TEST REPORT
X-ray inspection of Chicken Nuggets

Problem description

X-ray systems are ideal for inspection of packaged products and detection inside the parcel of a variety of possible foreign objects.

The low energy X-ray technology is particularly suitable for inspection of packaged products and un packaged products of small thickness and / or low density (low atomic number composition).

For packaged products, a great advantage is the ability to check the integrity of the packaging as well as positioning of product(s) inside the package. Also labels, sealing, etc can be assessed.

The InnospeXion HYMCIS X-ray scanners are built for in-line integration. The use of PLC as master of the HYMCIS control makes it easy to integrate a number of I/O functionalities, including alarms to different machinery along the processing line, sorting and grading auxiliary equipment, etc.

The products covered in this report are real samples (cf. Fig. 1):

-       800g Chicken Nuggets

Foreign objects in the form of 5 x 2 mm artificial soft bones (reference samples provided by the Danish Meat Research Institute) has been put atop of the product (not on all images as the samples contained natural bones itself, see below).

The products are inspected as packaged in boxes, as separate packaged bars and pouches, and as unpackaged products.

Inspection has taken place with the samples fed into a conveyor belt with and without positioning of selected foreign objects on top of the sample.

Fig. 1. The products covered in this report. Test samples of plastics, metals, glass and ceramics of various dimensions is placed on top of the products. The artificial foreign objects (reference soft bones provided by DMRI) have been placed atop the samples as noticed below

Inspection method

Fig. 3a. The Award-winning InnospeXion HYMCIS X-ray system (standard version), used in the assessment

Fig. 3b. The HYMCIS X-ray system is available for wide scanning (conveyors up to 1600 mm) and for applications requiring extensive cleaning using water jet and chemicals for disinfection (hygienic version, at right)

The products with and without impurities/foreign objects have been inspected using the InnospeXion HYMCIS low-energy X-ray systems.

For "large" boxes with >1 kg of product, the 15-40 kVp system is used. This system does not differ from the general systems except for a higher X-ray energy, and for a more robust conveyor tape suitable for the more heavy products.

The individual packages and the individual unpackaged samples have been inspected in the standard HYMCIS at a speed of 23 m/min, at an X-ray energy of 18 kV, 9 mA. The system has been operated in off-line (manual) mode, facilitating the acquisition of images. No specific sorting and/or automatic detection has been implemented.

The X-ray system is ultra compact, and based on the newest and most effective X-ray detection technology. This involves high stability, long life X-ray source, closed water cooling system, detector with 0.1 mm resolution, PLC master configuration, etc. Maximum conveyor speed at optimal detection settings is about 0.5 m/s. In the present set-up, a detector width of 220 mm has been used. This is just at the limit relative to the product dimensions, at least for the large boxes.

Maximum sample height for the 15-25 kV system is 60 mm. Specific system details are available upon request.

Results - comments
Below are provided images of the products with foreign objects as described above. No specific image processing has been attempted, the pictures are solely converted from 16-bit TIFF to 8-bit JPEG format, and the contrast has been optimized to display the grey level range of interest. In some cases, two images are shown of the same X-ray recorded image, displaying for example the low density (LD) part of the image and the high density (HD) part. The latter will display the foreign objects which are usually darker than the product owing to a higher absorption of the X-rays (caused by a higher atomic number composition of the foreign object, or by a higher density, or a higher thickness).

