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Non Destructive Inspection by broadband, high sensitive flexible array probe
広帯域・高感度フレキシブルアレイプローブによる非破壊検査

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1. Introduction

An ultrasonic array probe including the linear array and matrix array is used to perform sonography of the inside of the structure in nondestructiveness. These probes are conformed to test body and inspected by an ultrasonic wave, however this requires a bespoke probe and wedge for every surface which becomes impractical for many applications where the surface profile of the component is not consistent.

We have developed a flexible array probe (FAP) that conforms to the shape of the inspection part freely like figure 1 four years ago.We modified the FAP this time and, according to figure 2, located a damper to absorb vibration on the back and reduced a cycle by matching acoustic layer with resin. A result of these modification, the FAP performance of the time resolution have been extremely improved [1]. We will report it as below. In addition, This is called the "BFAP" broadband flexible array probe that was developed.

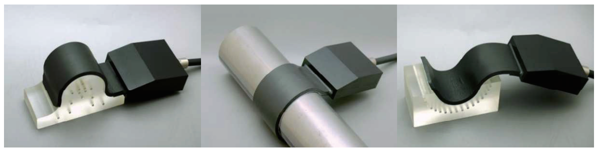


Fig.1 Various shapes of
broadband flexible array probe (BFAP)

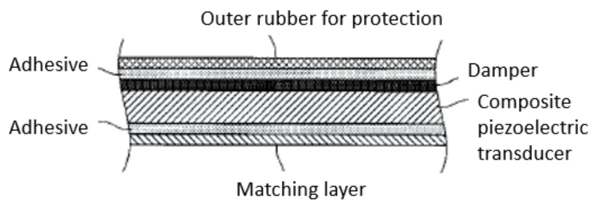
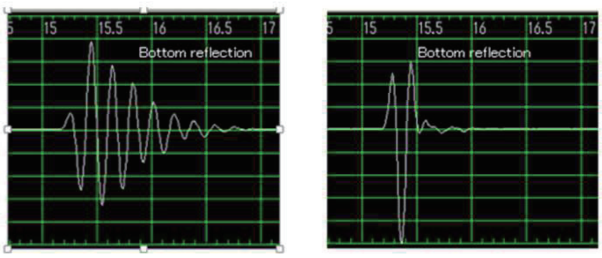


Fig.2　Construction of　BFAP

2. Structure and usage of BFAP

BFAP is kept flexibility using a special 1-3 composite piezoelectric transducer made of PZT and softer epoxy resin.The number of elements of the probe, element pitch and frequency are 32ch, 1mm, 5MHz each.

As for the probe, the acoustic matching layer is placed on the front of the transducer, and a damper is located on the back, which have been made restraint of the unnecessary vibration. The probe is conforms to the curved surface of the test body like figure 1, and inspected it.



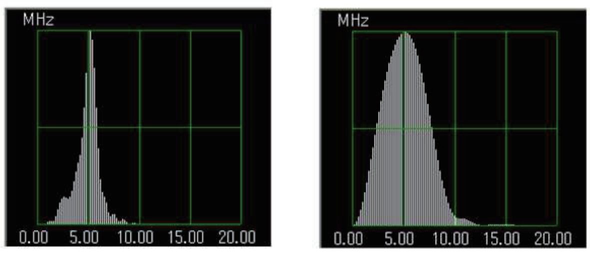
(a) FAP　(b) BFAP

Fig.3 Comparison of frequency bandwidth
between FAP and BFAP

3.Damper installation effect

In this study, we compared the BFAP with the conventional FAP by an experiment on the unnecessary vibration absorption effect by fitteded with a damper.

In figure 3、the bottom reflection signal of the thickness 20mm polystyrene block is shown.The bottom reflection signal of the FAP of figure 3(a) had the tail pull of the signal, and there was a cycle more than five, but a tail pull decreased with the BFAP of figure 3(b), and it was to 1.5. In the sensitivity of the probe, BFAP comes to have a bigger about 3dB, signal strength than FAP.In figure 4、The FFT result of the reflection signal of figure 3 was shown. In frequency band, FAP was 30%, but BFAP was excellently improved with 116%.



(a) FAP　(b) BFAP

Fig.4 Comparison of wave form FAP and BFAP

Then, We inspected the test block of figure 5 using an array device to confirm spatial resolution with the two probes. The test result by BFAP was able to display a hole than a test result due to the FAP clearly (figure 6). Therefore, it was proved that BFAP became broadband compare with FAP and the spatial resolution was improved.

