Application News

No. N127A

Industrial X-Ray Inspection System

Observation of Automobile Ignition Coil Using X-Ray CT System

Introduction

Environmental concerns and carbon-dioxide reduction have come under focus with the global warming phenomenon, and features such as the start-stop system that prevents automobile engines from idling and reduces gas emissions at traffic lights are becoming more common.

Because the start-stop system used in automobiles increases the number of times an engine is switched ON and OFF, it also increases the load on a variety of automobile components. One of these components is the ignition coil that creates an electric spark in the spark plug to ignite fuel when starting the engine and when the engine is running. Improvements must be made to the ignition coil to increase its durability and reliability. We present an example use of the inspeXio™ SMX™-225CT FPD microfocus X-ray CT system to observ the internals of an ignition coil.

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

Ignition Coil Observation

Several tens of thousands of volts are needed to create an electric spark from a spark plug and ignite the fuel in an automobile engine. While the spark plug provides the spark that ignites gasoline, it is the ignition coil that provides the high-voltage electricity to the spark plug needed to produce the spark. An ignition coil is a transformer that operates based on the principle of an induction coil. It uses a coil of wire and an iron core to generate a magnetic field, and boosts the 12-volt electricity provided by the battery to around 30,000 volts, which is then delivered to the spark plug.

Ignition coils have a primary coil and a secondary coil that differ in wire diameter and number of coils. Problems that can occur at ignition coils are poorly soldered joints at terminals, and voltage fluctuations arising due to improperly wound coils. The coils themselves are resin-sealed against dirt and water ingress, which makes X-ray imaging an effective method of observation.

Fig. 3 is a fluoroscopic image of the ignition coil shown in Fig. 2.

Fig. 2 Ignition Coil Appearance

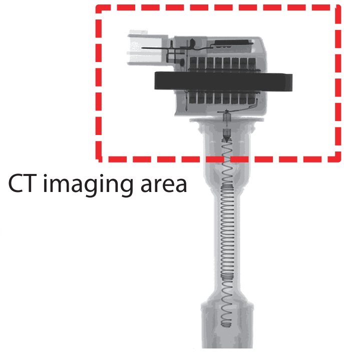

Fig. 3 Fluoroscopic Image of Ignition Coil

CT scan images of the portion of the ignition coil that contains the coils and iron core are shown in Fig. 4. The fluoroscopic image (Fig. 3) provided information from a lateral view, while CT imaging can be used to observe sections of the ignition coil from many directions.

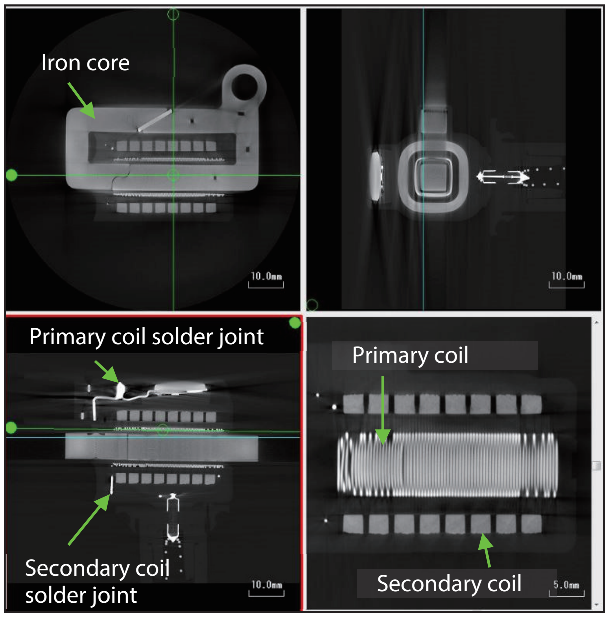

Fig. 4 CT Images of Ignition Coil

The imaging data obtained from these CT images is represented in three dimensions (3D) in Fig. 5.

Representing the sample in 3D in this way allows the observer to see inside the sample in a way that more closely resembles the arrangement of the actual sample.

