BIO-UPTAKE

In this sixth newsletter, the focus will be put on the quality control systems developed by AIMEN to analyse the quality of the manufactured bio-based parts. You will find all the details regarding this technology further below. Enjoy the read and don't hesitate to visit our website to explore our other innovative solutions!

www.bio-uptake-project.eu

OUR PREVIOUS EVENT

JEC WORLD 2026 - Paris

We attended JEC World 2026 in Paris this month. It was an excellent opportunity to discuss the project's next steps with consortium members, present the project to an international audience of composites professionals, and receive valuable expressions of interest for future collaboration.

If you attended the event but didn't have the chance to speak with us, please feel free to get in touch if you have any questions!

NEWS

To begin with, it should be noted that the quality control system presented in this article is a machine vision system implemented on the MOSES production line, to assess the quality of the over-injected garbage lids. The system was designed to maximise the visibility of small defects on the inspected part while maintaining a stable and reproducible acquisition setup.

Figure 1: (Left) Illumination configuration; (Right) System getting installed by AIMEN

The inspection station uses a camera with its sensor parallel to the inspection area, along with four high-power light sources arranged around the piece in a dark field position, which generates strong illumination and enhance the contrast between the surface and potential defects.

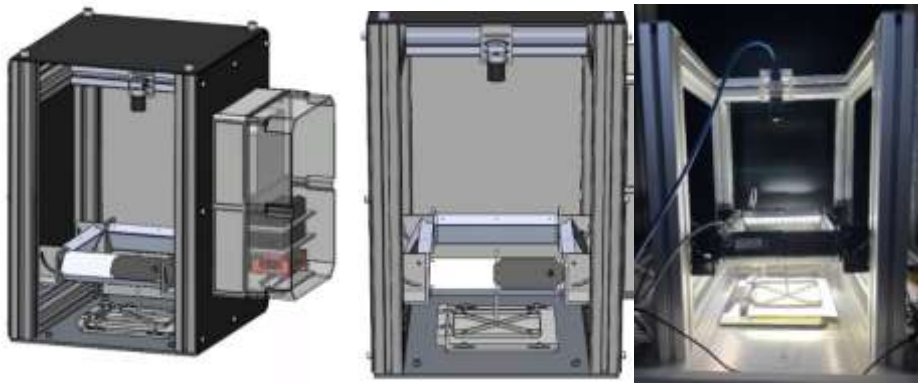

Figure 2: (Left-Middle) Mechanical design; (Right) Final integration

Additionally, a light polarization and red optical filters were applied to improve the visibility of subtle surface variations (image on the right below), and reduce glare produce by the base material (the organosheet).
Figure below shows the inside lid's view composition. The organosheet is the grey-ish area in the background which corresponds to the PLA laminate where the over-injected material will stick to. The inner structure, the over-injected new material PA+fibers, is the black thin wall that gives both, all the mechanical properties to withstand the work that the garbage lid is subject to do (the nerves), and the mobility of the lid provided by the hinges.

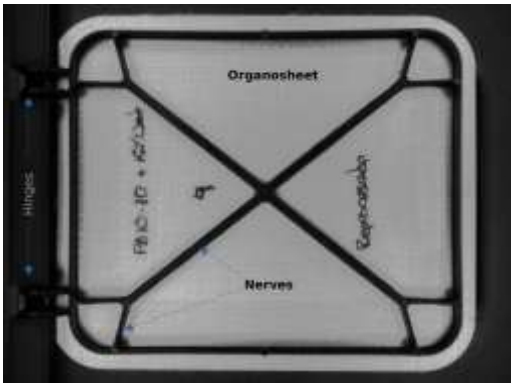

Figure 3: Garbage lid morphology

The defects selected to analyse for this use case come from the years of expertise MOSES has in the over-injection manufacturing process, choosing the most critical surface defects that can affect the structural nerves, detecting and classifying them into two types of failures, lack of material and overpressure.

The machine vision system applies machine learning techniques facing the challenge of not having a big dataset of data. The total number of inspection images is 139, being 103 used to train the model, including images coming from data augmentation techniques to increase variability and improve model generalisation, 25 for validation, and 11 for testing. After several approaches to find a model to resolve the problematic, the proposed solution consists of two specialised architectures, each designed to address a specific defect type.

1. **Lack of material:** This defect happens when the over-injection is not complete, leaving either a void or a puncture on the surface of the nerves. The latter is the more interesting defect due to the limitations of the human eye of resolving tiny holes that might appear on the structural nerves, that a vision system can resolve.

The machine learning model chosen is an instance segmentation approach based on Mask R-CNN. It decomposes the detection problem into three sequential stages.

- Region Proposal Network (RPN) identifies candidate regions in the image where a defect could potentially be present
- The regions are classified and refined into bounding boxes
- Segmentation branch generates a pixel-level mask inside each detected region of interest (ROI)

This architecture has proven its effectiveness for small and localised defects because the segmentation focuses on relevant candidate regions instead of analysing the entire image at once. The following table summarises the performance obtained on the validation set.

Metric	Value
Model architecture	Mask-R-CNN
Precision	0.256
Recall	0.244
F1 score	0.250

The resulting metrics were expected to be low given the limited dataset size and the variability within the data.

