

Envisioning the future of recycling: when AI meets process expertise



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THERE IS NO SUCH THING AS WASTE

Only a stock of valuable raw materials that must be sorted, cleaned and prepared to enter a new life cycle

The EU wants a circular economy in 2050. This is a great ambition, but a lot still needs to be done to convert the linear economy into a circular economy.

In a circular economy, raw materials are used optimally. The pursuit of zero waste recycling means minimizing the amount of residual waste that is ultimately incinerated or sent to landfill, and ensuring that this residual waste does not contain valuable materials that could have been better recycled. This ambition requires the development and deployment of smart technologies and solutions based on artificial intelligence, robotics and advanced engineering combined with expertise in the recovery of raw materials in the waste processing chain. This forms the core of the Bollegraaf Group's innovation processes.

Edmund Tenfelde, CEO Bollegraaf Group



Charles Daridon, Director Global Sales



In the near future we expect a complete redesign of advanced MRFs (Material Recovery Facility). These MRFs will maximize the performance of advanced mechanical recycling of various types of waste material.

It is all about CO₂! Increased recycling rates go hand in hand with CO₂ reduction. Take plastic, for example, in the process of turning waste into raw materials, there have been fascinating developments in recent years to implement new technologies. This is especially true for chemical recycling (e.g. pyrolysis, dissolution, depolymerization applied for plastics that cannot be recycled mechanically). Large volumes and dedicated qualities are necessary to make chemical recycling economically feasible. At Bollegraaf, we see the solution in, among other things, new, advanced separation technologies to achieve higher-quality mechanical recycling and a higher quality of recycled material, in combination with chemical recycling.



Rob de Ruiter, Director Innovations & Sustainability



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When AI meets process expertise, generating high-quality secondary raw materials from waste is no longer a dream. Together with our clients, this is our joint mission.

”

Martine Assié, Product Marketing Director

HOW CAN AI ADDRESS CURRENT CHALLENGES IN RECYCLING?

Holistic view on the smart process and the smart value chain



Reaching the true circularity of materials and, from a plastic waste perspective, working on the 'de-fossilization' of consumer and industrial products require a holistic approach to the materials value chain. In this perspective, (advanced) mechanical recycling is key and therefore experiencing an incredible fundamental shift.

The rapid development of smart technologies is leading the industry into a new era, the so-called Industry 4.0. It implies the generation of relevant and real-time process data powered by artificial intelligence and subsequently deployed into a relevant set of management tools. This unlocks a full array of possibilities for processors, ranging from advanced reporting and fact-based process optimization to automating key sorting steps.

On top of that, the economics of recycling have greatly changed over the past few years. For an industry that was mainly focused on maximizing its output, there is a clear call nowadays for high-quality sorted materials that will be further converted into secondary raw materials.

Further than a moving regulatory landscape, the dynamics of the international trade of recyclables has also tremendously changed, leading to a rising cost of waste disposal (through incineration or landfill). Process control in ever-changing conditions is more than necessary for MRFs to guarantee consistent output quality and survive the quest for the resources of tomorrow.

Therefore, data play a critical role in facilitating this process and eventually creating the MRF of the future. The ones who cannot adapt to these changes and challenges will not be able to survive the race.

