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Introduction

The purpose of the Paper is to provide an overview of the application of XSpectra®, our proprietary inspection technology, in the food segment of biscuits (the "**Product(s)**") to show on a preliminary basis the capacity of XSpectra® Detector to identify the presence of foreign bodies (also "**FBs**").

Tests were executed using both low- and high-density FBs and specifically foreign bodies that are hard if not impossible to be detected by conventional inspection systems (like X-ray, metal detector, etc) generally used on processing lines for this type of product.

Products were inspected in their paper package (81 c/pap type) to show that the detection technology is not affected by the type of packaging.

The Equipment

Tests were carried out at the Xnext Demo Center using a demo machine, equipped with XSpectra®, placed on a 6-metre conveyor loop. The aim was to recreate the typical operating conditions of a processing line for this type of product in order to carry out realistic tests.

The Products were inspected mainly using a geometric configuration of the inspection system in which the X-ray generator and the detector are placed in a lateral position with respect to the direction of movement of the Product.

The demo-machine used for testing has fixed distances in terms of source-product and product-detector. Therefore, when a dedicated machine is built, the geometric configuration can be further optimised, facilitating the operation of the foreign body detection software. We also do not rule out the use of an X-ray source more suitable for the type of product being inspected.

Tested Products

The sample Products used for the tests are alongside identified by type. All the Products were tested in their own paper package (as generically shown in the image below), with a weight between 250 and 700 grams, and using a belt speed of:

- **18 cm/s** for samples #1, #2, #3 and #6,
- **60 cm/s** for samples #4 and #5.

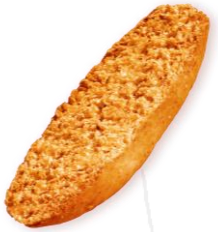
Sample #1
Shortbread biscuits with chocolate chips

Sample #2
Shortbread biscuits with cocoa and cream

Sample #3
Shortbread biscuits with chocolate chips

Sample #4
Wholemeal biscuits with chocolate

Sample #5
Wholemeal biscuits



Sample #6
Wholemeal croutons

FBs used for testing

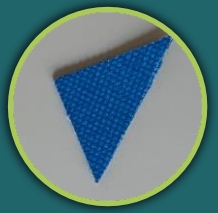
We used **11 different types of FBs**, to our knowledge, quite common for this type of production.

Also, we focused more on **low-density FBs** (from around 1.7 g/cm^3 down) **which are difficult if not impossible to be detected with conventional inspection technologies**.

FB1
Sucker
0.5x0.5x0.7 cm

FB2
EPDM gasket
1.5x0.5x0.5 cm

FB3
Nitrile glove
1cmx1cmx1mm



FB4
Belt fragment
4cmx2cmx1mm

FB5
Stainless steel wire
4cmx0.1mmx0.1mm

FB6
Pen cap
3.5x1x0.5 cm

FB7
Flooring material
3x3x2 mm

FB8
Rigid plastic fragment
5x3 mm

FB9
Dough residue
4x4x3 mm

FB10
Transparent plastic
2.5cmx1cmx3mm

FB11
Glass splinter
1cmx1cmx2mm

Background of the testing process

The purpose of these tests was to show the capability of XSpectra® to identify the selected FBs before the support of a dedicated detection software

The XNEXT proprietary inspection system, under normal operating conditions, performs the inspection analysis with the support of XInspector, a self-learning detection software, which allows the automatic detection of foreign bodies and non-conformities.

Starting from a consolidated background, XInspector is a software that from time to time is further developed and adapted for the specific application needs through a dedicated training. Since these are preliminary tests, XInspector was not used but instead the image analysis tool XSpectrum Analyzer was applied to process the data obtained from the inspection.

The results of the test and the relative images shown in this Report are therefore the result of simply exploiting the precision of the XSpectra® Detector.

Compared to conventional X-ray inspection systems available on the market, which operate at energy levels above 25 keV, XSpectra® is able to operate even at low energies (up to 5 keV). This represents a significant competitive advantage since product non-conformities can become more visible at low energies.

Background of the testing process

XSpectra® detects foreign bodies not by analysing a picture but by processing a “cube” set of data generated by the detector

In practice, the system analyses the number of photons for each energy band of the X-ray spectrum and within a specific space. The same set of data is then used to generate an integral image of the product with the contaminant, which is what is shown in the following slides.

Beside the above, as mentioned before, the **tests** were **executed using a standard demo machine available at XNEXT Lab**. Since the standard machine has fixed settings, in terms of geometric configuration (the distance between the X-ray generator and the detector, in relation to the size of the product packaging) the inspection system used is **obviously not optimized to inspect the Products**.

Furthermore, please keep in mind that the quality of the images that follows is affected by the PDF conversion and the image compression, necessary to reduce the file size. A better image resolution would also be achieved by processing the data generated by XSpectra® with dedicated algorithms.


