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Application News

No. N135

Industrial X-ray Inspection System

Example of Observation of Power Inductors Using inspeXio™ SMX™-225CT FPD HR Plus X-ray CT System

Introduction

Responding to the environmental impacts of energy consumption and higher fuel prices, energy saving has become an issue in various fields in recent years, and new designs that realize higher performance and higher functionality have been demanded in components used in products. Improved component performance is also expected to realize space saving and reduced electric power consumption. Among the inductors (coils) necessary to achieve low power consumption, this article introduces an example of nondestructive observation of the internal parts of electronic components called power inductors using a Shimadzu X-ray CT inspection system.

S. Iguchi

Features of Power Inductors

Inductors are electronic components that are made of coiled copper wire and are capable storing electrical energy. Because they are used to stabilize the electrical currents that flow on mounted boards, they are a necessary part of electronic circuit design. A wide variety of shapes and structures are used. Some types have a structure that allows inspection of the copper windings of the coil from outside, while others are chip-shaped. The chip-shaped type includes devices with a drum sleeve structure and devices with a sleeveless structure. In the drum sleeve type, the copper wire is wound on a core and the interior can be inspected from the two sides of the component. The sleeveless type also has copper windings on a core, but the internal part cannot be inspected because the copper wire is coated with a resin containing intermixed magnetic particles (magnetic resin). Because the condition of the copper windings cannot be inspected from outside, sleeveless devices are inspected with an X-ray fluoroscope or an X-ray computed tomography (CT) system in the nondestructive inspection.

Observation of Power Inductors

The Shimadzu inspeXio SMX-225CT FPD HR Plus X-ray CT inspection system (Fig. 1) is equipped with a 16 inch flat panel detector in the detection section and has a maximum CT image capture field of approximately φ400 × 300 mm, making it possible to capture images of an entire mounted board. However, magnification imaging is necessary for detailed observation of the power inductors mounted on boards, as many of these inductors are miniature devices. Here, the power inductor parts (Fig. 3) were cut from a mounted board product (Fig. 2), and an X-ray CT scan was conducted to investigate their detailed structures.

In Fig. 3, (1) is a drum sleeve type power inductor, and (2) is a sleeveless type.

Fig. 1 inspeXio™ SMX™-225CT FPD HR Plus Microfocus X-ray CT Inspection System

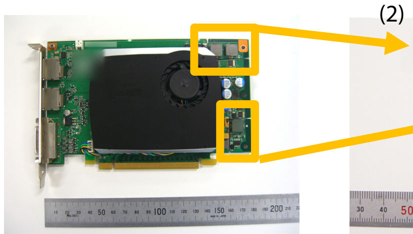

Fig. 2 Appearance of Mounted Board

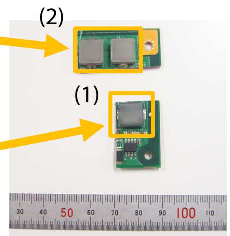

Fig. 3 Appearance of Power Inductors

Fig. 4 and Fig. 5 show CT fluoroscopic images of the power inductors with the drum sleeve and sleeveless structures, respectively. It can be understood that the drum sleeve type has an air gap around the coil and is open on the right and left sides. This construction is used to secure the necessary air gap for adjusting DC bias characteristics. In the sleeveless type, this air gap is not necessary because the magnetic resin around the coil plays the role of an air gap. Because an air gap is not necessary, downsizing is easy, and the device is not affected by humidity or vibration, since it is fixed by the magnetic resin. However, as a drawback of the sleeveless type, the resin coating may be cracked if excessive pressure is applied from outside.

