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Application News

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

Example Observation of Corroded Copper Pipe Microfocus X-ray CT System

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User Benefits

- ◆ The three-dimensional shape of the inner surface of the copper tube, which is difficult to observe from the outside, can be visualized in a simple manner.
- ◆ Microfocus X-ray CT system enables the observation of corrosion progress of a copper pipe on the same specimen because the test is non-destructive.

■ Introduction

Copper pipes are used for air conditioner refrigerant piping and water supply piping because of their high processability and corrosion resistance. However, copper pipes may corrode depending on the usage environment. It is important to study corrosion progress in a various environments to use the copper pipe safely for a long time.

A microfocus X-ray CT system is a useful tool to observe the corrosion of copper pipes. The X-ray CT system makes it possible to visualize the three-dimensional structure without destroying objects, including a copper pipe. In addition, it is possible to examine the progress of corrosion on the same test specimen because it is without losing the corroded part or changing the shape in the observation.

Herein, an example of an observation of a copper pipe corroded with aqueous formic acid solution using a Shimadzu inspeXio SMX-225 CT FPD HR Plus micro focus X-ray CT system (Fig. 1) is described.

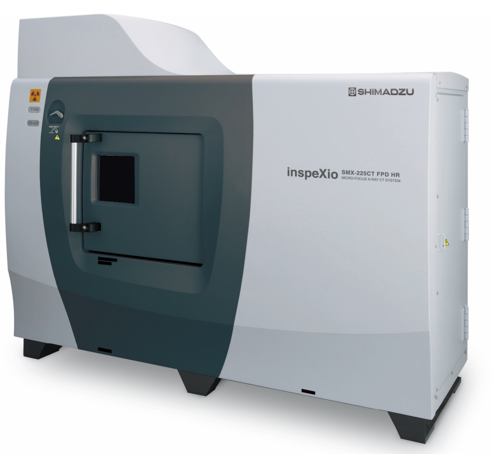

Fig. 1 Microfocus X-ray CT system
inspeXio™ SMX™-225CT FPD HR Plus

■ Observation of Copper Pipe

Fig. 2 shows the external appearance of a copper pipe before and after corrosion. The copper pipe has an outer diameter of 8.0 mm, a thickness of 0.8 mm, and a length of 30 mm. A 10 g/L aqueous solution of formic acid is used as the organic acid for corrosion. As shown in Fig. 3, the copper pipe was exposed to formic acid at room temperature by placing a vial containing the copper pipe in a sealed container containing an aqueous formic acid solution. CT scans were performed three times: “before exposure,” “after two months exposure," and “after five months exposure".

Fig. 2 External appearance of copper pipe before and after corrosion

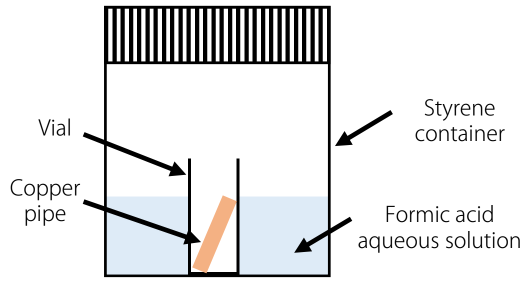

Fig. 3 Illustration of a copper pipe in corrosion treatment

Fig. 4 shows a longitudinal sectional image and a three-dimensional representation of the copper pipe before and after exposure. The red plane on the three-dimensional image indicates the position of the longitudinal image. In the longitudinal sectional image and the three-dimensional representation, higher density areas appear whiter as the density increases, whereas lower density areas appear blacker.

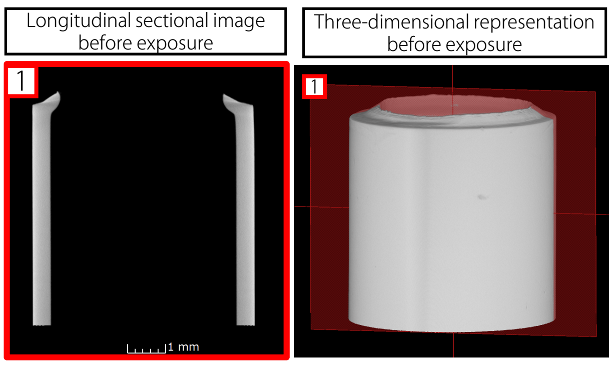

Fig. 4 Longitudinal sectional image and three-dimensional representation of the copper pipe before exposure

Fig. 5 shows cross-sectional images and longitudinal images of the copper pipe at three stages: before exposure, after two months exposure, and after five months exposure. There is no noticeable damage before exposure, but the longer the exposure period after exposure, the more the dent appears around the outer surface.

