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Application News

No. N138

Microfocus X-ray CT System

Observation of Dishwashing Sponge with inspeXio™ SMX™-225CT FPD HR Plus

Introduction

Sponges form a reticulated porous structure in natural spongin fiber, rubber, and synthetic resins, and have excellent water absorbing and water holding properties, flexibility, and elasticity. The functions required in sponges differ depending on the intended application. For example, in sponges for dishwashing, the function of efficiently removing stains is enhanced by overlaying a demembraned urethane layer with high cleaning power on a urethane layer with excellent detergent holding power. In order to produce sponges with functions suited to the purpose, it is necessary to change their structure, that is, the size, shape, and distribution of the pores. Determining whether the internal structure of a sponge can demonstrate functions suited to the purpose of use is important for product development and quality control.

Therefore, microfocus X-ray CT system is used as one technique for acquiring information about the internal structure of sponges. Microfocus X-ray CT systems are suitable for evaluating materials with complex reticulated porous structures like those of sponges because simple, nondestructive observation of the 3-dimensional internal structure of the target item is possible without special sample preparation.

This article introduces an example of observation and analysis of the porous structure of a dishwashing sponge using a Shimadzu inspeXio SMX-225CT FPD HR Plus microfocus X-ray CT system (Fig. 1).

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

Observation of Sponge

Fig. 2 shows an image of the appearance of the sponge used for CT scan in this experiment. The sponge has a three-layer structure with overall dimensions of φ91 × t 35 mm. In order from the top of the image, the sponge consists of a demembraned urethane layer with good water draining and foaming properties, a urethane layer which holds the dishwashing detergent, and a nylon unwoven fabric layer for removing tough stains.

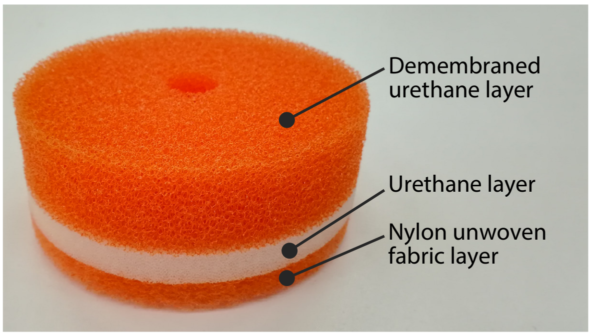

Fig. 2 External Appearance Image of Sponge

Fig. 3 shows a cross-sectional image of the sponge scanned with the X-ray CT system, displayed so that all of the layers can be observed at once. High density areas that easily absorb X-rays are shown in white, and low density areas with high X-ray transmittance are shown in black. It can be understood that the size and distribution of the resin part and pores of each layer are different, and white parts which are thought to be adhesive layers exist between the three main layers.

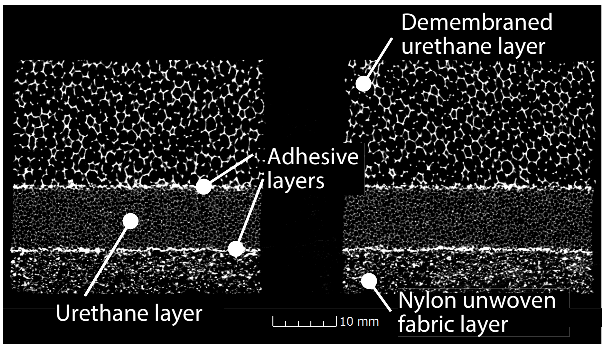

Fig. 3 Cross-Sectional Image in Direction Orthogonal to Sponge Layers

Fig. 4 shows cross-sectional images of each layer in the layer direction. Differences in the size and shape of the pores can be observed in the demembraned urethane layer, urethane layer, and nylon unwoven fabric layer.

In addition to these cross-sectional images, the scanned sponge can also be represented by a 3-dimensional image. Fig. 5 shows a 3-dimensional image of the same scanned data as in Fig. 3 and Fig. 4. For easy observation of the entire 3-layer structure of the sponge, portions of the CT data for the demembraned urethane layer and the urethane layer have been cut away in this representation.

