polishing screen, and post-sort stations to improve quality of outgoing recyclables. Unsorted organic materials are then transported to the Z-Best Composting facility in Gilroy, CA.

Montgomery, AL. The City of Montgomery, AL, provides solid

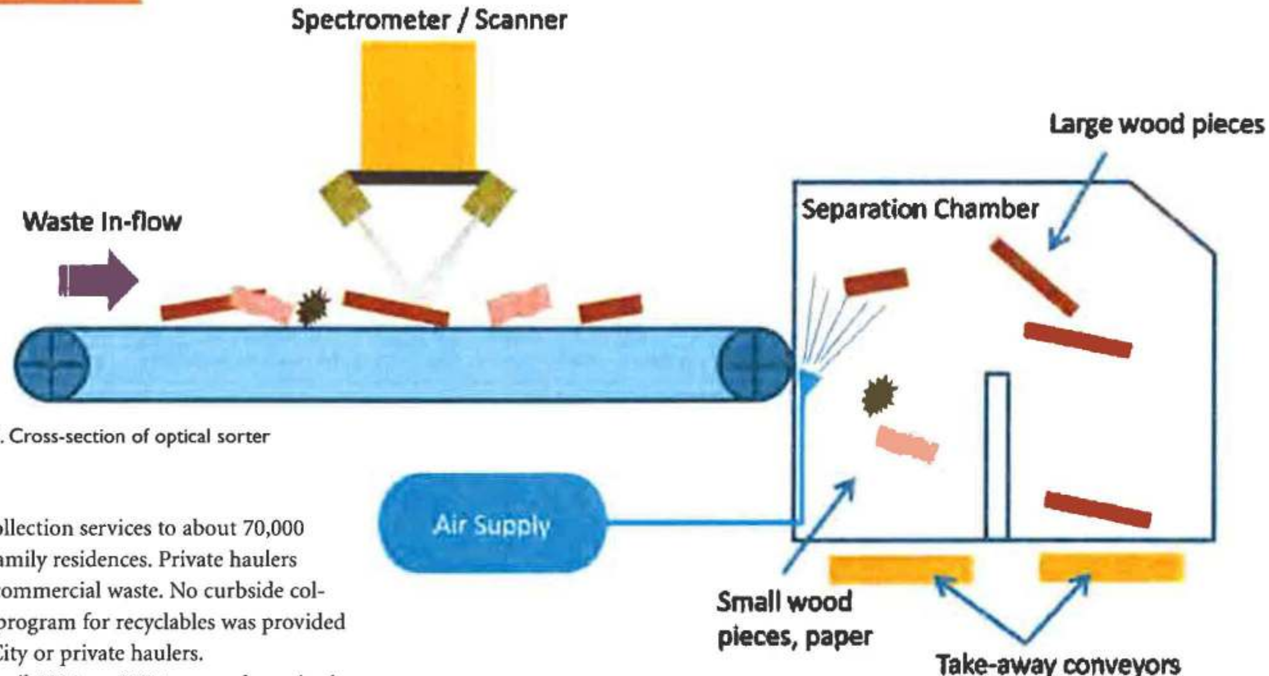

Exhibit 2. Cross-section of optical sorter

waste collection services to about 70,000 single-family residences. Private haulers collect commercial waste. No curbside collection program for recyclables was provided by the City or private haulers.

In April 2014, an 850-ton per day, mixed MRF facility started commercial operations in Montgomery (IREP). This 82,000 square foot facility is located on a 74-acre parcel, which was named the Infinitus Renewable Energy Park. The facility cost about $35 million to construct and is operated by Infinitus Energy, which was awarded the contract pursuant to a Request for Proposals issued by the City. The City entered into a 25-year contract with Infinitus Energy to process the City's residential wastestream delivered to the facility (100,000 put-or-pay agreement) at a tipping fee of $28 per ton. Under this agreement, the operator can process waste from surrounding agencies (within 90 miles of Montgomery). The facility includes four different separation technologies: a Bulk Handling System (BHS) debris roll screen, to size and separate materials, a Nihot drum separator, a BHS polishing screen, and a NRT SpydIR technology which utilizes near infrared light and cameras to detect material composition. The purpose of this technology is to improve separation of fiber, plastics, and metals.

