SHIMADZU
Excellence in Science

Application News

Microfocus X-ray Inspection System Xslicer™ SMX-1020
Microfocus X-ray CT System inspeXio™ SMX-225CT FPD HR Plus

Foreign Object Detection in Food and Inspection of a Plastic Bottle's Sealing Condition Using X-ray Fluoroscopy and Computed Tomography Techniques

Satoshi Iguchi

User Benefits

- 2D X-ray fluoroscopic inspection can be utilized for fast detection of foreign objects in food packages, ensuring quality control.
- X-ray computed tomography(CT) can pinpoint the 3D locations of foreign objects food products, aiding in their removal or mitigation.
- Leakage and deformation inspections of plastic bottles can be performed non-destructively.

■ Introduction

To uphold food safety standards, preventing contamination by foreign objects during production is crucial, and numerous measures have been implemented. Despite these efforts, contamination can still occur. Identifying contamination, and thereby preventing the distribution of flawed products, can be accomplished using X-ray inspection equipment, which enables fast, non-destructive detection of foreign objects. This application news presents case studies micro-focus X-ray nondestructive techniques to examine purposely mixed foreign objects in food products. A 2D X-ray inspection system, Xslicer SMX-1020(Figure 1), and an X-ray computed tomography system, inspeXio SMX-225CT FPD HR Plus(Figure 2), were used. Additionally, this application presents a case study analyzing the fitment of a plastic bottle cap before and after opening.

Figure.1 Microfocus X-ray Inspection System Xslicer™ SMX-1020

Figure.2 Microfocus X-ray CT System inspeXio™ SMX-225CT FPD HR Plus

■ Detection of Foreign objects in Food using X-ray Fluoroscopy

Foreign objects can be either those included in the raw materials or those introduced during the manufacturing process. In this example, a pebble was added as a foreign object in the raw materials. Additionally, a piece of stainless steel, which in often used in filters and other equipment, was used as a foreign object introduced during the manufacturing process. A photo of the pebble and stainless-steel piece in shown in Figure 3. These objects were purposely incorporated into the boxed chocolate biscuits and a bread sample as illustrated in Figure 4.

Figure 5 shows 2D X-ray images obtained by the Xslicer SMX-1020 system using the panoramic imaging function, which can automatically capture multiple images of large samples and stich them together into a single image. The region of interest (a) indicates the position of the pebble, while (b) indicates the position of the stainless-steel piece. Bothe foreign objects are denser than the food and the packaging materials, resulting in greater X-ray absorption. For more detailed inspection, such as shape observation, specific areas of interest can be visualized at a higher magnification, as shown in Figure 6.

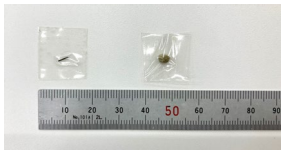
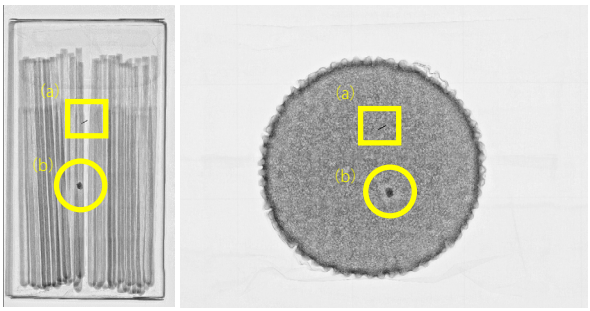


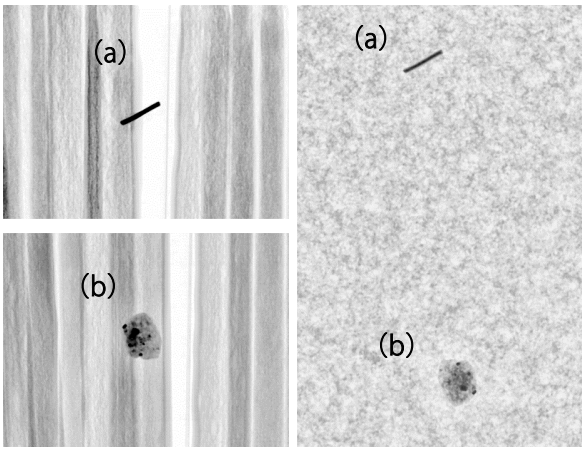
Figure.3 Foreign Objects Samples

Figure.4 Food Samples



Box Chocolate Biscuits Individually Wrapped Bread

Figure.5 2D X-ray Visualization Examples of Foreign Objects in the Food Samples



Box Chocolate Biscuits Individually Wrapped Bread

Figure.6 Enlarged Fluoroscopic Images of Foreign Objects in the Food Samples

■ Detection of Foreign Objects in Food using X-ray CT

While X-ray fluoroscopy can identify the presence and approximate vertical and horizontal locations of foreign objects in a food sample, it lacks depth information. In contrast, X-ray CT reveal the detailed locations of foreign objects with depth information. For example, Figure 7 shows images of the boxed chocolate biscuits obtained with the inspeXio SMX-225CT FPD HR Plus system. Furthermore, as depicted in Figure 8, X-ray CT technique enables volume and diameter measurements of foreign objects.