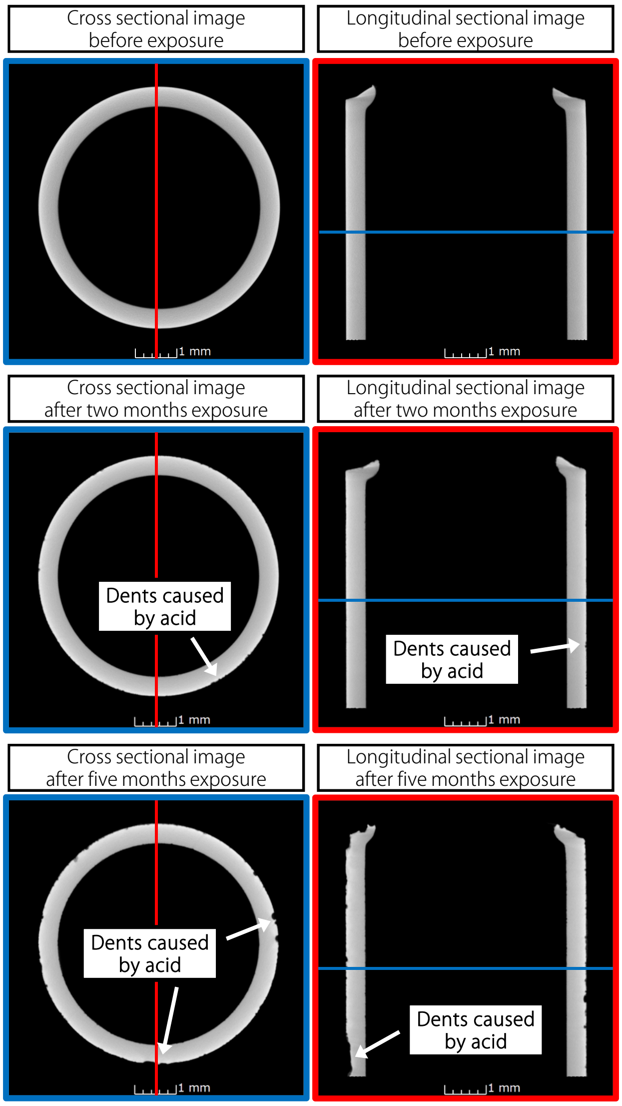

Fig. 5 Longitudinal and cross-sectional images of the copper pipe before and after corrosion treatment

Fig. 6 shows a three-dimensional data comparison for the outer copper pipe surfaces' corrosion state – before and after exposure. Fig. 6a and 6b show the states after two and five months of exposure**.** The shape deviation of the outer surface of the copper pipe after exposure to that before exposure is color-mapped by superimposing the data before exposure to each data. With increasing exposure period, corrosion progresses; in addition, deep and large dents are observed on the surface. Fig. 7 is a histogram showing the size of the area for each deviation. The relationship between deviation size and color is unified in Figs. 6 and 7. After two months of exposure, we observe an insignificant change; we obtain a large yellow-green area. A significant change is observed after five months of exposure; we observe that the area of blue-green to purple increases with the generation of deep dents, and the histogram spread to the minus side.

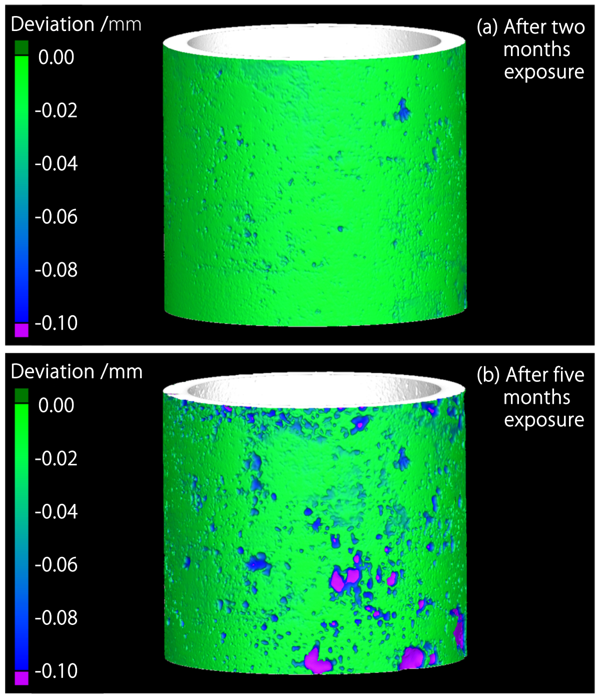

Fig. 6 Example of shape analysis: Three-dimensional representation of the corroded copper pipe

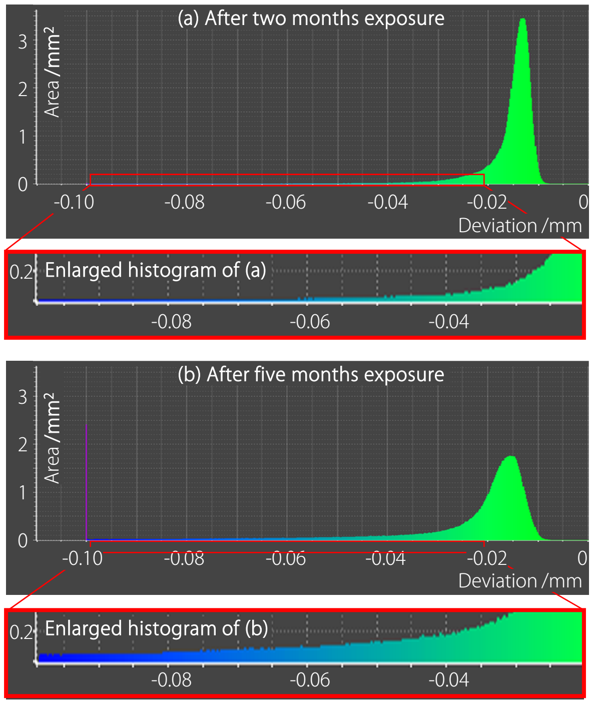

Fig. 7 Example of share analysis: Histogram of the corroded copper pipe

■ Conclusion

As demonstrated in this experiment, an inspeXio SMX -225 CT FPD HR Plus enables observation of the shape change of copper pipes due to corrosion progress on the same test specimen; the observation is conducted with sectional images and three-dimensional representations. This CT system is useful in **the** research of metal corrosion and the development of pipe material.

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