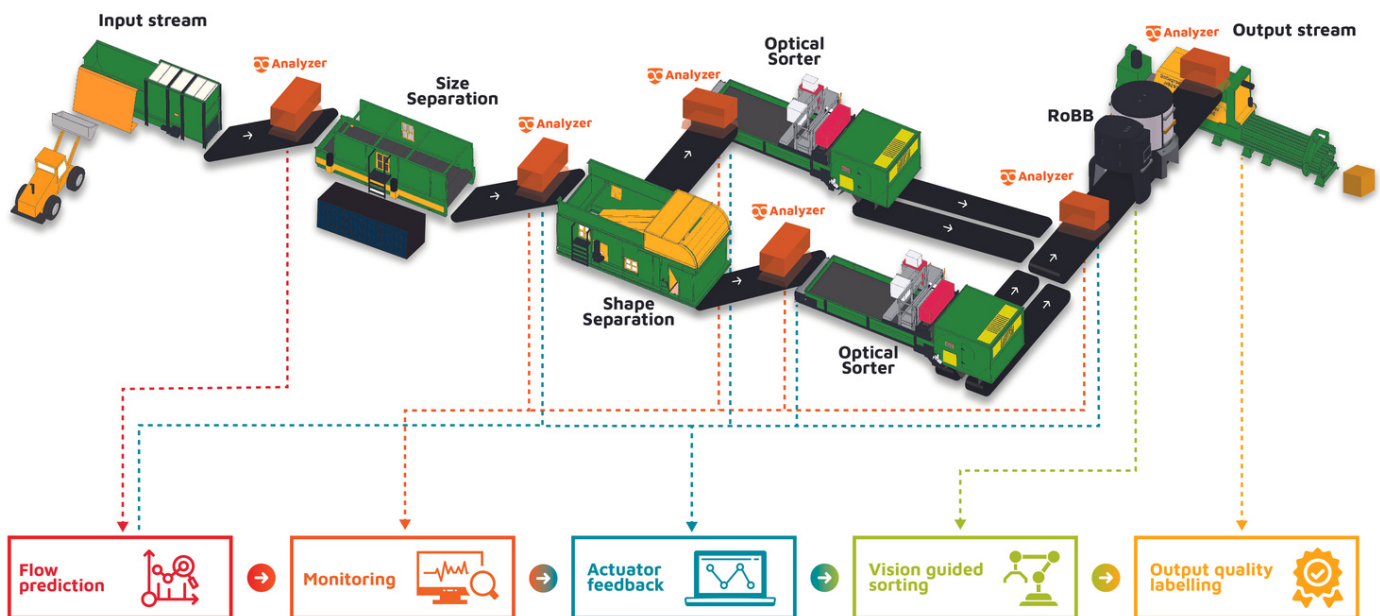


HOW CAN AI ADDRESS CURRENT CHALLENGES IN RECYCLING?

AI in the MRF of the future: next level of sorting

Unlocking the full financial value of waste

Insufficient real-time waste composition data results in operators receiving an inaccurate overview of their waste composition at various steps in the sorting process. The integration of AI vision systems at several key points in a sorting line is the first step to maximizing material purity and improving productivity while minimizing operational costs and environmental impact. Furthermore, unlocking waste composition data improves transparency within the value chain and thus enables the operator to maximize the performance of the downstream recycling processes. It also tackles current costly value chain inefficiencies, such as, for instance, the overreliance on manual labor for quality control and sampling purposes.



To measure is to know

The Bollegraaf Analyzer collects comprehensive and relevant data in real-time from various key points in the sorting process. By leveraging this data with our artificial intelligence, the integration of our vision systems results in the following applications: 1- flow prediction , 2- process monitoring, 3- actuator feedback, 4- vision-guided sorting, and 5- output quality labeling.

FLOW PREDICTION

From black to orange box



Insufficient waste composition data results in an incomplete picture for the operators about the composition of their waste stream, which in turn slows down decision making.

The consequences:

- There is no control over material composition entering the sorting line and its quality;
- Potentially poor quality of input material will consequently influence the quality of output. Therefore, it is difficult to guarantee the purity of the output material

Placing a Bollegraaf Analyzer, a so-called "orange box" in the beginning of the waste sorting line can give a deep understanding of the plant's efficiency.

Through real-time and automated composition analysis of the infeed materials, sorting and recycling processes can be optimized in a timely manner.

The input stream data may also be used to throttle or increase feeding of the line to maximize process efficiency.



MONITORING

You cannot optimize if you do not measure



Bollegraaf AI-powered Analyzers provide continuous and accurate waste composition analyses at key points in the sorting plant. By combining various datasets, Bollegraaf Analytics Dashboard will be customized based on customers' KPI's.

The necessary information is extracted from the sorting facility and is displayed comprehensively through operating and performance indicators that support data-driven decision-making.

Our 24/7 monitoring system gives alerts for changes in the composition of input or output in case of deteriorating process performance or anomalies. It also makes it possible to create purity labels for outgoing batches of material.

Nowadays, quality control mainly relies on manual sorting and random sampling. These labor-intensive and unreliable processes can be automated today, guaranteed product purity can be given and recovered materials from waste can be traded at their true value.

ACTUATOR FEEDBACK

Validate performance of every step in the sorting process

Waste composition remains extremely volatile. Factors like, for instance, seasonality, packaging trends, waste collection and regulations all influence its change.

Measuring composition before and after the actuator enables a quick response and performance optimization of steps in the sorting process.