In October, 2015, the facility operator announced that the facility had temporarily stopped operating and all City municipal solid waste diverted to the City's landfill. As of this writing, the developers and the City are discussing options that would allow the IREP to re-open.

Indianapolis, IN. Covanta, the operator of the City's waste-to-energy (WTE) facility, announced its desire to own and operate a mixed MRF facility similar to the facility operated in Montgomery. The facility was recently approved by the City's Board of Public Works and the Mayor. Similar to Montgomery, the City of Indianapolis does not operate a citywide curbside recycling program. Only 10% of the City's residents are currently signed up through a subscription program. Thus, the objective of

Exhibit 3. Technologies Used to Separate Plastics

Technology	Description
Near-infrared	Sensor uses an infrared beam to identify the plastic type by recognizing a light intensity reading unique to each polymer.
Laser	Referring to an impurity's spectrum, physical footprint, this is able to detect and separate it from the product flow.
X-Ray	Distinguishes waste based on density useful for detecting additives.
Color sorting	Separates shades of color seen by the human eye for mixed bottles or flake.

the facility would be to enhance the City's overall recycling rate and enable the City to achieve the state's 50% recycling goal. Covanta proposes that the $45 million, 100,000-square-foot facility (constructed at Covanta's expense near the WTE plant) recover metals, plastics, and fiber with the remaining residue delivered as fuel to the company's WTE facility.

The project is controversial with recycling advocates because its single bin program is claimed to hamper efforts to develop a citywide, single-stream recycling programs. These advocates contend that the project will produce a contaminated recovered materials stream. Further, they contend that energy recovery, rather than recycling is the major focus of the project.

Edmonton, Canada. The City of Edmonton, Canada, has implemented a unique collection of advanced solid waste management facilities. Solid waste arrives at the City's Integrated Processing and Transfer Facility where it is manually and mechanically separated into three streams: composting, biofuels, and residuals sent to the landfill. This mixed waste processing facility includes manual picking stations, rotating screens, and magnets. A processed fuel is then diverted to the Enerkem Biofuels and Chemical Facility where it is converted to ethanol and other chemicals.

Conclusions

Taken as a whole, mixed MRFs have operated well since their reincarnation in the early 1990s and continued refinement through today. The sorting technology, which has been evolving for the last 25 years, has been proven to work and is reliable. Complete, pre-engineered integrated systems have been available now for years from a growing selection of established companies dedicated to the solid waste industry that can provide planning, engineering, manufacturing, controls, and startup, whether for new facilities, or retrofits of existing older facilities.

With that said, the following conclusions are offered for consideration:

- MRFs have the potential to help communities significantly increase their waste diversion and recycling rates.
- The integration of newer technologies offers a substantial increase in throughput of mixed wastestream coupled with the ability to recover previously unrecoverable materials and/or materials previously unwanted (i.e., food scraps–organics).
- High-tech systems represent a significant investment over more manually intensive and older, less advanced facilities. This has to be balanced and their value thoroughly vetted in the planning stage with an economic proforma that is based on realistic, and in the authors opinion, conservative assumptions and estimates of the volume of recyclables that can be produced, demand for the recycled materials, changes in feedstock, the quality of recyclables that can be recognized, and the value that the market will put on those materials.
- Operators should anticipate that plastic and fibers if commingled with dirty materials and/or mixed in with finished bales of those recycled materials may have a lower value placed on it by the end recycler than as compared to a bale of clean material. Thus, keeping different incoming wastestreams separate, at the front end of the system, if possible, is key in maximizing clean recovered materials and limiting the contamination risk posed by intermingling dirty materials.

Despite the recent controversy associated with a few new mixed MRF facilities, the processing systems do an excellent job of what they are supposed to do: maximize the separation of like materials.

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