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Application News

No. N140

Microfocus X-ray CT System

Internal Observation of Aluminum Die Cast Parts with inspeXio™ SMX™-225CT FPD HR Plus

Introduction

Die casting is a process in which various types of parts are molded by injecting molten nonferrous metal alloys into a precision mold under high pressure. Since it is possible to mass-produce casting with high dimensional accuracy, there is a high market need for die cast products. Among these products, aluminum die castings are used in numerous applications because aluminum is inexpensive, lightweight, and easily recycled. However, in the case of aluminum die cast parts, there is a high probability that casting defects, that is, voids remaining in the interior of products, may occur in the manufacturing process. If voids exist in a product, they may cause various problems, including reduced mechanical strength and fatigue strength and oil leaks. X-ray inspection is one effective inspection method for detecting these casting defects, and among X-ray techniques, X-ray CT is a particularly effective inspection method because it is possible to capture information concerning the size and position of casting defects in 3 dimensions.

This article introduces an example of observation of casting defects in an aluminum die casting using a Shimadzu inspeXio SMX-225CT FPD HR Plus microfocus X-ray CT system (Fig. 1).

N. Nakamura

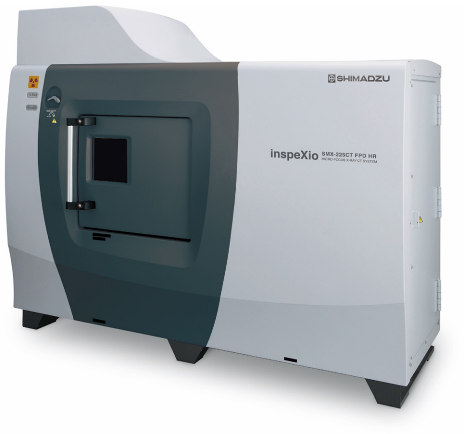

Fig. 1 inspeXio™ SMX™-225CT FPD HR Plus Microfocus X-ray CT System

Features of inspeXio SMX-225CT FPD HR Plus

The inspeXio SMX-225CT FPD HR Plus microfocus X-ray CT system (Fig. 1) is a highly versatile instrument which is equipped with a 16-inch flat panel detector in the light receiving section and has a wide installable work size of φ400 × 300 mm, supporting observation of work of various sizes. For particularly large-sized work, it is also possible to change the shield box to a large-scale type [*1]. As an example of a specification change, an installable work size of φ600 × 600 mm and work weight of 50 kg are possible.

Aluminum die castings are used in various types of products, such as automotive parts and electronic parts, and also have a wide range of sizes. The inspeXio SMX-225CT FPD HR Plus, which is capable of scanning samples from small to large sizes, is an effective instrument for internal observation of aluminum die castings.

Observation of Aluminum Die Casting

Fig. 2 shows the external appearance of the aluminum die casting used in this observation. Fig. 3 shows a fluoroscopic image of the aluminum die casting observed by X-ray fluoroscopy, and Fig. 4 shows enlarged images of the areas in the blue and red squares in Fig. 3.

A fluoroscopic image is created by expressing the differences in the amount of X-ray transmission through the sample interior in shades of black and white. Here, aluminum, which has high X-ray absorption, appears black, while air, which has low absorption, appears white. Looking at the enlarged images in Fig. 4, numerous casting defects can be observed in the parts indicated by the yellow arrows and the surrounding areas. However, it is not possible to determine the depth of those defects.

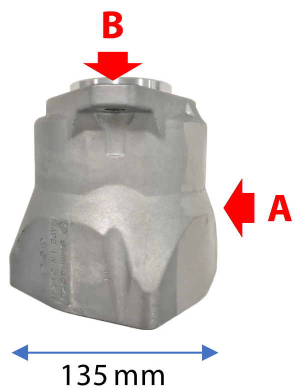

Fig. 2 External Appearance of Aluminum Die Casting

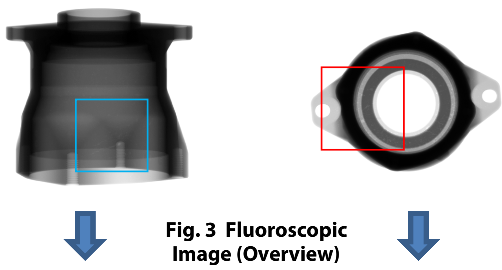

Fig. 3 Fluoroscopic Image (Overview)

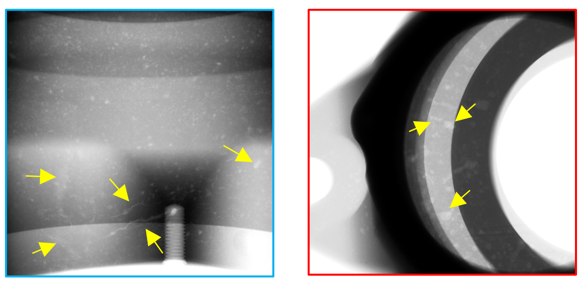

Fig. 4 Enlarged Fluoroscopic Images

Therefore, in order to obtain detailed information on the casting defects, a CT scan was conducted, and cross sections were observed by using the multi planar reconstruction (MPR) function, which reconstructs images of arbitrary cross sections from the cross-sectional images acquired by CT (Fig. 5).

