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Real-world test

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It was March 2019, and after years of planning, research, and engineering, the first test bales destined to become a new commodity called rFlex were rolling off the line at TotalRecycle, a large single-stream materials recovery facility (MRF) in eastern Pennsylvania.

These bales and the pilot program producing them represented a potential answer to a question that had long challenged recyclers, packagers and plastics producers: How could flexible plastic packaging, one of the fastest-growing materials in the post-consumer waste stream, fit into a recycling system that wasn't designed for it?

Flexible plastic packaging (FPP), a broad category including plastic pouches, wraps, bags and films, had a reputation for clogging MRF screens. Meanwhile, the variable mix of plastic resins used in these packages meant its pathway into recycled plastic products wasn't straightforward.

"As a plastics manufacturer, we know how important packaging recyclability is to our entire value chain, from our direct customers all the way through to the end consumers and we know that recycling can help protect the environment," said Jeff Wooster, global sustainability director at Dow, a company that helped to back the project. "It motivated us to launch this industry collaboration to address the challenges around FPP recovery."

Over the next year, researchers would work to tackle these issues head-on in the pilot MRF, with the goal of investigating how to collect, separate and prepare flexible plastic packaging for recycling – all within the context of a typical U.S. curbside recycling program.

First came the research

Materials Recovery for the Future (MRFF), a collaborative research program sponsored by leading members of the flexible packaging value chain, launched in 2015 with a comprehensive agenda aiming to recover flexible packaging and ensure the recovery system captures the material's value.

The first several years of the program included foundational research, led by recycling and sustainability consulting firm RRS, to prove how flexible packaging flowed in single-stream MRFs, how optical sorters could be used for separation, and what the economics of a system to capture flexible plastic packaging would look like if scaled to large single-stream MRFs across the U.S.

At the same time, potential end market uses of the material were investigated, with the results of sortation research driving estimates of the products that could eventually be sold.

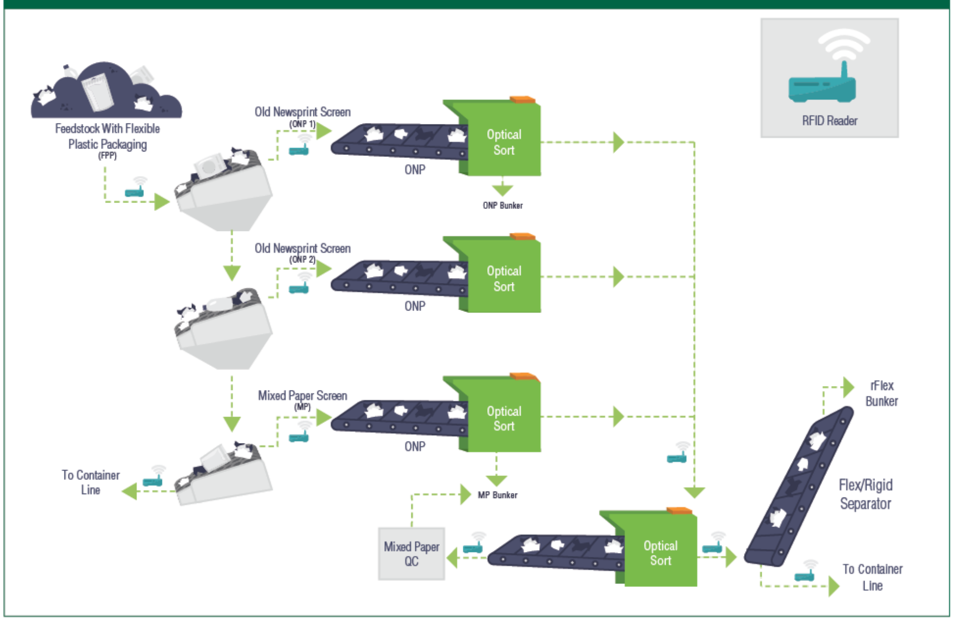
By 2018, research in large MRFs across the country showed promise. Flexible packaging behaved predictably in sorting plants, flowing with two-dimensional fiber, and anti-wrap screens solved most of the clogging issues. Optical sorters in test facilities were able to identify and eject flexible plastic packaging from the fiber stream. And while the equipment needed would cost several million dollars to retrofit, it had the potential to create new MRF products, improve the quality of others and increase a MRF's level of automation and flexibility.

"Our early research was designed to see if sorting this material was possible," said Chris King, a senior engineer at RRS. "We observed that anti-wrap screens worked well and the consistent flow of FPP with 2D material meant that there was a good opportunity to recover it."

But other questions could only be answered with a real-world trial of the concept. How well could the system function, day in and day out, in the grueling environment of a busy MRF? What would the actual mix of package types look like, when sourced from residents instead of modeled from sales data? And would it produce bales that could be sold to real end markets?

A pilot program required a major investment, but if successful, it would allow the group to accelerate the research dramatically in a short time.

THE FPP SORTATION STEPS AT THE TOTALRECYCLE FACILITY



Opticals on a MRF fiber line

The MRFF project group announced in June 2018 that it had found a partner MRF. TotalRecycle, owned by J.P. Mascaro and Sons, would install four optical sorters and peripherals on its existing fiber lines to extract flexible packaging, which it would eventually collect from residents as an officially accepted recycling program material.

