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.

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.

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 fitted 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 frequency band, FAP was 30%, but BFAP was excellently improved with 116%.

![Fig.1 Various shapes of broadband flexible array probe (BFAP)](image1)

![Fig.2 Construction of BFAP](image2)

![Fig.3 Comparison of frequency bandwidth between FAP and BFAP](image3)

![Fig.4 Comparison of wave form FAP and BFAP](image4)
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.

5. Summary

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

Reference


<table>
<thead>
<tr>
<th>Table 1</th>
<th>Performance comparison between FAP and BFAP</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>FAP</td>
</tr>
<tr>
<td>Wave cycle</td>
<td>more than 5</td>
</tr>
<tr>
<td>Frequency band</td>
<td>only 42%</td>
</tr>
<tr>
<td>Sensitivity</td>
<td>0 (reference)</td>
</tr>
<tr>
<td>Spatial resolution</td>
<td>poor</td>
</tr>
<tr>
<td>Flexibility</td>
<td>excellent</td>
</tr>
</tbody>
</table>

Fig.6 Comparison of spatial resolution between FAP and BFAP

Fig.7 Inspection of the CFRP using BFAP

Fig.8 Inspection of the breast phantom using BFAP