1P2-3

Separation performance of longitudinal and shear waves using piezoelectric probe with two degree-of-freedom

２自由度を有する圧電プローブを用いた縦波および横波の分離性能

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1. Introduction

We focus on ultrasonic probes having sensitivity in plurality of directions for non-destructive testing and evaluation and their applications. In ultrasonic array flaw detection with conventioal ultrasonc probe, artifacts may appear because the probe miss-detects unnecessary waves generated by mode convirsion. It is unable to distinguish whether the received signal is longitudinal or shear wave using conventional probes. Therefore, we have previously reported the principle to transmit and receive longitudinal and shear components of elastic wave independently using matrix-like probe with multiple electrodes[1-3], to design a probe by changing the shape of probes to obtain better performance[4], and method of discriminating between longitudinal and shear waves using array signal processing and 3 degree-of-freedom (3-DOF probe)[3].

However, there has been no reported on the method for separation and measurement longitudinal and shear wave.

The purpose of this study is to propose a separation and measurement method of longitudinal and shear waves, and to evaluate the separation perforance using 2-D finite element method (FEM).

2. Separation and measurement method of longitudinal and shear waves

Figure 1 shows schematic view of separation and measurement method of longitudinal and shear wave. In order to separate and measure longitudinal and shear wave, an array signal processing and a two degree-of-freedom probe (2-DOF probe) are used. The former is used to emphasize ultrasonic waves in the arbitrary propagation direction and the latter is used to transmit and receive ultrasound waves which have vibrations in arbitrary directions. By combining array signal processing with 2-DOF probes, it is possible to transmit and receive ultrasonic waves which have an arbitrary vibration direction and an arbitrary propagation direction.

2-DOF probe has the shape of 1 × 4 truncated pyramids. 2-DOF probe has multiple channels, as shown in Fig. 1. The probe can measure the normal and tangential component by taking sum and difference of outputs of the electrodes on the left and right side of pyramids, respectively. By considering the electrode on one side of the pyramid as one element, array signal processing is applied to the output of each electrode. Then, the longitudinal and shear components are measured using the delay sum waveforms and sensitivity, as shown in Fig. 1.

3. Simulation condition and results

Figure 2 shows schematic view of simulation condition. Transient analysis was simulated from 0 to 37.5 μs at 0.5 ns intervals to verify that longitudinal and shear wave can be separated using the proposed method. When half-sin pulse waves of longitudinal and shear waves were excited at 1 MHz from line sound source with the direction of 20°. The incoming direction was assumed to be known. Also, sensitivity was measured by inputting forced displacement in any directions.

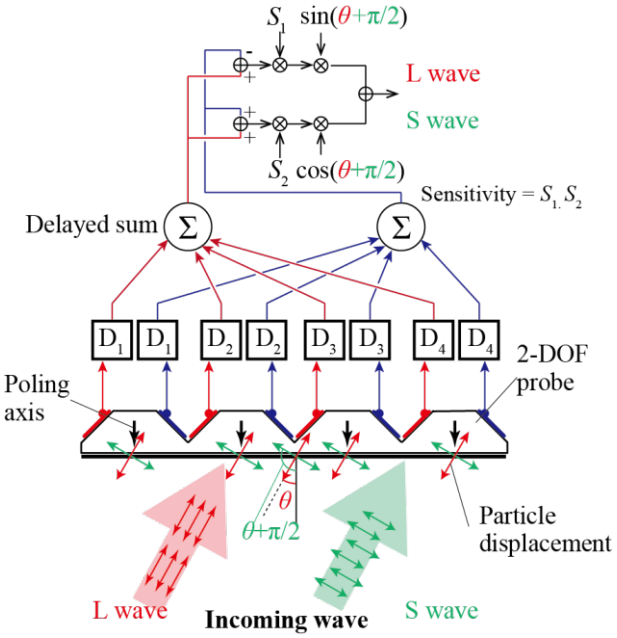

Fig. 1 Schematic view of separation and measurement method of longitudinal and shear wave.

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Figure 3 shows simulation results of time waveforms. Figures 3(i-a) and 3(ii-a) show time waveforms obtained using proposed method when longitudinal and shear pulse waves were input. According to Figs. 3(i-a), the magnitude of obtained longitudinal component was larger than that of shear component. Similarly, according to Fig. 3(ii-a) the magnitude of obtained shear component were larger than that of longitudinal component. Figures 3(i-b) and 3(ii-b) show components which are parallel and orthogonal to incoming direction between probe and medium using proposed method. Comparing Figs. 3(i-a) with 3(i-b) and Figs. 3(ii-a) with 3(ii-b), these results showed similar tendency as regards vibration locus. Consequently, it was suggested that longitudinal and shear components can be separated and measured using proposed method. From this result, there is possibility of suppressing artifacts occurs because the probe miss-detects unnecessary waves generated by mode conversion.

