Advanced X-Ray Inspection Techniques for Electronic Devices

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Introduction

Bak USA manufactures laptops and tablets for educational and not-for-profit organizations. Their socially conscious business model and commitment to manual product assembly not only provides local jobs but also facilitates visual inspection, leverages innate human dexterity, and provides employees with a sense of ownership. While Bak USA's rugged Seal 8 tablets are well-suited to extreme climates and environments such as field service for the construction industry, the ruggedized nature of these devices makes them difficult to disassemble and examine during failure analyses. This challenge drove Bak to explore alternative nondestructive evaluation (NDE) solutions such as x-ray computed tomography (CT) and digital radiography (DRT).

Bak requested EWI's assistance in determining whether CT and DRT could be used to identify a range of common assembly issues. EWI analyzed a Seal 8 model with manufactured defects representative of the most common issues seen during quality checks, as well as a defect-free device for comparison.

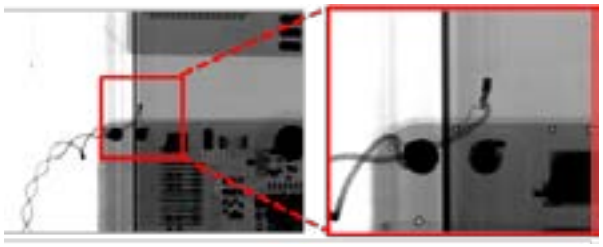

Figure 1: Dislodged solder connection

Figure 2: Disconnected coaxial cable

X-Ray Vision for Quick and Easy Problems

Digital radiography (DRT) is an x-ray imaging technique in which a single radiological image is taken digitally. Using EWI's Nikon XTH 225, DRT was used to quickly identify obvious and large missing components. For example, a connector was dislodged at the solder point, as shown in Figure 1. These kinds of defects are easily spotted and usually require only one image. However, less quantifiable issues such as semi-secured connections required DRT images from different angles and close-ups to fully validate the problem. For example, an additional DRT image was required to determine that the coaxial cable was not fully engaged with the connector of the Wi-Fi module, as seen in Figure 2. These DRT images were taken using EWI's 180 kV transmission X-ray source with resolution of up to 1 micron.

DRT can be used for quick identification of quantitative issues and some qualitative issues. Leveraging the machine vision analysis expertise of EWI's automation group, DRT presents a viable option for automated feature identification during final inspection. However, certain issues such as paper-thin features and non-metallic materials are not visible using DRT. In these cases, CT was used.

Going Beyond Digital Radiography

CT is an imaging technique which provides 3D x-ray images of external and internal components by fusing x-ray image information from multiple angles. In this case, CT provided more detail about previously detected assembly issues. Where DRT images showed only subtle contrast, the CT reconstruction process exposed new and distinct components and features. For example, Bak's design includes a thin gasket which is placed around the perimeter of the device to make a waterproof seal. This gasket can become twisted during assembly and the issue is unlikely to be detected during inspection. Since the gasket and the surrounding plastic polymer have similar x-ray attenuation, they are more difficult to differentiate using a single image. Figure 3 shows the area of interest, while figure 4 shows different planes of the scan, highlighting the misalignment caused by the twist. The blue box shows the plane where the gasket is comfortably fit into the U-channel. The red box shows the plane where the gasket is narrower due to the twist, thus decreasing the waterproof capabilities of the device. As seen here, the benefits of CT are realized when detailed images are required for crucial failure forensics at a specific location.

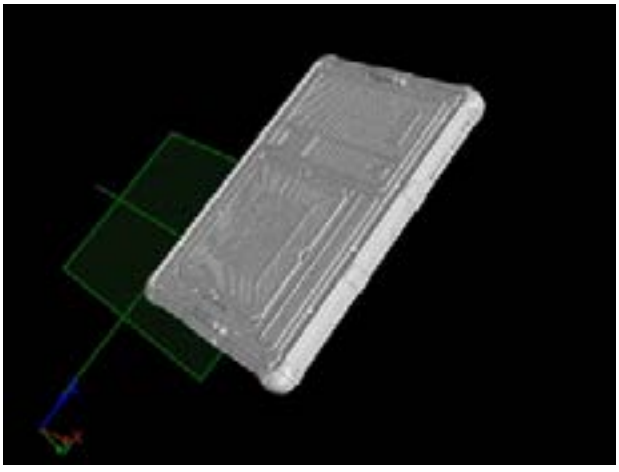

Figure 3: Area of interest of gasket cross-section

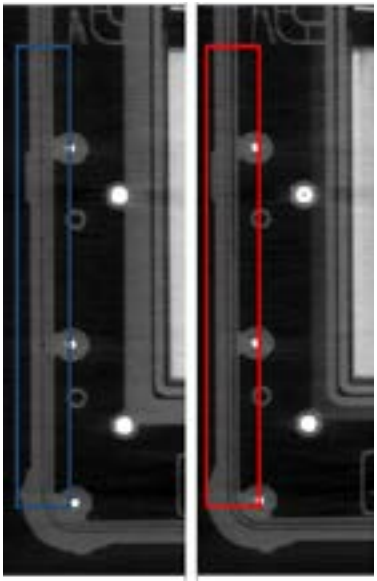

Figure 4: CT images of the twisted gasket in two planes

Choosing Between Digital Radiography and Computed Tomography

Table 1 below shows the types of defects that were identified using the two different inspection techniques. Defects are graded on a scale of 1 to 5, with 1 indicating that the defect type cannot be clearly identified and 5 indicating that the defect type can be consistently identified.

Defect Type	DRT	CT
Missing Components (>5mm)	5	5
Missing Components (<5mm)	3	5
Unsecured Connections	4	5
Thin Components (<1mm)	1	5
Non-Metallic Materials	2	4

Table 1: DRT and CT feature identification comparison

Compared to DRT, CT offers additional inspection capabilities such as the identification of small, thin components. It can also be used to identify a wider range of non-metallic materials. While CT was effective in identifying all of the potential assembly issues, long scan times prevent efficient integration into Bak's production quality control.

Conclusion

This technical feasibility study led EWI to conclude that the majority of assembly issues could be identified using a limited number of DRT images. While DRT isn't as effective with less quantifiable defect types, the assembly issues most commonly encountered by Bak were missing components. Through an increased understanding of the advantages and limitations of DRT and CT, Bak has now implemented effective failure analysis techniques designed to improve their quality control program.

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