Main
Test Findings
XNEXT
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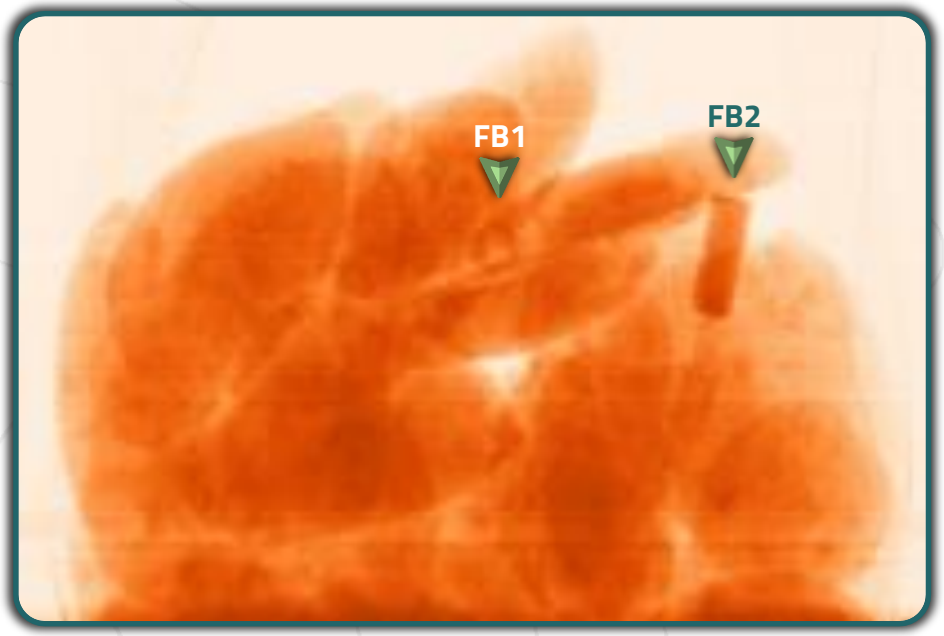
Sample #1 (1/2)

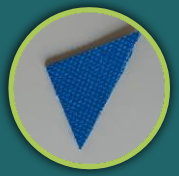
FB1

FB2

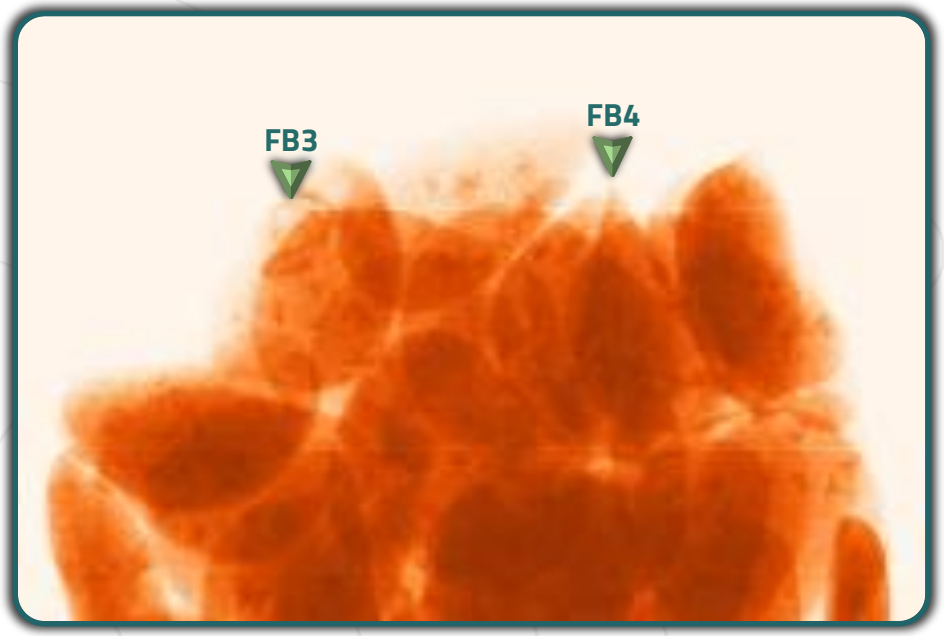


Sample #1 (2/2)