Advantages:

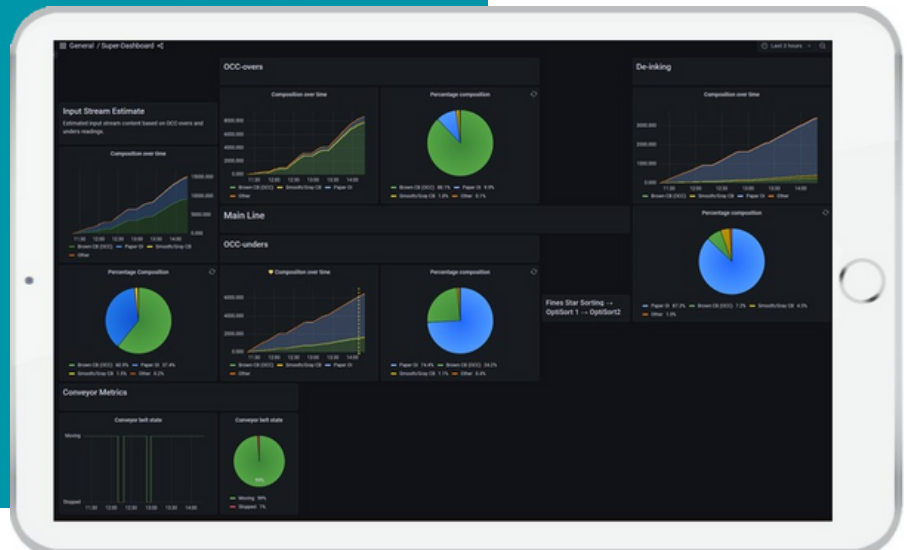
- Feedback based on data
- 24/7 monitoring
- No human in the loop

KPI's

- Composition
- Belt uptime
- Object size
- Material spread

Use cases

- Bale composition reports
- Detect deteriorating performance
- Detect anomalies



“ In collaboration with Bollegraaf, we have recently modernized our de-inking paper sorting line. We are currently monitoring the performance of our newly designed process, which includes the latest technology in high-speed optical sorting, the Bollegraaf Opti-Sort. Performance of such equipment depends on the preparation of its input material. This is why we have decided to monitor the performance of our upstream screening stage using Bollegraaf Analyzers. By continuously monitoring material composition, size and shape before and after our OCC screen, we can adjust our screening parameters and optimize material preparation before it enters the optical sorting sequence. This feedback loop on our screening performance is a crucial element that allows us to significantly improve consistency of quality and recovery of our de-inking paper.

Patrick Jonk,
General Manager at SPK bv

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VISION-GUIDED SORTING

Reaching the next level of sorting

“ Bollegraaf was the only company to be able to offer a solution to successfully integrate the robotic technology in our existing plant which treats lightweight material. ”

Christian Hündgen,
Managing director Hündgen
Entsorgung GmbH & Co. KG

Quality control and improvement

Bollegraaf AI-based vision systems can today be integrated into sorting solutions such as robotic sorters, optical sorters, balers.

For example, the Bollegraaf automated quality control solution, RoBB, is a sorting robot with an AI-guided vision system. It is built around an array of optical sensors, such as NIR (near infrared), RGB and height cameras. This identifies and classifies items based on material composition, shapes, color and other attributes that a human eye could easily recognize. Its cognitive computing process is based on deep learning networks that are able to self-learn and recognize patterns in the same way the human brain does.

A huge benefit of such AI-based vision systems is that they utilize multiple detection methods to differentiate material. Based on the collection of mainly RGB data, powered by artificial intelligence, waste stream composition is estimated at the object level. This allows a deeper level of waste composition analysis up to food/non-food differentiation between two objects made of the same material. The Bollegraaf Analyzer understands objects as a whole and is able to recognize flexible models.



OUTPUT QUALITY LABELING

Waste sampling made easy

Complete insight into your output composition



Easy and fast waste sampling



Increased cost-effectiveness



Increased satisfaction of customers

The Bollegraaf Analyzer is a multi-purpose example of how the Bollegraaf Group integrates AI into her sorting solutions. A valuable application of the Analyzer is to label the output of the sorting facility. This gives a multitude of advantages.

The Bollegraaf Analyzer gives updates about the trends, current composition, and estimated shipment value at frequent intervals. This maximizes the profit per shipment. Furthermore, the information received from the Analyzer can be used to give transparency to customers and the senior staff at the company. Paving the way for well-informed decision-making to increase future profitability.

Implementing a Bollegraaf Analyzer at the end of the line will reduce the number of man-hours needed to sample waste. In addition, the Analyzer will prevent the rejection of shipment by customers due to not meeting contractual obligations, which could result in extra fees, man-hours, and in turn increased costs.

Customers want to receive reliable information about the exact composition of their shipment. The Bollegraaf Analyzer enables you to give your customer what they want by providing an exact composition analysis of the shipment. That increased transparency can result in a competitive edge for your company. Which in turn will result in an improved relationship between you and your customer.