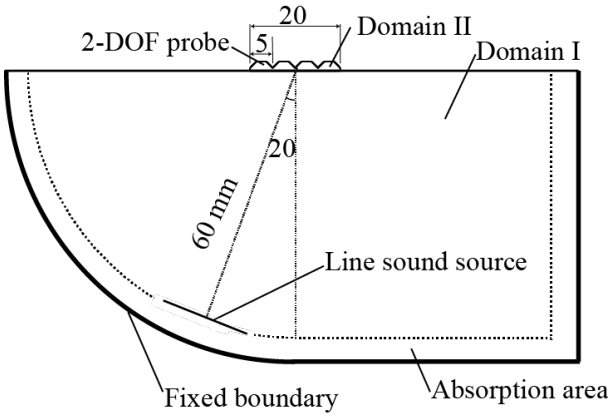

Fig. 2 Schematic view of simulation condition.

4. Conclusion

The purpose of this study is to propose a separation and measurement method of longitudinal and shear waves, and to evaluate the separation perforance using 2-D finite element method (FEM). By combining array signal processing with 2-DOF probes, separation and measurement method of longitudinal and shear waves was proposed.

As a result, the magnitudes of obtained longitudinal components were larger than that of shear component when the longitudinal pulse wave was input. Similarly, the magnitudes of obtained shear components were larger than that of longitudinal component when the shear pulse wave was input. Consequently, it was suggested that longitudinal and shear components can be separated and measured using proposed method. In addition, by comparison with displacement used as reference, it was found that similar tendency as regards vibration locus. Consequently, it was suggested that longitudinal and shear components can be separated and measured using proposed method. From this result, there is possibility of suppressing artifacts occurs because the probe miss-detects unnecessary waves generated by mode conversion. In our future work, we will fabricate a 2-DOF probe and determine whether it has biaxial sensitivities.

References

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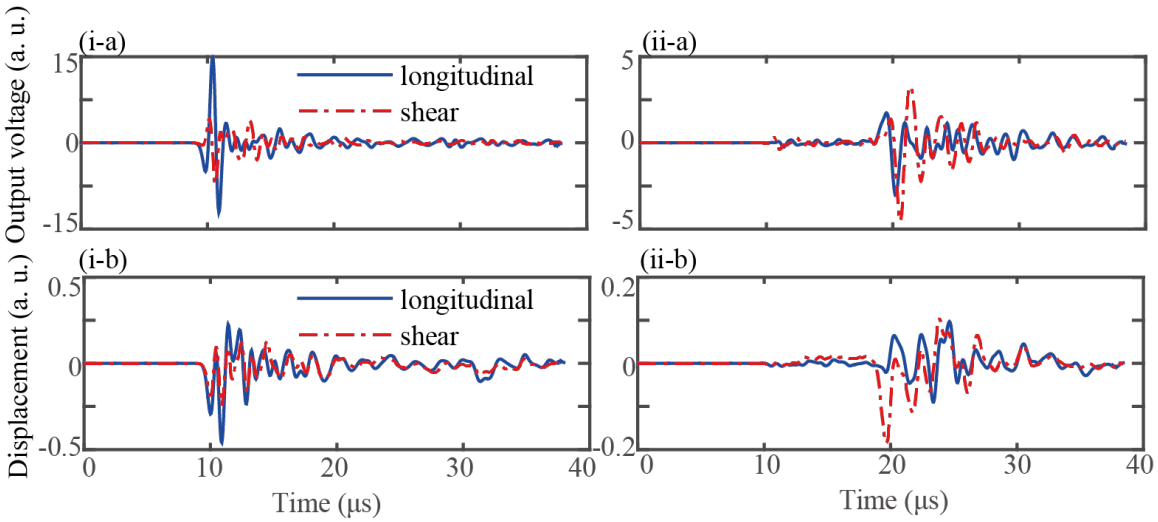

Fig. 3 Simulation result of time waveforms of (a) output voltages and (b) displacement of boundary between probe and medium when incoming pulse of (a) longitudinal and (b) shear waves were input from the direction of 25°.