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Application News

No. N133

Industrial X-ray Inspection Systems

Observation of Automotive Computer Using inspeXio SMX-225CT FPD HR X-Ray CT System

Introduction

Various electronic devices are installed in automobiles for use in performance- and safety-related control functions. Control by electronic devices also supports driving and a comfortable environment in the vehicle. With the increasing complexity of safety-related functions such as driving automation and erroneous start suppression function in recent years, higher performance in the electronic devices that control those functions has become an issue. From the environmental viewpoint, improved fuel combustion efficiency and optimum control of the engine depending on vehicle running condition are also demanded. These types of control are performed by electronic control units (ECU), also called "car computers."

Cars equipped with these electronic devices vibrate constantly while in operation, and are also affected by temperature changes due to the atmospheric temperature and heat from the engine and road. Normal operation is necessary even in this severe environment. Since reliability requirements are high, ECUs and other electronic devices are almost always enclosed in cases, but this means it is not possible to inspect the devices themselves from their external appearance. Thus, nondestructive inspection by X-ray techniques is required. This article introduces an example of observation of an ECU by using an X-ray CT system.

S. Iguchi

Observation of Car Computers (ECU)

Various sensors are installed in automobiles to enable normal operation even in difficult environments. ECUs contain many components that read information from sensors in order to optimize engine combustion efficiency and monitor and control the attitude of the automobile, temperature, tire air pressure and other important conditions so as to ensure safe travel. Control components with higher functions and performance have been adopted to realize higher safety and traveling performance. Use of stacked boards and higher density components by space-saving are also progressing so that these devices can be installed in the limited space of the automobile. In the past, components that were sure to operate were used from the viewpoint of reliability, even if their performance was low, but because recent compact, high performance components are now frequently used, high surface mounting technology is required, even in solder joints with boards. Although dedicated inspection equipment is used in operation-related electrical current tests, an X-ray fluoroscopy system has long been used to evaluate reliability due to changes in use conditions. Higher analytical accuracy is possible by using an X-ray CT system in these evaluations. Fig. 1 shows the Shimadzu microfocus X-ray CT system inspeXio SMX-225CT FPD HR, and Fig. 2 shows an image of the external appearance of an ECU , and Fig. 3 shows the fluoroscopic image of ECU taken with this system.

Fig. 1 Microfocus X-Ray CT System inspeXio SMX-225CT FPD HR

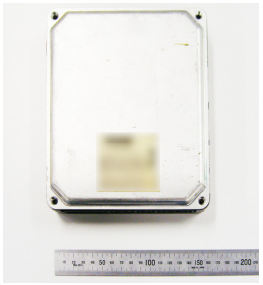

Fig. 2 Image of External Appearance of ECU

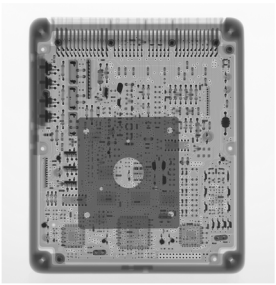

Fig. 3 Fluoroscopic Image of ECU

Because a 16-inch flat panel detector is used in the receiving section of the inspeXio SMX-225CT FPD HR, providing a maximum large field-of-view of approximately 300 × 300 mm, the entire ECU can be shown in a single image. This makes it possible to check for missing and damaged terminals and components and large bending of parts. The position of the board can also be observed, making it possible to check for contact between the board and parts and the ECU case.

Observation of the interior of parts and more detailed observation of the solder condition of joints is also possible by increasing the magnification ratio. Fig. 4 is a fluoroscopic image of the area around an IC taken by magnification radiology. Here, the internal wiring in the IC and the solder joints can be observed. Voids in solder joints with the board can also be confirmed by further enlargement of the solder joint area (Fig. 5).