CASE STUDY

Composition analysis of the de-inking paper line at a facility in the Netherlands

Challenge

Improving logistics and related cost efficiency in trading operations with our customers*

*Recyclers send material to paper mills that perform quality control based on random sampling of delivered material. When a deviation is manually measured, trucks are sent back to the supplier.

Solution

Real-time composition analysis of the de-inking paper line (output).



The Bollegraaf Analyzer was placed on the output conveyor of the de-inking paper line in the mechanical and optical sorting plant with a capacity of 400.000 kg input per day, approximately 50% of which is paper.

Source of waste:
Amsterdam region

Belt parameters
Speed: 1 m /s
Width: 1,2m

Type of waste: paper, cardboard and impurities

Material composition on average:
80-95 % De-inkable paper
5-15 % Impurities (brown cardboard, smooth cardboard, tetra, plastics)

To evaluate the system's accuracy, we compared the Analyzer output (mass estimates per targeted class of material and camera images from recording with model predictions) with the reference output (weighed and hand-sorted material).

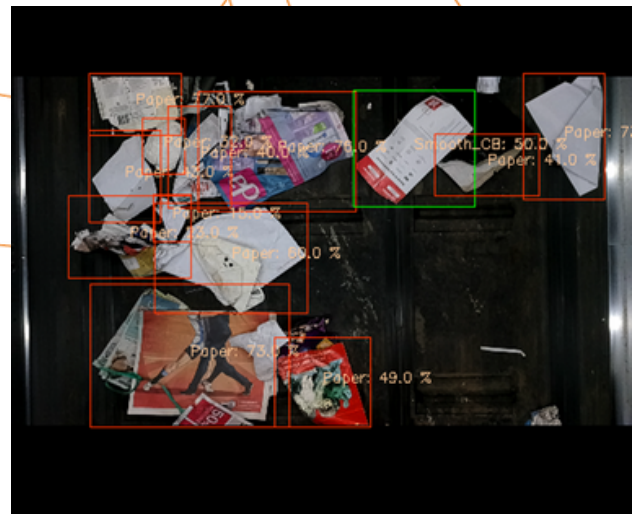
Example of an accuracy test made together with the customer:

Material class	Weighted out of reference sample	Manual sampling (Weight %)	Composition Analyzer (weight %)	Measured deviation (Analyzer vs Manual)
Brown cardboard	5,7 kg	10,8%	11,2%	0,4%
Smooth cardboard	3,65 kg	6,9%	4,8%	-2,1%
De-inkable paper	43,15 kg	81,6%	83,0%	1,4%
Other	0,4 kg	0,8%	1,1%	0,3%
TOTAL	52,9 kg			

Vision system recognition and classification are key



False positive causes bad results



Good recognition causes good results

Classification is key and keeping up with high performance requires frequent uploading of new samples on customer-specific datasets. Material flow and properties change over time and these changes need to be captured.

Creating a world of difference with AI

Reaching true circularity of materials by a holistic and innovative approach on waste sorting and recycling processes.

There is no "one solution that fits all". The requirements of every single customer are unique, waste material input changes over time while regulations evolve. The waste value chain requires transparency and collaboration to reach true circularity of secondary materials.

Our customers are central in this approach, and creating solutions based on their individual challenges with true impact is our collaborative journey.

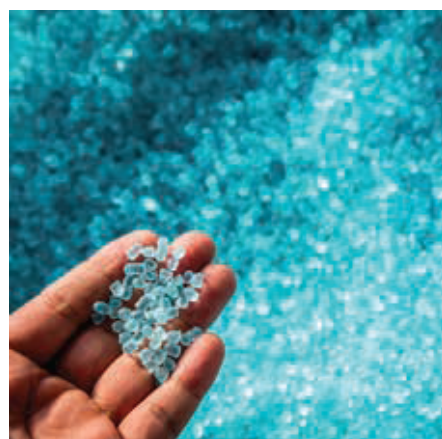
Innovation encompasses both, development of state-of-the-art sorting processes based on the best sorting technologies and application of AI-vision systems. We believe that Bollegraaf's premium equipment quality and unique engineering expertise empowered with artificial intelligence systems represent the one-of-a-kind synergy which is destined for success!

Edmund Tenfelde
CEO Bollegraaf Group



“ In collaboration with our clients, we make a difference – a world of difference – in the market. Together, we face fundamental challenges with decisive technology. That is how we are building on a truly sustainable global future.

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**CREATING A
WORLD OF
DIFFERENCE**