WHITE PAPER:

DETECTING GLASS PARTICLES IN GLASS JARS OF BABY FOOD

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Abstract

IBEX technology has been successfully demonstrated in detecting glass beads down to 1 mm in diameter in glass jars of puréed baby food in a standard X-ray imaging system using a conventional X-ray detector. Such contaminants present little or no contrast in X-ray absorption, a technique widely used in food safety inspection, making them very difficult to detect. By applying IBEX MAP (Multi-Absorption Plate) technology to recover energy-dependent information in a single image acquisition from a standard X-ray detector with the X-ray source working at a single peak kV, images are generated based on contrast between the materials, rather than from a combination of thickness and density. Contaminant fragments can then be highlighted by their material difference from normal product.

There are no inherent barriers to applying this technology at speeds compatible with food processing lines.

Introduction

Food safety is obviously very important, and infants are at particular risk if their food is contaminated.

Glass jars running through a production line occasionally get chipped, potentially leaving small fragments of glass in the contents of the jar. These are a health hazard, particularly to a baby, and such fragments are not necessarily easy to spot visually on spooning out the contents, since glass is optically transparent, while the food is generally opaque. Identifying and rejecting contaminated or damaged jars of baby food before they leave the factory is a critical step in the quality assurance process.

X-ray inspection systems are used routinely in the food industry to monitor product quality. However, low -density contaminants such as glass and plastic in food are difficult to detect, since there is little or no X-ray absorption contrast between the contaminant and the food product. IBEX technology brings the contaminants to light by recovering energy-dependent information from conventional X-ray detectors in images collected at a single source kV setting. This leads to differentiation between materials directly, independent of their thicknesses or absorption contrast, since their X-ray attenuation characteristics are a function of energy.

The capability of IBEX technology to detect glass beads down to 1 mm in diameter in glass jars of puréed baby food in a single-energy X-ray imaging system has been demonstrated. There are no intrinsic obstacles to applying this technology on a production line.

Multi-Absorption Plate (MAP) Technology

IBEX MAP (Multi-Absorption Plate) technology modulates the X-ray spectrum reaching the detector in a regular manner across its surface. This gives access to energy-dependent signals which enable materials information to be extracted, rather than combined density-thickness information. In addition, sophisticated mathematical models are used to

detect subtle contaminants in repeatable products such as chocolate bars or jars of baby food. IBEX technology is described in detail in our White Paper, available from the Resources page of our website.

Experiment

Samples were measured using an in-house, fixed cabinet X-ray system fitted with a conventional, low-power, tungsten-target X-ray source running at 160 kV, 0.5 mA (80 W). Given this low power compared to typical inspection systems, the total integration time per image was 7.5 s (3.75 mAs) in order to give high signal-to-noise within this test. (This time would be much reduced on a production tool). The detector was a Rayence 1417 WGA CMOS flat-panel detector equipped with an IBEX Multi-Absorption Plate (MAP). Jars were mounted by hand against an alignment jig.

First, 20 glass jars of puréed baby food, all the same variety, were measured. The images analysed in order to build the mathematical model of normal product, including the acceptable variation within "normal", and to train the analysis system in the materials

Figure 1: Left: one of the jars of puréed baby food used in the trial. Right: glass beads deliberately introduced as contaminants.

"signatures" of the baby food and jar. Sample images were corrected for flat-field and dark-field prior to IBEX materials analysis.

Five additional jars were deliberately contaminated with glass beads 1 mm, 2 mm and 3 mm in diameter placed in the bulk of the baby food (Figure 1). These were then measured along with a further 14 uncontaminated jars, in random order, in the test run.

Results and Discussion

Besides low/no absorption contrast between the glass bead contaminants and the baby food in glass jars, a particular challenge in this case is that the shape of the sample varies slightly between samples. The shape of the meniscus of the contents is not constant; neither are the details of the shape of the glass jar and its local thickness. These variations must be recognised within the model of "normal", whilst retaining sensitivity to deviations from normal caused by contaminants.