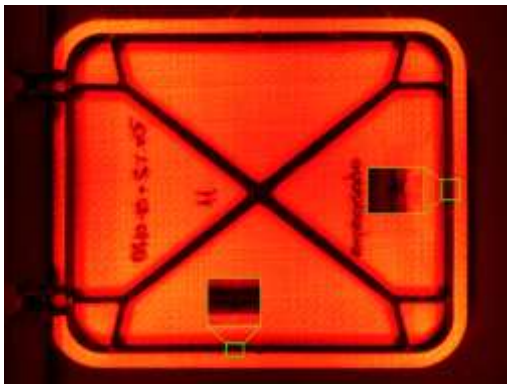

Figure 4: Lack of material close-up look. Punctures undetectable standalone by the human eye

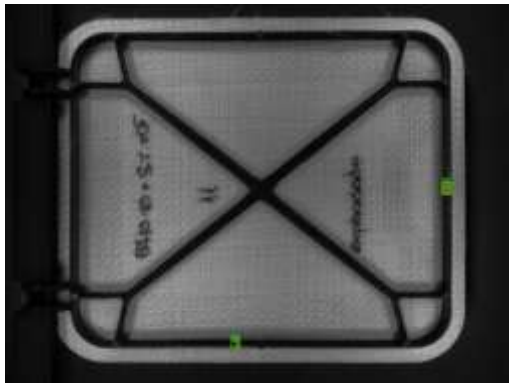

Figure 5: Lack of materials detected by the vision system

2. **<u>Over-pressure:</u>** It is overflowed material that goes beyond the mould cavities during the over-injection process due to pressure variations. The mould starts opening and the material starts overflowing and potentially breaking the structure of the organosheet, where also the material goes inside. This defect was large in the very first over-injected parts, when the process was not fine-tuned yet. After MOSES technicians fine-tuned the process parameters, the over-pressure became almost difficult also for the human eye to be catch (images below).

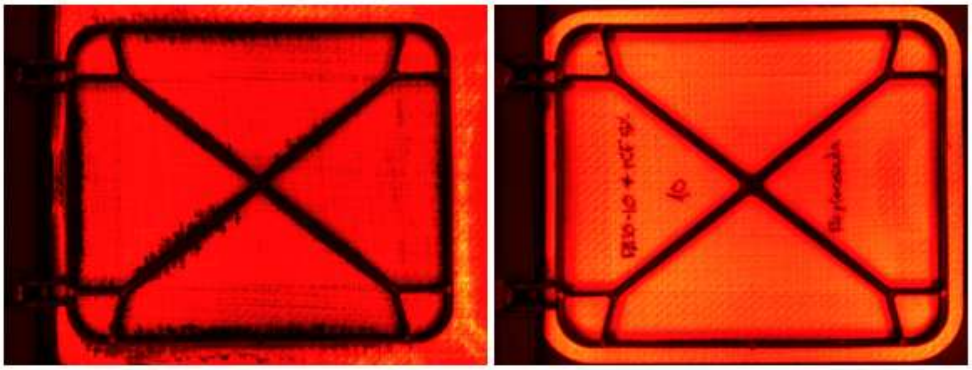

Figure 6: (Left) Big overpressure around the nerves; (Right) Subtle over-pressure with new fine-tuned parameters

The U-Net architecture is selected for this defect because it typically appears as a large deformation pattern with a more continuous structure. In this context, this architecture is better suited due to its designed for dense segmentation tasks, where the defect occupies larger spatial regions and follows more continuous patterns.

Despite this architectural suitability, the overall segmentation performance remains limited. One of the main challenges arises from the visual similarity between the defect and the structural features of the component. The overpressure typically appears along the reinforcing nerves of the part, which already produce strong edges and intensity variations in the image. Also, the latest improvement in the production parameters makes this defect very tiny compared to the large over-pressure defect obtain in the initial stages. As a result, the defect pattern can easily be confused with the normal geometry of the component.

In addition, the dataset presents a significant class imbalance, with only a small number of images containing the overpressure defect. This limits the model's ability to learn the variability of the defect appearance and reduces its generalization capability.

Figure 7: Over-pressure defect close-up, subtle overflown material around the structural nerves

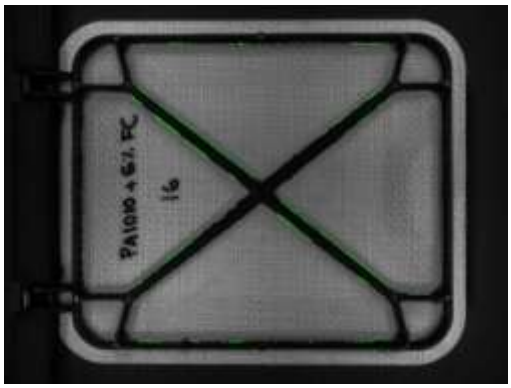

Figure 8: Partially over-pressure defect detected with the U-Net architecture

Metric	Value
Model architecture	U-net
Precision	0.445
Recall	0.758
F1 score	0.278

In conclusion, separating the problem into two specialised models, the system can leverage the strengths of each architecture while mitigating the limitations imposed by the small dataset. This modular design also simplifies future improvements, allowing each model to be independently optimised. Furthermore, both models demonstrate that can identify relevant defective regions and provide a promising starting point for further improvements as additional labelled data becomes available.

NEXT EVENTS

You want to meet us in person, so don't hesitate to come to these events and follow our social media to see where we will be located!

- **European Biomass Conference and Exhibition 2026**: 21st of May, The Hague (Netherlands)

  The entire Bio-Uptake team will be attending European Biomass Conference and Exhibition 2026, on the 21st of May in The Hague. This major international event will provide an excellent opportunity to present the Bio-Uptake project to a wide audience of experts in biomass, bioenergy, and the circular bioeconomy, while also showcasing the products and solutions developed throughout the project. We look forward to engaging with researchers, industry representatives, and policymakers, and to exploring new opportunities for collaboration.

MORE INFORMATION ON BIO-UPTAKE

If you want to know more about us, visit our linkedin page to see the presentation of the different partners. You will discover the majority of the members involved in the project and their role with videos and images!

Stay connected with us and we will resume our content with another newsletter around mid-2025.

Register to our newsletter

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