4. Applied example of the inspection by BFAP

With the application to the thin CFRP (carbon fiber reinforced plastic) which used good spatial resolution as application of BFAP (figure 7). It shows an artificial defect right under 2mm from the surface of the CFRP definitely. It has begun to be used for the inspection such as the main wings of the airplane[2]. In addition, the shape to the living body and the acoustic matching are good, too, and the detection is possible about simulated tumors of the breast phantom like figure 8.

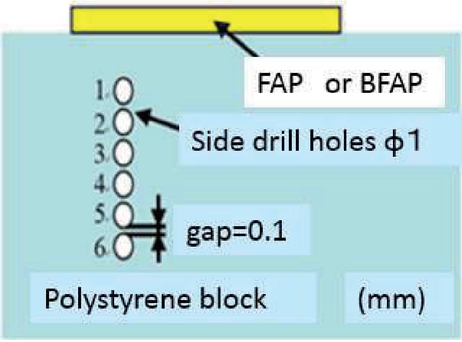


Fig.5 Test block : polystyrene block
with side drill holes

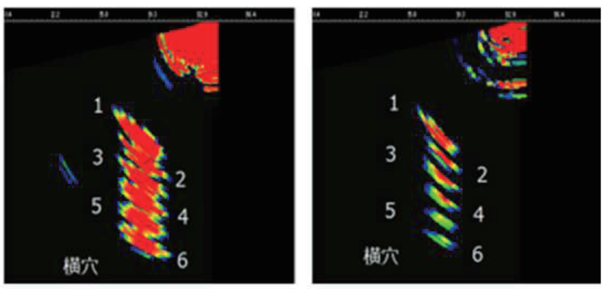


Fig.6 Comparison of spatial resolution
between FAP and BFAP

5.Summary

BFAP has been confirmed that it has been improved as shown in Table 1 in comparison with the conventional FAP.

Reference
1. Y. Tanaka, K. Ohira, D. Hirano, A. Sakai, Y. Ogura: Reports of the JSNDI spring-symposium (2014) pp.5-6 [in Japanese].
2.N. HANKINSON, R. FREEMANTLE, A. BOND-THORLEY, V. DUMALI: 18th World Conference on Nondestructive Testing, 16-20 April 2012, Durban, South Africa.

Table.1
Performance comparison between FAP and BFAP

	FAP	BFAP
Wave cycle	more than 5	only 1 and half
Frequency band	only 42%	around 120%
Sensitivity	0 (reference)	better than 3dB
Spatial resolution	poor	excellent
Flexibility	excellent	very good

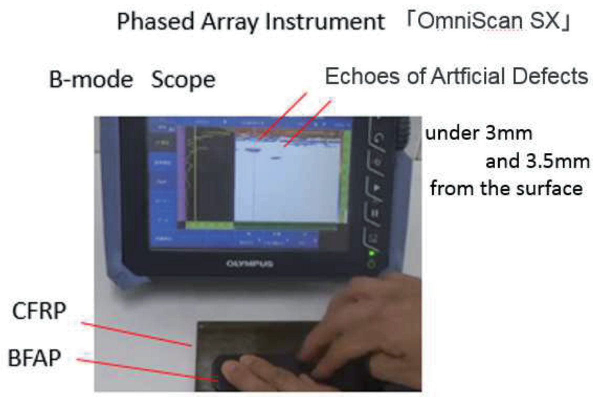


Fig.7 Inspection of the CFRP using BFAP

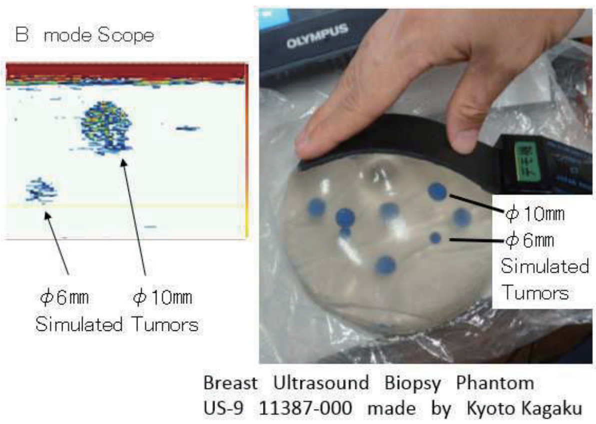


Fig.8 Inspection of the breast phantom using BFAP