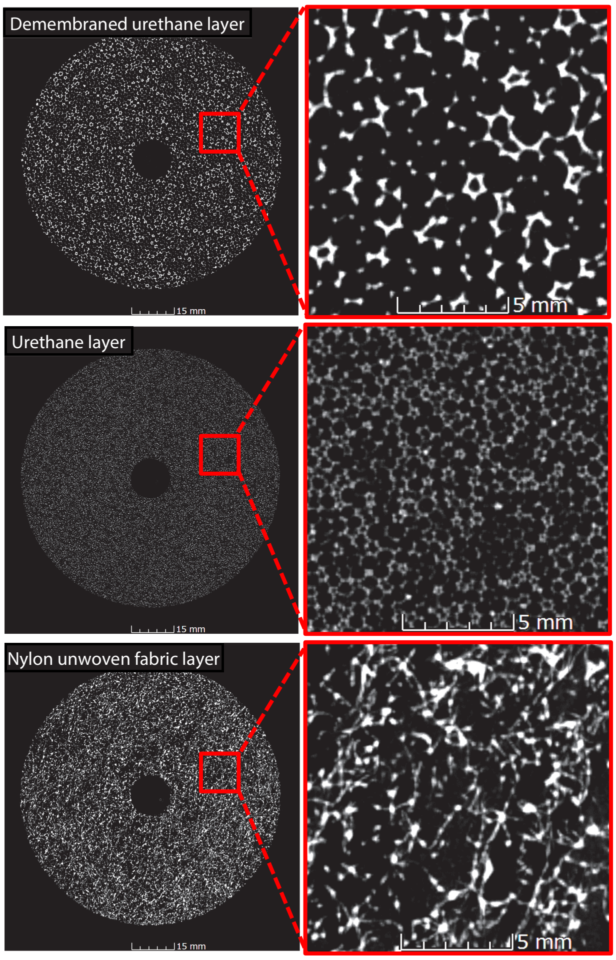

Fig. 4 Cross-Sectional Image in Direction of Sponge Layers

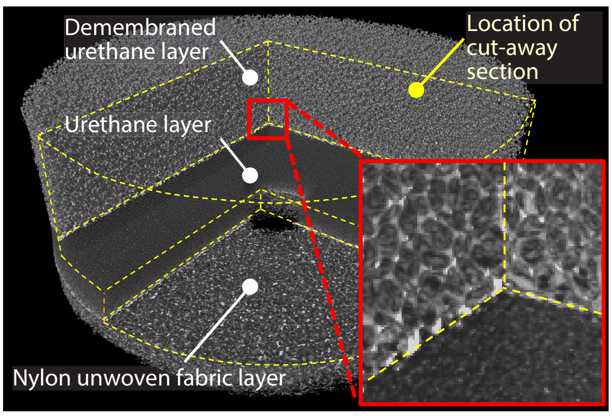

Fig. 5 3-Dimensional Representation Image of Sponge

A porosity analysis of the sponge and calculation of the sizes of the pores are also possible by using the 3-dimensional representation image. Fig. 6 shows an image in which the pores have been colored according to their different volumes. In addition to the pore volume, it is also possible to calculate other information, such as the pore position, surface area, and spheroidicity, in order to investigate whether a sponge has a structure capable of demonstrating appropriate water permeability and water holding properties. The analysis results can also be expressed as a histogram, as shown in Fig. 7.

Table 1 shows the calculated values of the average and standard deviation of the pore volume by layer. It can be understood that the average values of the demembraned urethane layer and urethane layer differ by a factor of more than 10, and there are large variations in the average pore volume of the nylon layer in comparison with the other two layers.

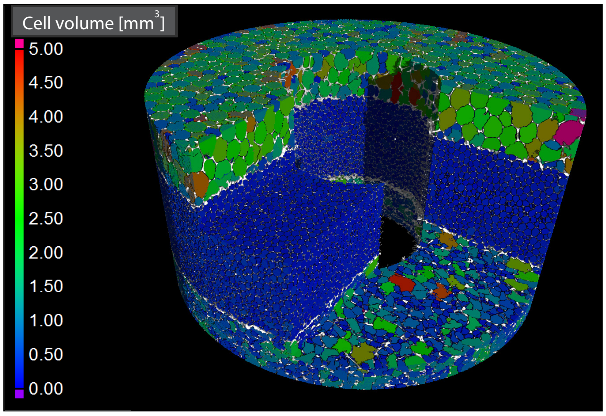

Fig. 6 Example of Porosity Analysis: 3-Dimensional Representation Image of Sponge

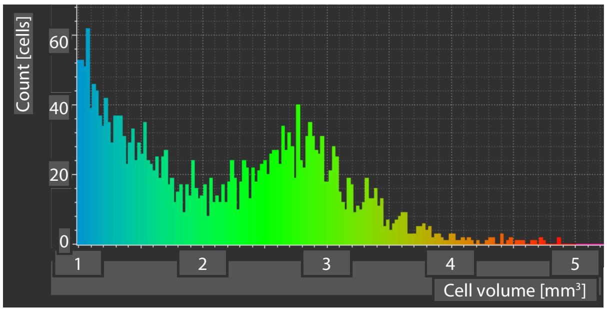

Fig. 7 Example of Porosity Analysis: Histogram of Sponge Pore Volume

Table 1 Average Value and Standard Deviation of Cell Volume of Each Sponge Layer

	Cell volume Average (mm^3)	Cell volume Standard deviation (mm^3)
Demembraned urethane layer	2.45	0.75
Urethane layer	0.19	0.04
Nylon unwoven fabric layer	0.40	0.37

Conclusion

As demonstrated in this experiment, the microfocus X-ray CT system is a useful tool for product quality control and improvement by nondestructive observation of the internal structures of the individual layers of sponge products and analysis of the size and shape of voids.

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Microfocus X-Ray CT System

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