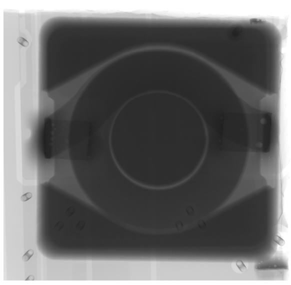

Fig. 4 Fluoroscopic Image of Drum Sleeve Type Power Inductor

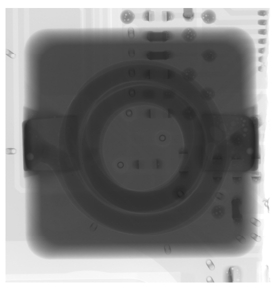

Fig. 5 Fluoroscopic Image of Sleeveless Type Power Inductor

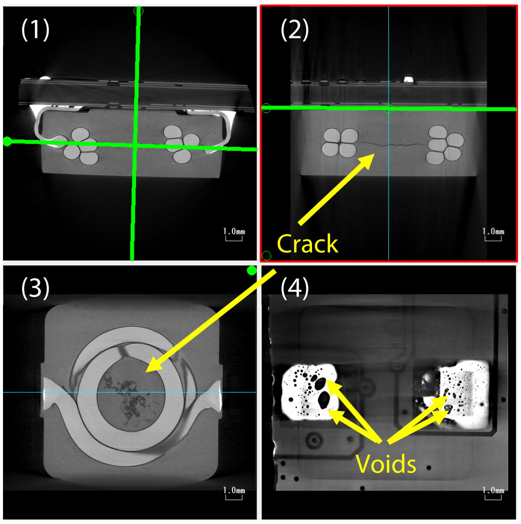

Fig. 6 MPR of Sleeveless Type Power Inductor

Next, Fig. 6 shows MPR (Multi Planar Reconstruction) displays of the CT scan results of the sleeveless power inductor. MPR is a function which makes it possible to display arbitrarily-selected cross-sectional images reconstructed from the images acquired in a CT scan. Here, (2) and (3) show cross-sectional images mutually orthogonal to CT image (1), and (4) shows a cross-sectional image at an additional arbitrary angle. Because higher density areas appear as brighter white areas in a CT image, the coil, which is made of copper wire, appears whiter than the magnetic resin. Furthermore, as indicated by the arrows in each view, a crack in the magnetic particle resin can be observed near the center of (2) and (3), and voids (air bubbles) can be seen in the solder connecting the power inductor and the board in (4).

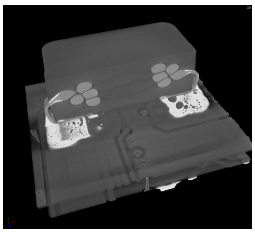

Fig. 7 VR Image of Sleeveless Type Power Inductor

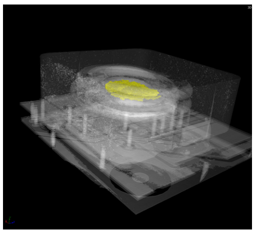

Fig. 8 Internal Crack in Magnetic Particle-Containing Resin

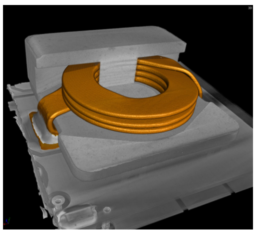

Fig. 9 VR Image of Drum Sleeve Type Power Inductor

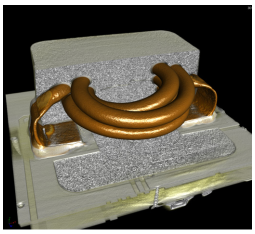

Fig. 10 VR Image of Sleeveless Type Power Inductor

For observation in a form even closer to the real object, VR (volume rendering) images of CT slice images can be displayed by using the 3-dimensional software VGSTUDIO MAX. This technique enables more detailed observation of the shape of the coil wire and the condition of solder connections with the board during mounting (Fig. 7). Since the crack shape and condition of crack propagation can also be observed 3 dimensionally by crack visualization, as shown in Fig. 8, analysis when production abnormalities occur and study of nonconformities generated in manufacturing processes are also possible.

Among other applications, it is possible to extract only the coil part, as illustrated in Figs. 9 and 10, and observe the winding condition. Deformation of the coil wire can also be checked by comparison with normal product data.

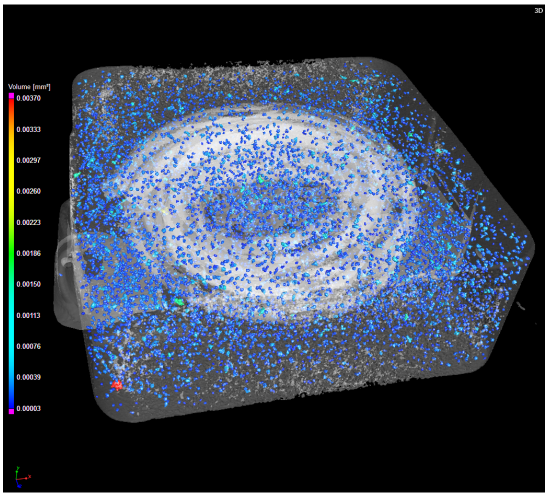

Fig. 11 Analysis of Voids in Magnetic Resin of Sleeveless Power Inductor

Air bubbles (voids) in the magnetic resin can be visualized, and their positions and volumes can be quantified by using an optional function of VGSTUDIO MAX (Fig. 11). Since this technique is not limited simply to checking the condition of void occurrence, but can also be used for an in-depth investigation of the occurrence of defects based on various types of quantitative information, it is useful for improving production efficiency, for example, by changing the magnetic particle resin blend and filling conditions to increase yield.

Conclusion

Because the Shimadzu X-ray CT inspection system enables nondestructive observation of the internal parts of products, it can be used to observe the progress of the internal condition of the same product in each stage of a test when conducting cyclical tests such as vibration tests and thermal shock tests, and as a result, it is possible to reduce the number of tests and labor required. Besides its usefulness in process analysis of product failure, the X-ray CT system is an effective tool for shortening product development time and reducing costs by reducing the number of samples.

In addition, various types of analyses are possible by using software suited to the specific purpose.

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