Results

Contents of the bag scanned inside packaging
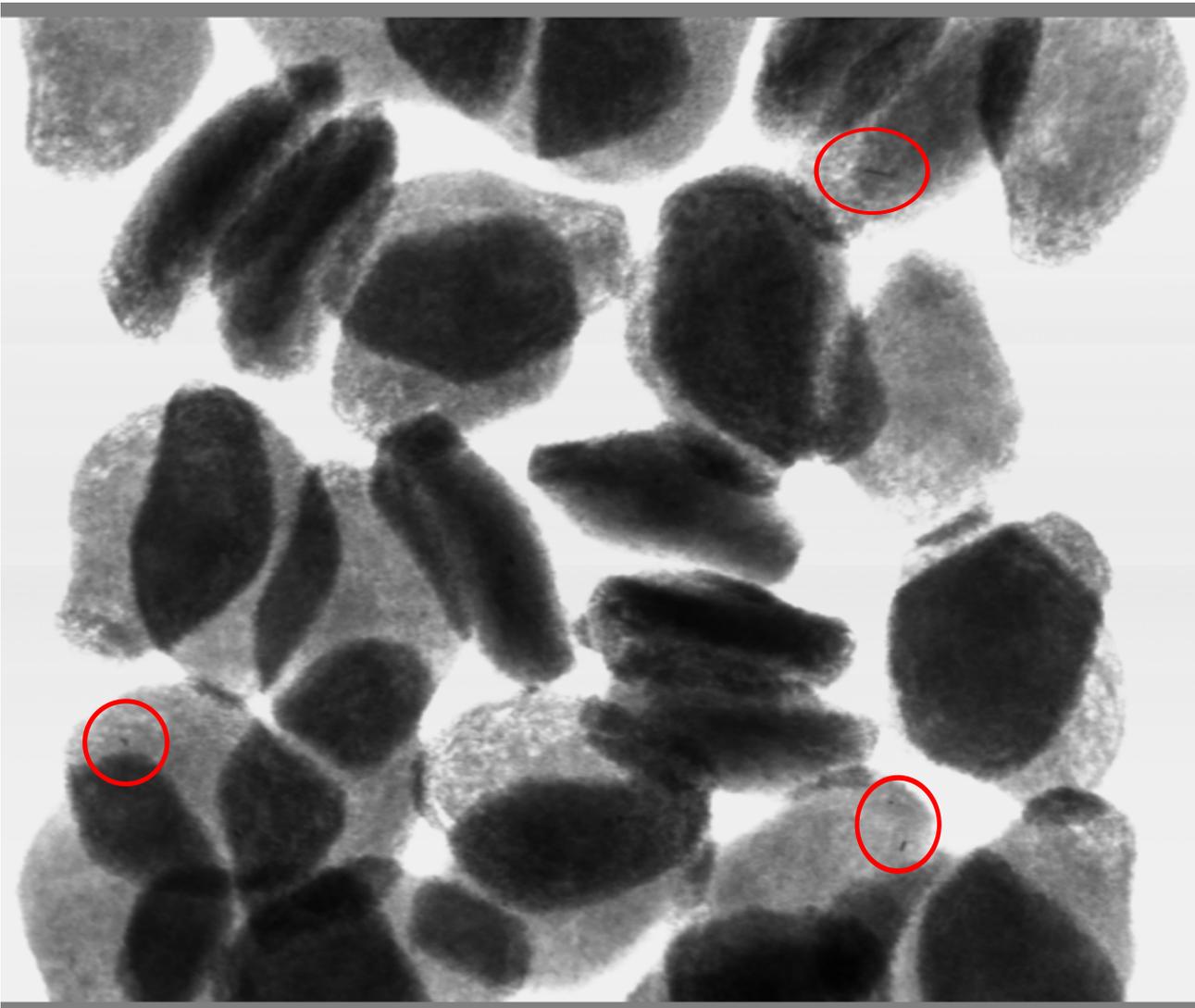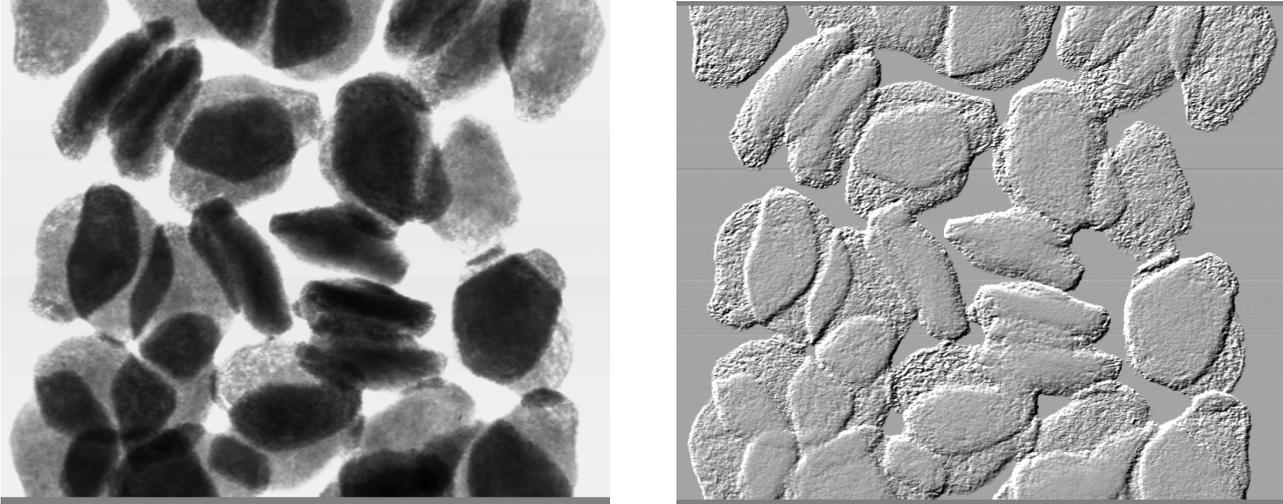
Figur 1: Tiny bits of bones are visible and have been circled with red rings in the image. No "artificial" bones have been added, the detected bones are in the product

