A Flexible Ultrasonic Probe for Measuring from Curved Surface

曲面から計測を行う柔軟性超音波探触子

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1. Introduction

Ultrasonic measurements are used in non-destructive inspection and medical fields. Ultrasonic wave is transmitted by an ultrasonic probe, but the shape of the ultrasonic probe has been determined, and it is necessary to use different probes according to the specimen. When the object to be inspected is a curved surface, a probe whose shape matches the curved surface is used. However, it is necessary to prepare plural types of probes, which raises the problem of high cost. Therefore, we developed a flexible ultrasonic probe that can be deformed the probe itself according to the specimen and it was able to measure by ultrasonic waves from the curved surface. Weld flaw detection and curved surface imaging have been reported so far using soft probes, flexible linear array probes, and flexible matrix array probes [1].

2. Flexible ultrasonic probe

There are three types of flexible ultrasonic probes: soft probes, flexible linear array probes, and flexible matrix array probes. The basic structure is three-layers that these are an acoustic matching layer, a PZT-epoxy 1-3 composite transducer, and a damper, each of which has flexibility. Three flexible ultrasonic probes are shown in Fig. 1 to Fig. 3. The soft probe in Fig. 1 is a pen type of ultrasonic probe with one transducer. It is possible to measure ultrasonic waves from a convex and concave surface or curved surface with a flexible probe tip. The flexible linear array probe of Fig. 2 is a band-like ultrasonic probe, which can be wound around pipes, arms, fingers or the like to measure by ultrasonic. The radius of curvature can be bent to a minimum of 5 mm. The flexible matrix array probe of Fig. 3 has a flexible ultrasonic transducer arranged in a matrix, and 64 elements with 2.5 mm of element pitch and 8 x 8 are standard. The frequency of these probes is 5 MHz or 10 MHz. As shown in Fig. 3, ultrasonic measurement can be performed on a spherical three-dimensional curved surface.

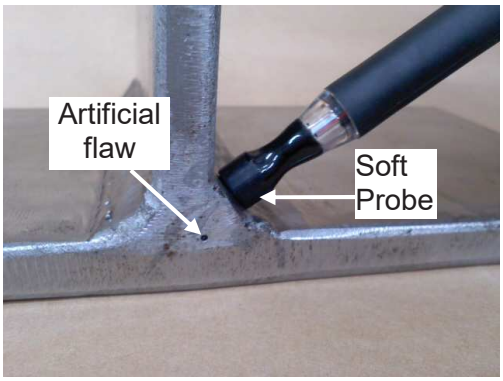

Fig. 1 Soft Probe.

Fig. 2 Flexible linear array probe.

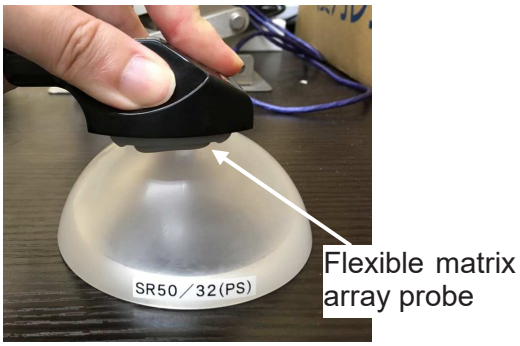

Fig. 3 Flexible matrix array probe.

3. Measuring from curved surface

We will describe an example of ultrasonic measurement from a curved surface using soft probe, flexible linear array probe, and flexible matrix array probe. Figure 4 shows the waveform of

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the fillet weld that is inspected as shown in Fig. 1. Artificial defects are set at fillet welds in Fig. 1. The reflected waveform from the artificial defect was detected in Fig. 4, and it can be seen that the weld zone flaw detection is possible using the soft probe. The results of measuring the mammary gland phantom with a flexible linear array probe are shown below. There was a false tumor in the mammary gland phantom as shown in Fig. 5, and the linear array probe was measured along the curved surface. Figure 6 shows the measurement results of the mammary gland phantom. A pseudo-tumor is imaged in the B-mode image, which shows that ultrasonic measurement can be performed from the curved surface. Next, the results which were measured by the flexible matrix array probe are described. As shown in Fig. 7 (a), the spherical block sets a triangular flaw. Figure 7 (b) shows the C-mode image, but the shape of the flaw was imaged. Also, as shown in Fig. 8, we observed a pipe elbow with artificial erosion of wall. The observation result is shown in Fig.9. C-mode image showing erosion shape and B-mode image showing erosion depth were respectively observed. From these results, it was shown that ultrasonic measurement from a curved surface is possible by using a flexible ultrasonic probe. Also, it is possible to acquire B-mode images and C-mode images using array probes.