FB3



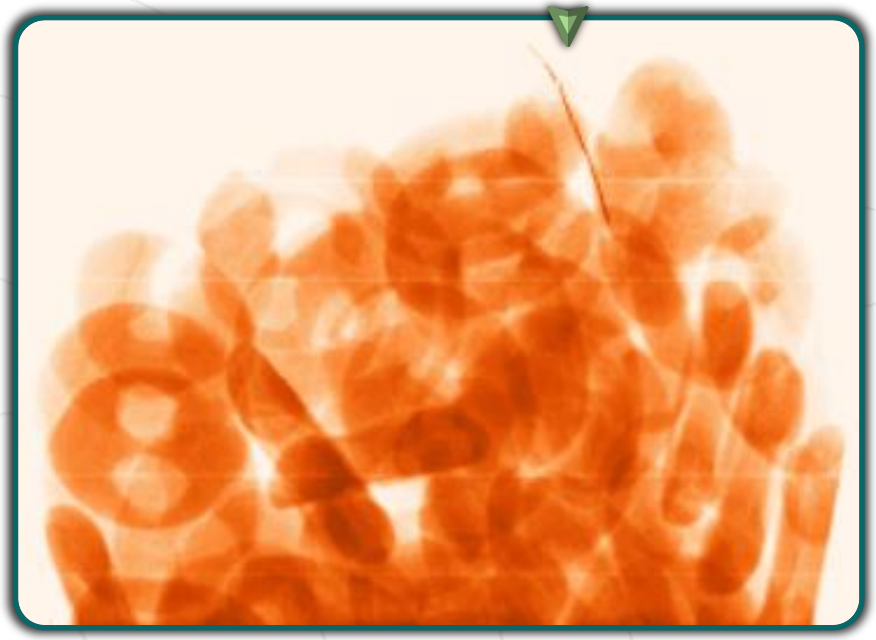
FB4



Sample #2

FB5

FB5



Sample #3

FB6

High-density contaminants have also been included in the same package:

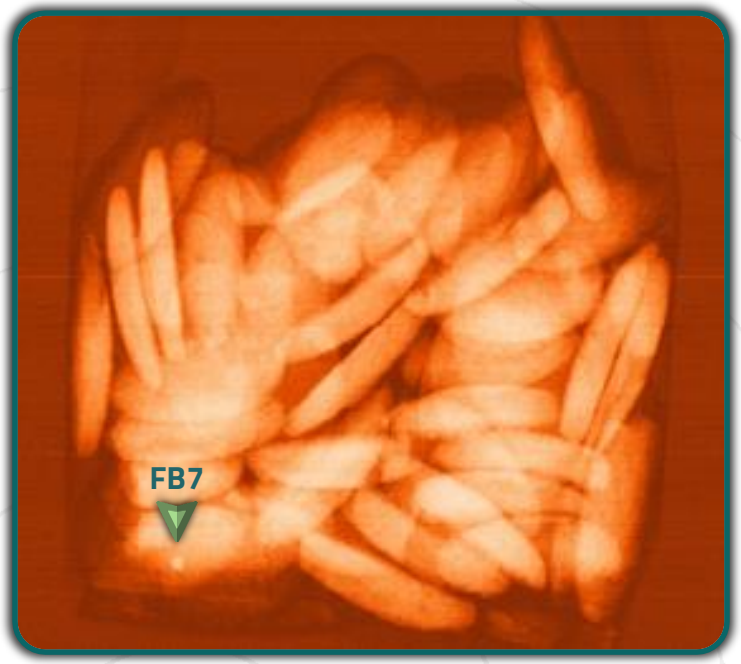
- A paper clip
- A bronze bushing
- A stainless-steel hex nut

To provide evidence that any high-density foreign bodies would be easily detectable.