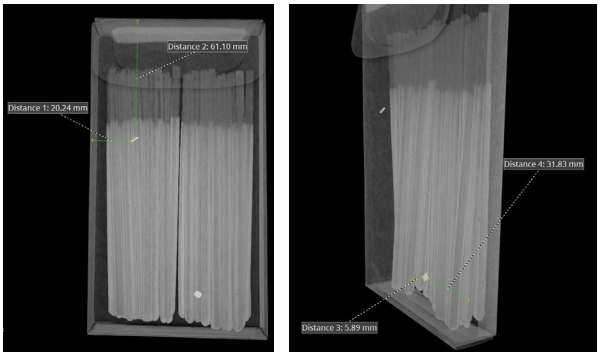


Figure.7 Examples of Foreign Object Localization Using X-ray CT Images

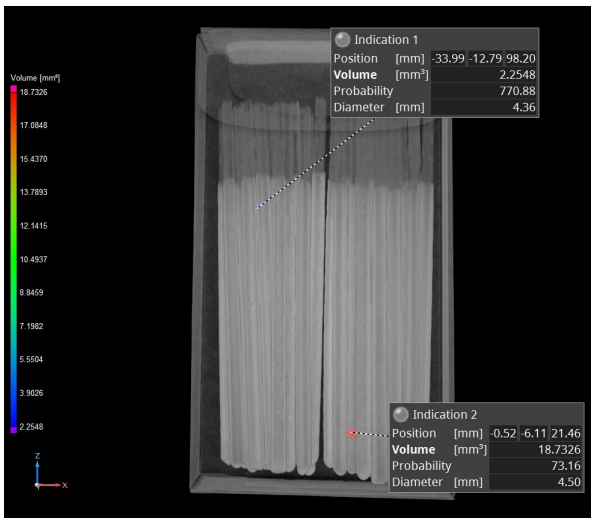


Figure.8 Example of Volume Measurement for Foreign Objects

■ Inspection of a Plastic Bottle's Sealing Condition

Figure 9 depicts a plastic bottle containing tea. In the context of beverage packaging, it is crucial for plastic bottles to remain sealed to preserve product integrity. This study focused on examining the structural integrity of the sealing mechanism of plastic bottle caps and fitment alterations before and after the cap was opened. Figure 10 displays 2D X-ray images of the top the plastic bottle before the cap was opened. These images reveal the thread engagement between the cap and the spout, preventing tea leakage. The more detailed sealing structure is revealed in the CT images along the user-defined cross-sectional planes, as shown in Figure 11.

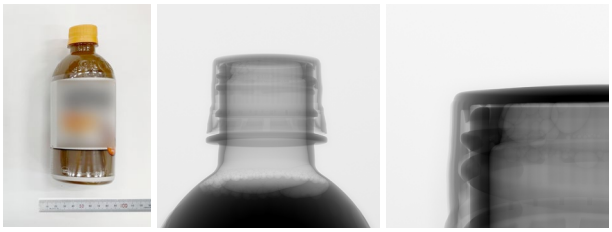


Figure.9 Plastic Bottle Sample

Figure.10 Fluoroscopic Images of Plastic Bottle

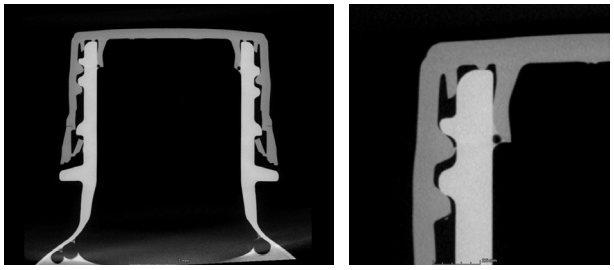


Figure.11 CT Slice Images of Plastic Bottle

Figure 12 illustrates a three-dimensional comparison between the fitting conditions before and after opening the cap. The CT data obtained before opening the cap served as the reference data. The data obtained after opening and re-tightening the cap were than aligned with the reference, and the resulting displacement was visualized using color cording. Although no significant alteration was observed in the vertical direction, a deviation of approximately 0.4mm was noted in one direction.

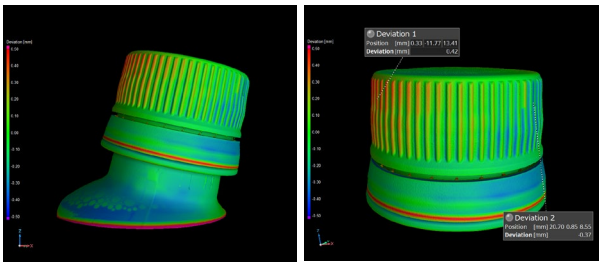


Figure.12 Three-dimensional Comparison Between the Fitting Conditions Before and After Opening the Cap

■ Conclusion

X-ray fluoroscopy can visualize foreign objects in food and estimate their positions. X-ray CT can identify more precise positions, visualize shapes, and measure the volume of foreign objects in three dimensions. These techniques improve production inspections, Ultimately leading to better quality control and safer products. These technologies can also be used to confirm the structure of containers for food and beverages. By inspecting the sealing conditions, it is possible to visualized the presence of liquid leakage, as well as fitment alterations before and after opening the container.

01-00598-EN First Edition: April. 2024

SHIMADZU
Shimadzu Corporation
www.shimadzu.com/an/