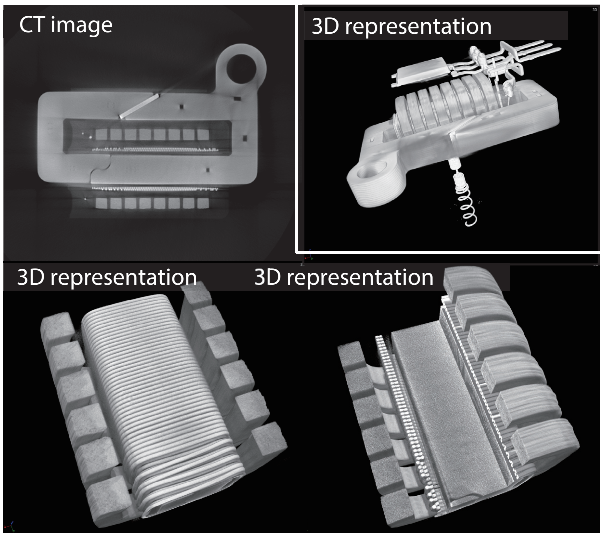

Fig. 5 CT Image and 3D Image Representations of Ignition Coil

Next, zoomed-in images of the areas where the primary and secondary coil wires are joined to the terminals are shown in Fig. 6 and Fig. 7. Magnifying the images enables observation of how the wires are coiled and connected to the terminals, and enables observation of solder voids (air bubbles). In particular, a small-diameter wire is used for the secondary coil (yellow arrows), and magnifying the image provides crisp images of this wire.

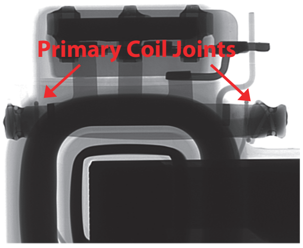

Fig. 6 Fluoroscopic Image of Primary Coil Joints

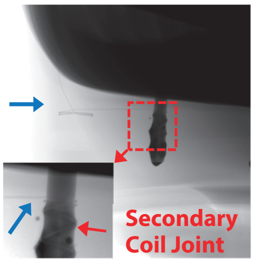

Fig. 7 Fluoroscopic Image of Secondary Coil Joint

Zoomed-in CT imaging was performed on the coil wires and joints, and 3D-representations of these images are shown in Fig. 8 (primary coil) and Fig. 9 (secondary coil). This enables confirmation of how the wires are coiled round and soldered to the terminals. The images show how there are 2 coils present in the secondary coil wire before it coils round the terminal.

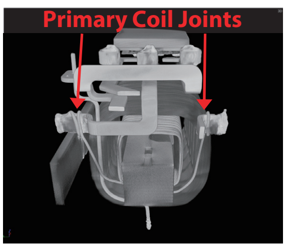

Fig. 8 3D Image of Primary Coil Joint

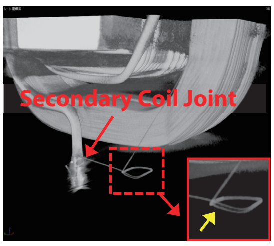

Fig. 9 3D Image of Secondary Coil Joint

An example analysis of voids (air bubbles) inside the solder joints at the primary coil wire terminal is shown in Fig. 10.

Using 3D image processing software not only enables visualization of solder voids, but also enables the measurement of void location, volume, and surface area.

The results of this analysis show there are more comparatively small voids than large voids.

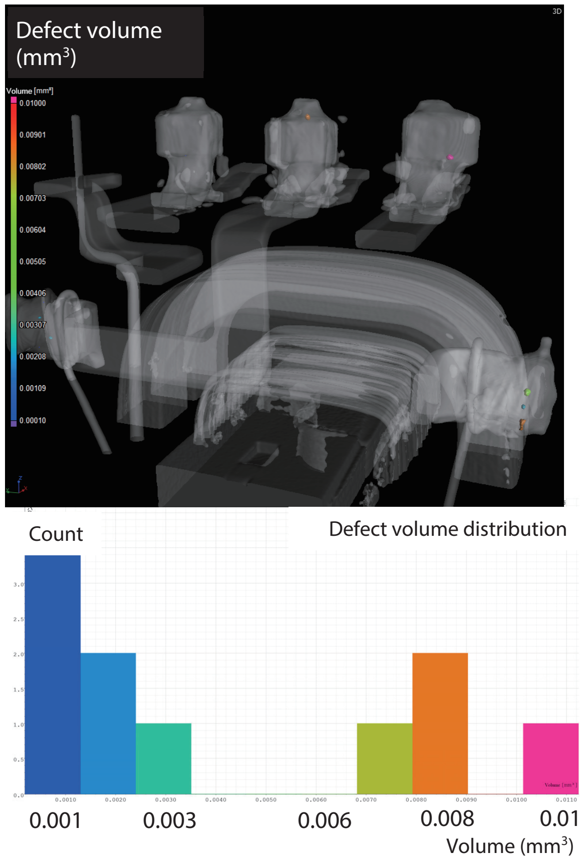

Fig. 10 Void Analysis of Primary Coil Solder Joints

Conclusion

As described in this article, the inspeXio SMX-225CT FPD can be used to successfully observe nondestructively and in 3D the shape and solder status of components inside a resin-molded product.

Using dedicated software also enables various analyses to be performed, which can be used not only for confirmation of product quality, but also for manufacturing process examination and to compare samples before and after testing.

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