Using IBEX materials contrast technology, the glass contaminants stand out well against the puréed baby food, despite some local variations in jar thickness. All five contaminated samples were correctly identified, with a clear, quantitative distinction between contaminated and uncontaminated jars. An example is shown in Figures 2 and 3. Figure 2 shows the absorption contrast image, generated by stripping out the effect of the MAP. It is hard to see the glass bead contaminants in this image. Figure 3 shows an example with the contaminants identified using IBEX

Figure 2: Absorption contrast image of a contaminated jar of baby food. The glass bead contaminants are barely visible. The pale rectangle in the bottom left of the image comes from the alignment jig used in this test where the samples were positioned manually.

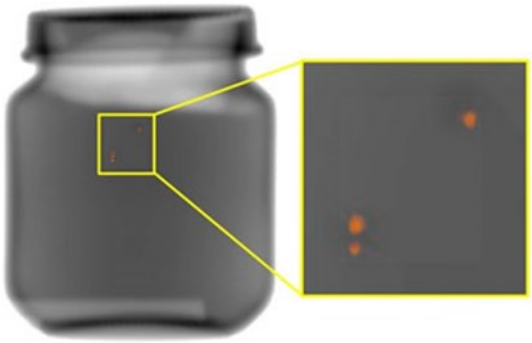

Figure 3: IBEX materials technology detects the contaminants. Here, they are highlighted in orange overlaid on the MAP-stripped absorption contrast image.

materials technology, highlighted in orange overlaid on the absorption contrast image.

In this demonstration of capability, there were no false positives and no false negatives. Images of all 19 test jars, with contaminants highlighted, are shown in Figure 4.

Figure 4: MAP-stripped absorption contrast images of all 19 jars in the test set. The glass contaminants were successfully detected in the five contaminated jars. These are framed in yellow with the contaminants themselves highlighted in orange.

Contaminant detection based on IBEX materials technology delivers a measure of "contaminant significance" for each sample. The values for uncontaminated samples are scattered around some mean value, while values for contaminated jars are markedly different (Figure 5). This allows a threshold to be set to discriminate between contaminated and uncontaminated jars, as a pass/fail criterion in a production environment.

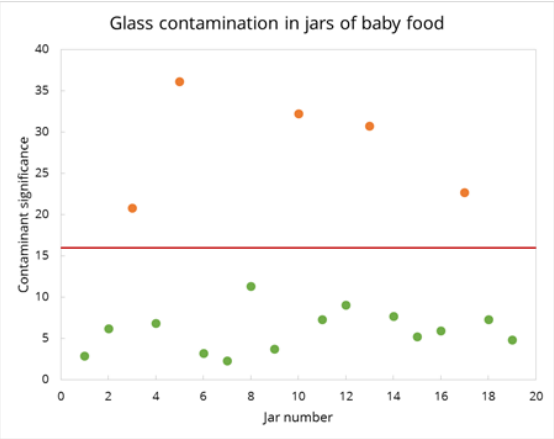

Figure 5: Quantitative measures of "contaminant significance" enable thresholding in a production QA environment. This test showed clear differences in this measure between contaminated and non-contaminated samples.

Conclusions

In a demonstration of capability, IBEX materials contrast technology successfully identified five jars of baby food deliberately contaminated with glass beads from a test set of a total of 19 jars. The difference in the quantitative measure of "contaminant significance" between clean and contaminated jars opens the possibility of pass/fail thresholding in a production environment. There are no inherent barriers to this technology being applied at production-line speeds and it may be used with flat-panel or line detectors.

See more IBEX white papers and other resources by visiting our website, www.ibexinnovations.co.uk.

About IBEX

IBEX Innovations Limited was created in 2010 to develop and commercialise an innovative X-ray detector technology.

IBEX is based in modern facilities on the NETPark Science Park in the North-East of England, where it employs a team of highly skilled scientists, engineers and business professionals.

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