4. Conclusion

Three types of flexible ultrasonic probe were developed and it was shown that ultrasonic measurement and imaging from a curved surface are possible.

References

[1] Y. Tanaka et al: Acoustic imaging kennkyuukai **AI-2017-10(2017)**. [in Japanese]

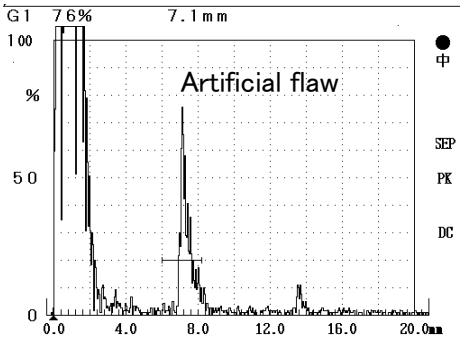


Fig. 4 waveform of fillet weld.

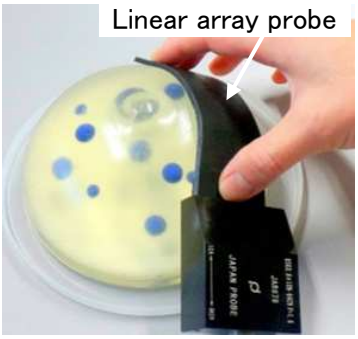


Fig. 5 Measurement of mammary gland phantom.

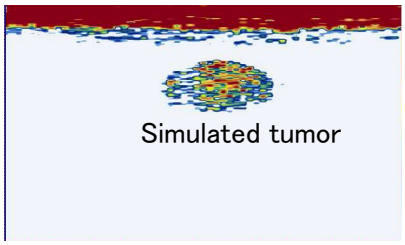
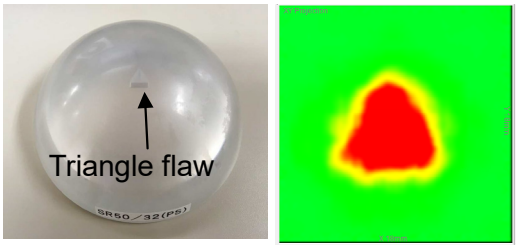
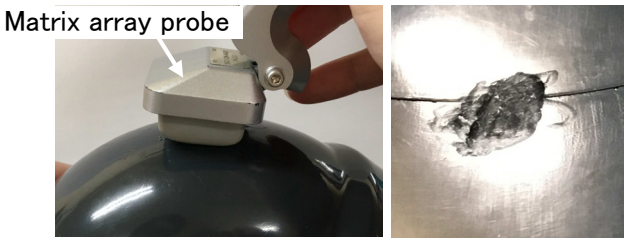


Fig. 6 B mode image of mammary gland phantom.



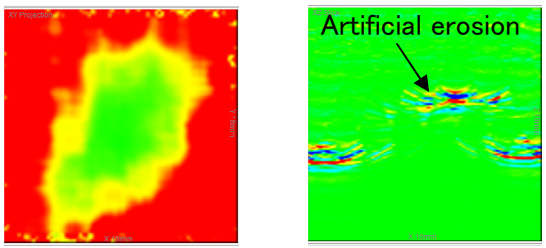
(a) Spherical block (b) C mode image

Fig. 7 Spherical triangle flaw image.



(a) Measurement (b) Erosion shape

Fig. 8 Erosion wall measurement of pipe elbow.



(a) C mode image (b) B mode image

Fig. 9 Measurement result of pipe elbow.