MPR makes it possible to observe cross sections a and b, which are orthogonal to the scanned cross section ①, and c shows an arbitrary cross section from b. Moreover, the positions and angles of the lines on the MPR can be moved freely.

In conventional inspection and observation by mechanical cross-section polishing, there is a possibility that plastic deformation of the metal or penetration by the abrasive may cause changes in the condition of casting defects, that is, crushing of the defects. These changes in the defect condition do not occur in nondestructive inspection by CT.

It is also possible to create a 3-dimensional image from the CT scan data (Fig. 6). Representation in 3 dimensions can clearly capture the position, size, shape, and others of casting defects, which is not possible with conventional X-ray fluoroscopy.

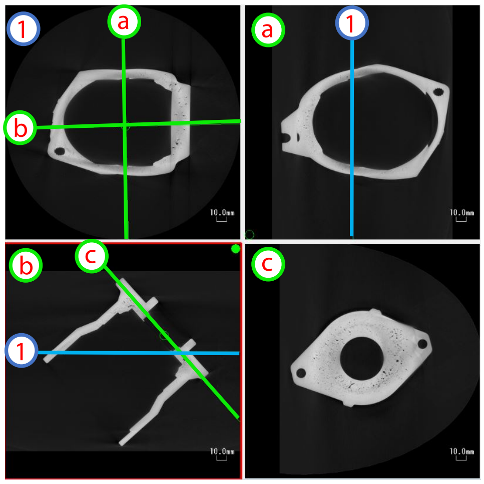

Fig. 5 MPR Images

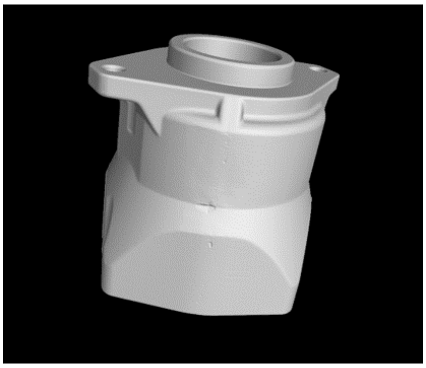

Fig. 6 3-Dimensional Image

Next, an image analysis was conducted based on these cross-sectional images. Fig. 7 to Fig. 9 show the results of an analysis using the optional porosity/inclusion analysis module of the 3-dimensional analysis software VGSTUDIO MAX. In Fig. 7 and Fig. 8, the detected casting defects are color-coded by the defect volume. These results are graphed in Fig. 9, where the abscissa shows the volume and the ordinate shows the count of the defects. In addition to volume, various other items can also be quantified, including the defect diameter, position, surface areas, and others.

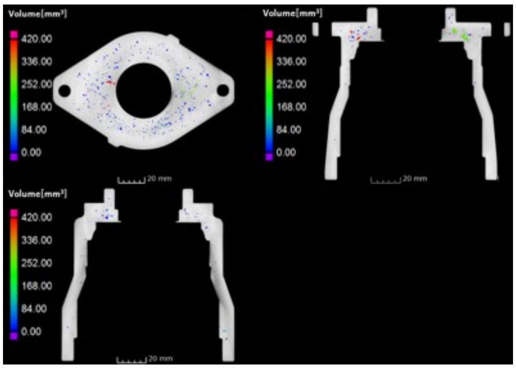

Fig. 7 Cross-Sectional Image Color-Coded by Defect Volume

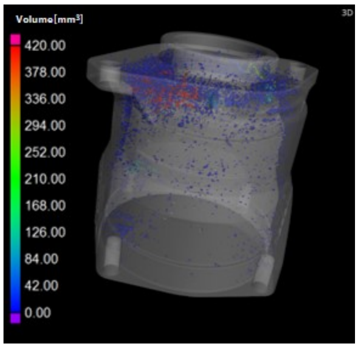

Fig. 8 3-Dimensional Image Color-Coded by Defect Volume

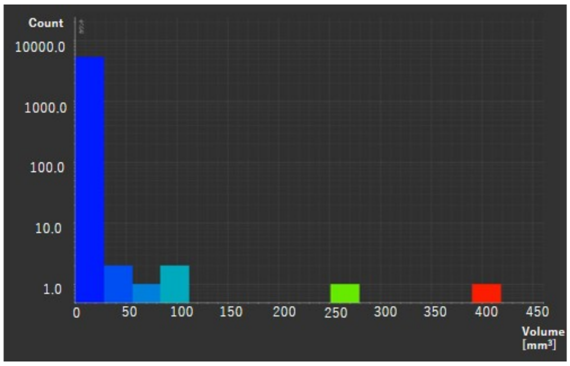

Fig. 9 Results of Casting Defect Analysis

Conclusion

Casting defects occur in aluminum die castings due to poor design of the casting shape, unsuitable molten metal flow conditions, and other factors. Determining the size, shape, and position of these casting defects and implementing improvements based on a review of the design and manufacturing process are important for improving reliability. The 3-dimensional information acquired by CT scans can be used not only in analyses of internal defects, but also wall thickness analyses and comparison of the product shape with CAD data, and in simulations such as stress analyses that consider internal defects. Thus, X-ray CT is an extremely effective tool for structural evaluations of aluminum die casting.

*1 The large-scale shield box is a made-to-order product.

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