By January 2019, the upgrade at TotalRecycle was underway. The system to sort FPP, procured and installed by Van Dyk Recycling Solutions, included Tomra AutoSort 4 optical sorters placed on each of the three fiber lines to eject FPP from the fiber. These high-end optical sorters have a wide build, allowing them to eject material across an entire fiber belt and work at high speeds with material spread out as much as possible.

A fourth Tomra Autosort 4 cleaned up the resulting FPP stream by ejecting the remaining fiber. Finally, a Lubo Paper Magnet was used to separate rigid items, such as containers, from the FPP stream.

This system reconfigured the entire fiber side of the MRF and effectively removed FPP from the fiber stream with very minimal need for manual quality control, while sorting the new test bale made of FPP rather than landfilling it as a residual. But how well could it perform its dual function over time – consistently capturing as much FPP as possible while minimizing any losses of fiber material?

Breaking down the bale

By March 2019, the rFlex system was up and running, with the optical sorters ejecting any FPP that entered the MRF. Cutting open the bales made of this material, however, revealed a problem.

The system was capturing far too much fiber – audit results showed less than half of the bale consisted of the target FPP. Fiber made up 43% of the bale, far from the desired outcome of 15% or less. Contamination such as flattened containers and miscellaneous trash accounted for another 15%.

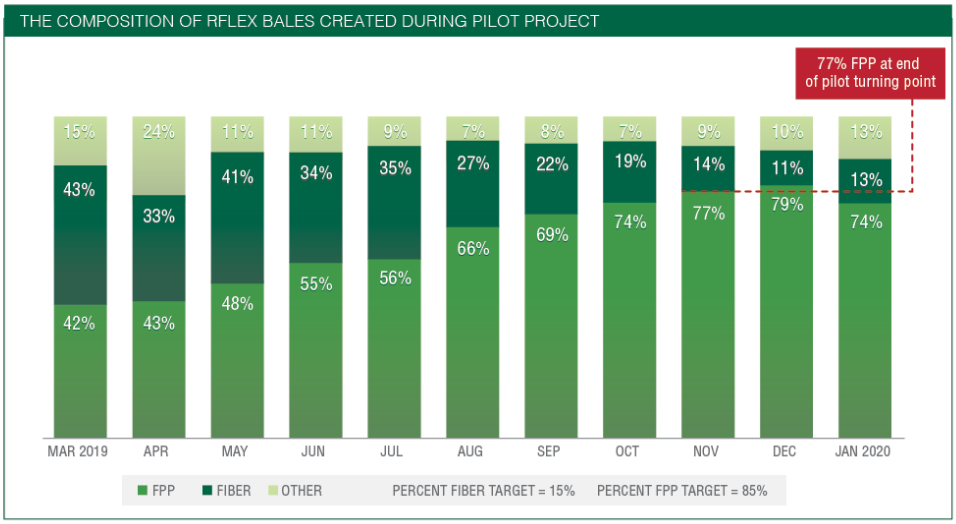
"It would have been great to see perfect performance from day one," said J.P. Mascaro, Sr., director of recycling at J.P. Mascaro & Sons. "But that's why it's important to do this pilot – proving out the solution under real-world conditions can show you issues that you'd never seen in a few days of testing."

Monitoring the system in action revealed what was causing the issues in the rFlex bale quality.

Exceptionally rainy spring weather was drenching uncovered recycled material; the wet paper clumped together, making it hard for the optical sorters to separate out the FPP. As the rains slowed, the material became easier to sort. This finding underscored the importance of transitioning to lidded carts for residential material collection.

Another fix involved a balancing act between automated and manual sorting. The fourth optical sorter, which cleaned paper out of the rFlex stream, was initially calibrated less aggressively. After seeing the results, the MRF tuned it to fire on as much fiber as possible – and added a manual quality control station as a human checkpoint after the optical sorters did their job to pick any missed FPP for the rFlex bale.

The process of system optimization took nine months – but it saw results. At the end of the tuning period, the level of fiber in the bale was one-fourth what it had been at the outset. The bale averaged 77% FPP – very close to what had been achieved in the experimental settings back in 2016, but this time consistently produced in real-world conditions.



THE COMPOSITION OF RFLEX BALES CREATED DURING PILOT PROJECT

Working to capture all types of FPP

Flexible plastic packaging comes in a dizzying array of shapes, sizes and forms, from 4 ounce baby food pouches to 35 pound dog food sacks. The MRFF pilot aimed to capture this entire assortment, with few exceptions (such as extremely small packages or anything made of PVC). And it aimed to ensure that if FPP was accepted in curbside programs, it would successfully find its way to the rFlex bale, rather than ending up as residue or contaminating other MRF products.

To see how possible this really was, the RRS research team used RFID technology to trace sample packages through the MRF and calculate how many ended up in the rFlex bale. This RFID test was repeated at the beginning, middle and end of the pilot to track progress. Each test involved tagging thousands of packages, seeding them into the MRF system over several days of testing, and analyzing which tags were read by each of 10 RFID readers at specific locations in the MRF.