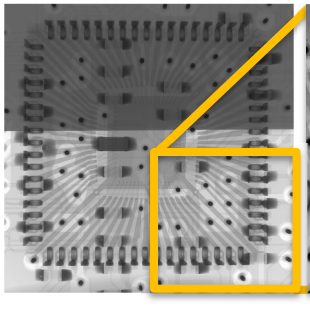

Fig. 4 Fluoroscopic Image of IC Part

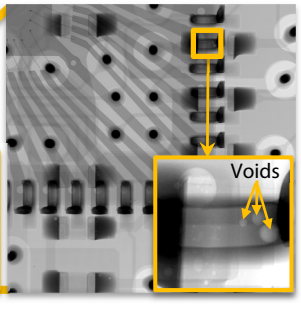

Fig. 5 Fluoroscopic Image of Solder Joint

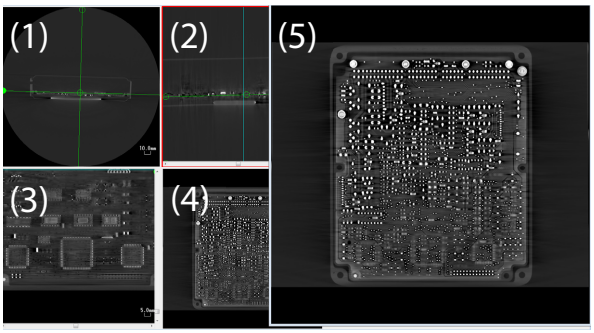

Fig. 6 MPR Images of ECU

Next, a CT image of the entire ECU was taken, and Multi Planar Reconstruction (MPR) images were generated as shown in Fig. 6. MPR is a function that arranges recorded CT images in virtual space and displays the images of arbitrary cross sections. As shown here, it is possible to display the CT image, as seen in (1), cross-sectional images orthogonal to (1), as in (2) and (3), and also cross-sectional images from any arbitrary angle, as in (4). Since enlargements of the necessary section images can also be displayed, detailed checks and observation are possible. In these MPR images, (1) shows a cross section near the center of the ECU, and (2) and (3) are the vertical and horizontal orthogonal sections from the section in (1). (4) shows the board surface from the section in (2). It is also possible to enlarge arbitrary section images, as shown in (5). Because CT imaging shows higher density areas in white, solder joints, electronic components, and the wiring of the board appear whiter. Thus, it is possible to confirm the presence or absence of parts and solder from this general image.

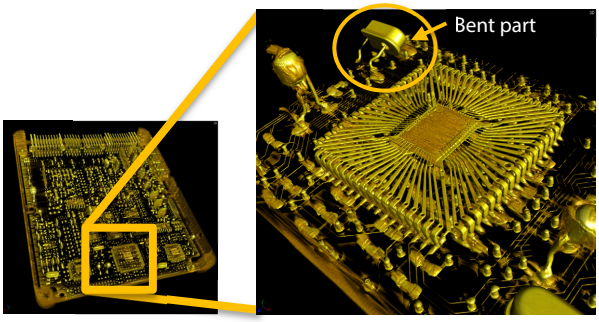

Fig. 7 Enlarged VR Image of IC

A Volume Rendering (VR) of the CT image can be displayed by using the 3D software VGSTUDIO MAX (Volume Graphics GmbH), and bending of parts and terminals and the presence or absence of parts on the back side of the board can be observed in 3D by observing a shape closer to that of the actual object. It is also possible to check the wiring and solder joints of terminals and small parts inside ICs by partially-enlarged CT imaging (Fig. 7).

Next, Fig. 8 shows an enlarged VR image of connectors connecting automotive wiring. Although solder joints are used at many of the terminals, voids in the solder (if present) may coalesce and develop into cracks due to the effects of vibration and thermal expansion.

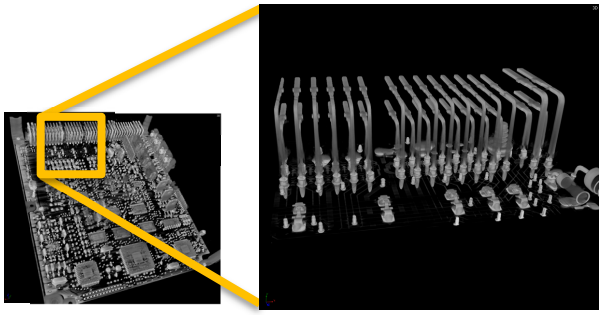

Fig. 8 Enlarged VR Image of Solder Joints

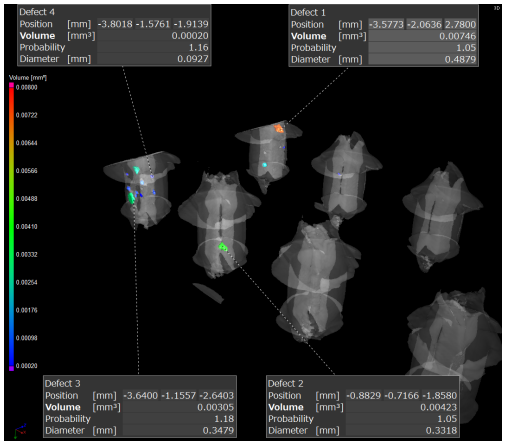

Fig. 9 Analysis of Voids in Solder

Individual voids can also be visualized, and their positions, volumes, and surface areas can be quantified by using an optional function of VGSTUDIO MAX (Fig. 9). While this feature can be used to check for the occurrence of voids, it is also useful also for improving production efficiency, for example, improvement of yield, by ascertaining the condition of defects from various types of quantified information and adjusting the reflow conditions accordingly.

Because the X-ray CT system is a nondestructive technology, it is possible to perform vibration tests, thermal shock tests, and other cycle tests with the same product and observe the internal state in each stage of the test. It is also possible to reduce the number of tests and the number of units of each testing device. Moreover, since the X-ray CT system is useful in analysis of the destruction process and reduces development time and the number of samples required, it is also effective for reducing costs and speeding up work.

Conclusion

The inspeXio SMX-225CT FPD HR enables observation and analysis of assembled products without disassembly. Because it is possible to change production conditions and compare products before and after various types of tests, it is useful not only in production processes, but also in development processes.

Various types of analysis are possible by using software suited to the purpose, and applications are not limited to investigation of product defects, but also include study of production processes and comparison of the same samples before and after tests.

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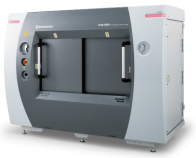

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