Sample #4

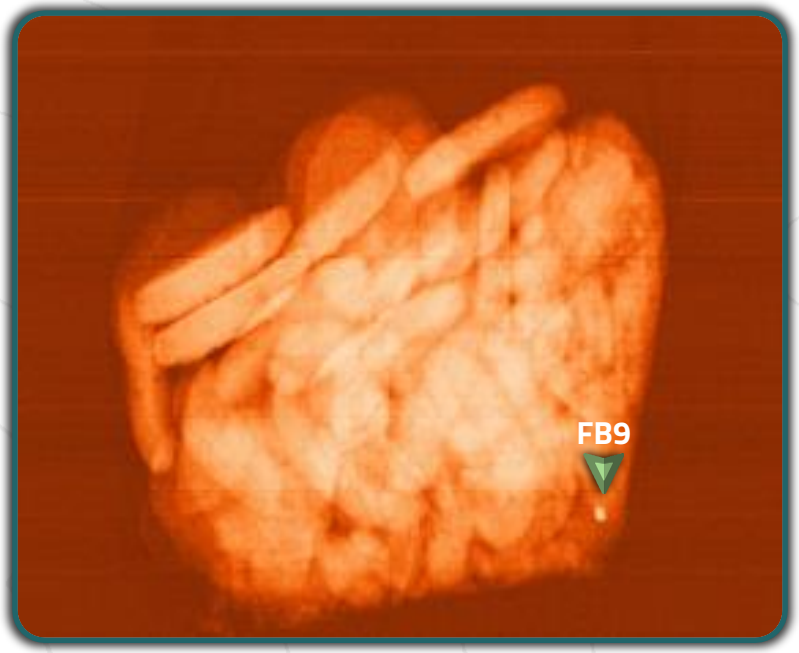
FB7

FB8



Sample #5

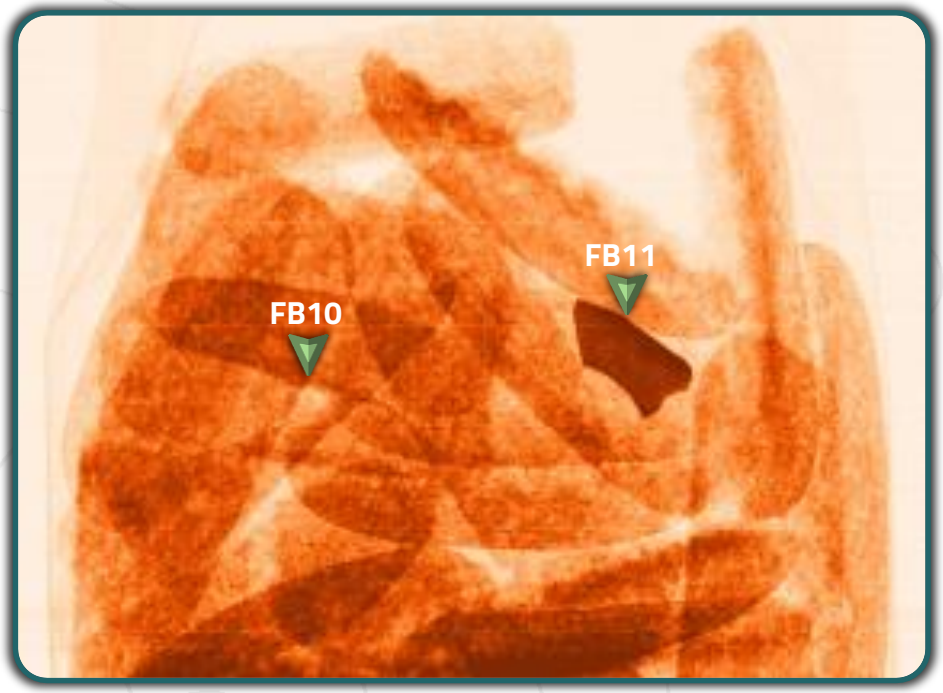
FB9



Sample #6

FB10

FB11



Comments on the results

We deliberately did not use high-density foreign bodies (e.g. ferrous and non-ferrous metals) and focused mainly on a set of low-density contaminants (most of them from 1.25 g/cm^3 down) that are difficult if not impossible to detect with conventional X-ray systems.

In order to make all the main contaminants always clearly detectable by the system, **it is necessary to integrate the performance of the detector with a set of dedicated detection algorithms, which take into account the specific features of the combination Product-FB**. As already mentioned in the background of the testing, these results have been achieved by simply exploiting the accuracy of the XSpectra® Detector.

The moment we have a consistent number of products available for inspection and also having access to the processing line, to perform a field test, we will be able to adapt the detection algorithms to the specific needs and requirements of the customer and offer a high accuracy level in identifying contaminants that at present conventional inspection systems cannot detect.

Final remarks

Although the results achieved are already remarkable, when compared to the performance of a conventional X-ray inspection system, there is room for further improvement that could be achieved through:

- the use of XInspector automatic detection software, developed for this specific application;
- a geometric configuration of the system optimized for the product features

XInspector is a self-learning software, which means that the performance and efficiency increase as the statistical data acquired during the inspection of contaminated/non-conforming products increase. Like any AI software, the more it learns to recognize product non-conformities, the more efficient it becomes.

In relation to the above, once installed on the processing line, XInspector can achieve a continuous improvement of its accuracy.

In conclusion, we would like to emphasize the fact that the inspection system, both in its software and hardware parts, is continuously evolving. In particular, we periodically introduce technological upgrades as Xnext is primarily a technology innovator. This innovation will be made available to our customers.

About Xnext

who we are

Xnext is high-tech SME, a technology innovator with the ambition to revolutionize the quality inspection sector, overcoming the weaknesses of conventional solutions. A team of professionals made of data scientists, electronic and nuclear engineers, mathematicians and physicists, AI and software developers

what we do
(why we are so unique)

We perform a real-time (few milliseconds) chemical-physical analysis of the product to identify foreign bodies and defects or non-conformities not detectable by existing inspection technologies

how we do it

Thanks to XSpectra®, our patented technology. It is not simply innovative but rather disruptive as it performs a multi-energy analysis of the x-ray spectrum (up to 1,024 energy bands) and detects also low-density contaminants. Like no other, it is the result of a unique synergy between photonics, nuclear micro-electronics and Machine Learning software

XNEXT

ADVANCED INSPECTION TECHNOLOGY

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