Chicken Nuggets scanned in single layer (part 1 of 2)
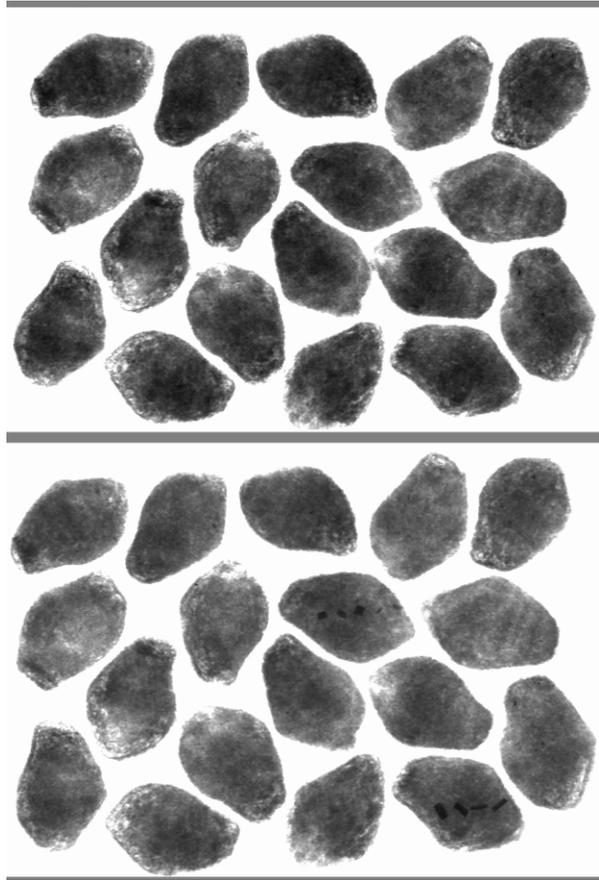
Chicken Nuggets scanned in single layer (part 1 of 2)
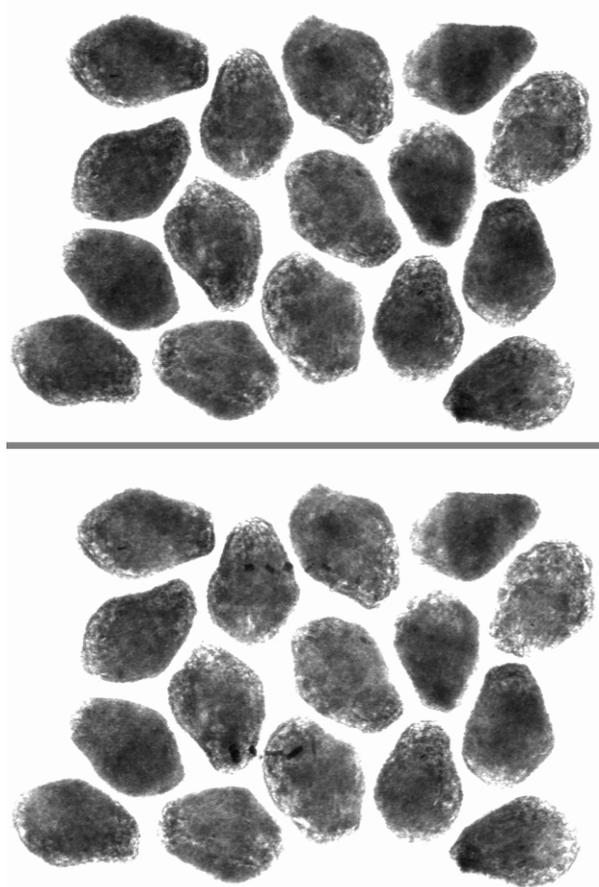
Quick bone-detection test (without correct settings)

The image shows that the majority of soft bone (artificial) are detected, at dimensions down to about 1-2 mm.

Discussion

The results unveils the capability of the low X-ray energy technology to detect even small and thin foreign objects in the considered range of products. It also allow the assessment of the packaging around the product, i.e. its integrity, positioning, etc. If the product is enclosed in plastics which may have welds (seals), these welds may in most cases be assessed as well.

When evaluating the detection capability for foreign objects, it is necessary as well to evaluate the possibility that natural variations within the product may give rise to irregularities that may be allowed for. The automatic detection algorithm has NOT been optimized for the product, however it is not a problem to detect soft bones down to 5 x 2 mm (cylindrical shaped).

Low energy X-rays provides much sharper images, of higher contrast. Thereby, they enable a better and more straightforward automatic detection. The low energy X-rays also stipulate much smaller radiation levels and they are intrinsically safer compared to conventional X-ray systems. They use less electrical power, and does not include any lead.

Notes

The InnospeXion low energy X-ray scanner is available in a number of tailored versions, specifically suited to specific tasks concerning overall interfacing, design of conveyor, conveyor attachment to existing production line and integrated software with TTL-based triggering for ejection and sorting. The system is available as stand-alone units or as completely integrated PLC controlled systems operating in automatic, self-regulating mode.

The softbone provided by DMRI have Hounsfield densities of 400 and 500 respectively.

Please contact InnospeXion or your local representative for further information.