The RFID test process revealed areas of progress and areas where improvements were needed. First, the test showed successful capture of the majority of packages, and improvement over time – with average capture rates over 70% in the two later tests. Second, some packages in the mix were very efficiently captured, with a capture rate of 90% for the best performing package, retail carry bags, by the end of the pilot.

“RFID testing helps us see the strengths and weaknesses of the system,” said King. “Once you know what those are, you can work on improvements.”

However, smaller packages were much harder for the system to capture, and they were more affected by maintenance issues, weather and other unknowns. This was especially visible in the third test; as small baby food pouches were fed into the system, many fell through a spot where the disc screen was heavily worn, and thus never even had a chance to get captured into the rFlex bale. Larger packages weren’t affected in the same way.

Additional research continues on better sorting for smaller packages to catch them up to the high-performance level of the larger FPP items.

Benefits for MRFs and communities

As the technical feasibility of sorting FPP came into view, another research track focused on economic details.

In 2018, RRS had developed a financial model investigating the potential benefits of recycling FPP. For MRFs, these were three-fold: 1) moving FPP from residue destined for landfill to a potentially profitable bale; 2) reducing labor needed to clean the fiber lines; and 3) improving the quality of the fiber bales, even with increased levels of FPP in the feedstock. The economics were most favorable in areas with higher landfill tip fees due to the avoidance of residue disposal costs.

As the pilot progressed, these potential benefits were borne out. Starting in September 2019, residents in local communities were gradually instructed to start including FPP in their curbside recycling. Volumes of FPP increased, but even after implementing the quality control steps mentioned earlier, the amount of labor needed to run the system was reduced by 38%. Before and after audits of fiber products showed a significant reduction in contamination as well – from 1.4% to 0.3% in old newsprint (ONP), and from 1.6% to 0.5% in mixed paper.

Adding an additional category of recyclable material does challenge some recent market trends – but the MRFF pilot suggests it can pay off. With the efficiency benefits taken into account, the economic model shows that FPP recycling could be a reasonably priced addition to residential collection contracts.

And as additional markets develop for rFlex bales, FPP recycling could grow into a profitable commodity on its own.

Marketing a new commodity

But what could those end markets be? This remained a key unresolved issue for the MRFF research, and one that intersected with every aspect of the pilot project.

After months of effort to produce consistent bales alongside research to determine exact bale composition, two main market pathways emerged: mixed bale and plastics-only markets. Mixed bale material markets include producers of recycled building products that use a combination of fiber, plastic and (in some cases) other material such as glass and aggregate. Plastics-only markets would remove the fiber from the bale through wet or dry washing, and then use the plastic component to make pellets or molded durable goods.

“The rFlex End Markets Network that’s grown out of this research program is critical,” said Susan Graff, vice president of RRS and MRFF project research director. “It’s the group that connects demand for recycled plastic products with MRF supply to build circular economies one region at a time. Through rFlex testing and peer review we’ve been able to create new domestic product manufacturing opportunities using a low-cost, high-performing recycled feedstock that can substitute for virgin materials.”

By spring 2020, bales had been shipped to local, regional and international companies interested in investigating rFlex uses. As the COVID-19 pandemic hit, some of this testing halted, and results were not available until after the publication of the pilot research. Since that date, successful test results in the mixed bale markets have come in, and rFlex bales from the pilot facility have been purchased for use in the manufacture of roof cover board.

“We believe it is important to capture the value of post-consumer flexible packaging. That means putting it back into service as a useful, functional end product,” said Brent Heist, a packaging sustainability leader at Procter & Gamble and the MRFF project chair.

The research continues

By June 2020, 18 months after the equipment installation, the results of the pilot were published and released widely. The report described successes on many fronts, along with planned work toward continued improvement.

The FPP capture rate of 74% is being addressed with additional modifications to attain a 90% target. End market tests continue, and the life cycle impacts and costs of sorting and reclaiming FPP are being inventoried to verify the efficiency of recycling this material.

These unanswered questions motivated continuing the MRFF research conducted by RRS through a project award from the REMADE Institute. The project, titled “Determining Material, Environmental and Economic Efficiency of Sorting and Recycling Mixed Flexible Packaging and Plastic Wrap,” will examine the footprint of rFlex production, transportation and recycling. Scheduled to be completed in 2021, the project will release interim findings on an ongoing basis, starting with engineering support and an additional RFID test in August 2020 to further refine the bale.

Heist added, “Our report represents a milestone, but not the end of the MRFF vision. We’re excited that work to develop end markets for post-consumer flexible packaging will continue with the American Chemistry Council and the REMADE Institute to expand on what we’ve learned and accomplished so far.”

The qualities of flexible packaging that make it environmentally beneficial – its low weight and the small quantity of raw material needed in its production – have motivated its use and also made it difficult to recycle. The MRFF-sponsored research has shown that an industry-wide collaborative approach can develop practical solutions to these recycling challenges in a short window of time.

The next phase of MRFF will circle back to the original motivations for using flexible packaging while developing a full understanding of its impacts beyond its first life as a package.