1P2-15

Harmonic Imaging of Defect in Flat Plate Using Guided Wave generated by High-intensity Aerial Ultrasonic Wave

強力空中超音波励起によるガイド波を利用した平板中欠陥の高調波イメージング

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1. Introduction

Non-destructive inspection is performed by visualizing the propagation of guided waves generated on a flat plate by using high-intensity aerial focused ultrasonic waves and a laser Doppler vibrometer.

In this report, we introduced the imaging of the thinned area[1] in the metal flat plate using the harmonic multi beam[2] due to the nonlinearity of high-intensity ultrasonic waves.

2. Experimental devices and method

Fig. 1 shows experimental devices. The devices consist of ultrasonic sound source, laser Doppler vibrometer (LDV), and the other devices. This sound source is a focus sound source that has a structure in which 335 transducers (drive frequency : 40 kHz) are distributed evenly inside a hemisphere (diameter : 150 mm).

The experiment is performed according to the following procedure. First, to avoid the influence of side lobe of focus sound waves on LDV measurement, sound waves are irradiated to the target by pipes (material: acrylic; inner diameter: 8 mm; length: 30 mm; thickness: 2 mm) and acoustic windows (material: acrylic; dimension: 300 × 300 mm; thickness: 3 mm; window diameter: 12 mm) and then in order to observe the guide wave of the target surface generated from the excitation area, the vibration velocity waveform of each measurement point is measured with LDV. In addition, the waveform of the obtained vibration velocity contains harmonics due to the nonlinearity of high-intensity ultrasonic waves, and the fundamental frequency and harmonic components are extracted by a band pass filter (center frequency ± 1 kHz) from this vibration velocity waveform. The above measurement and signal processing are performed in all the measurement areas, and the guide wave is observed from the obtained vibration velocity distribution of the measurement area at each time of each frequency.

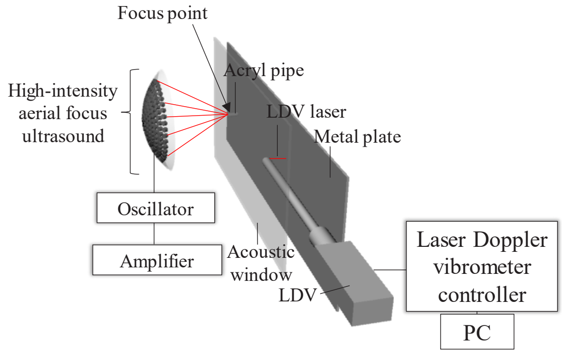
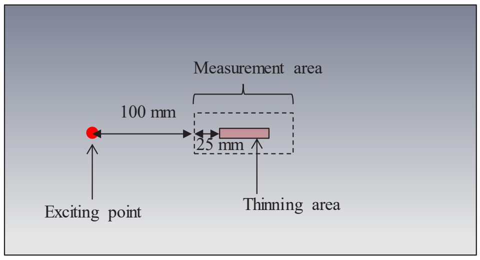
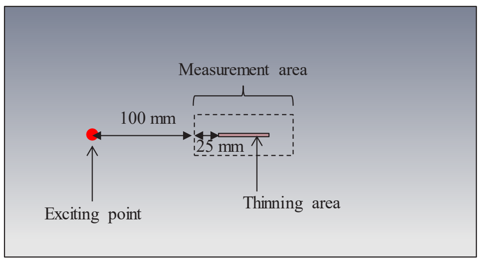


Fig.1 Experimental devices



(a) Sample A



(b) Sample B

Fig.2 Schematic view of samples

In the experiment, sound waves were irradiated for 10 cycles of input signal, and an input voltage of 24 V is supplied and the waveform is acquired over a measurement time of 10 ms. Measurements are made at 1 mm intervals.

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3. Sample detail

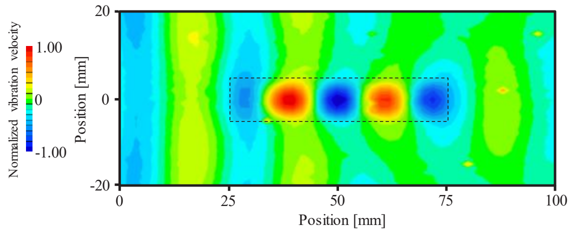
Figs.2 (a) and (b) show the schematic view of sample A and B. We prepare a 3-mm-thick aluminum plate with dimensions of 500 × 250 mm. The sample A has the thinning area whose size is about 10 mm width, 50 mm length, 0.5 mm depth, and the sample B has the thinning area whose size is about 3 mm width, 50 mm length, 0.5 mm depth in figure. The exciting area and the measurement area of 40 × 100 mm are shown in the figure.

4. Result and discussion

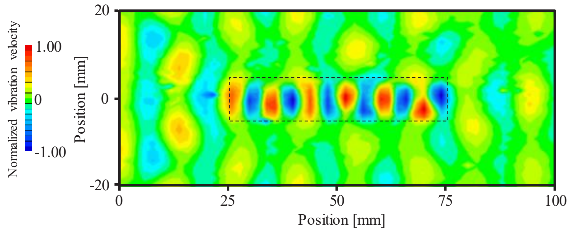
Figs. 3 (a) ~ (c) show the imaging results of guided wave propagation on the surface of sample A at certain time. Figures (a) ~ (c) sequentially show the fundamental frequency of 40 kHz, the second harmonic of 120 kHz and the third harmonic of 200 kHz. From the results, a mode occurs in the thinning area at any frequency, and the thinning area is imaged from that mode. Also, the higher the frequency increases, the shorter the mode interval becomes, and the defect is imaged accurately.

Figs. 4 (a) and (b) show the results of visualization of guided wave propagation on the surface of sample B at certain time. Figures (a) and (b) sequentially show the fourth harmonic at 160 kHz and the fifth harmonic at 200 kHz.From the results, the thinning area is not imaged at the fourth harmonic of Fig. (a).

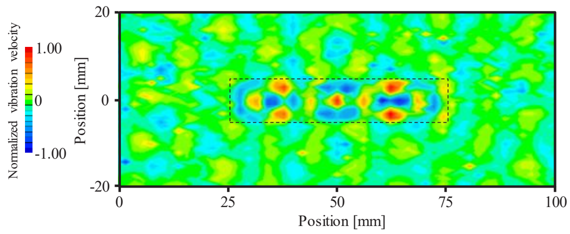
However, as shown the result of the fifth harmonic in Fig. (b), a mode is generated along the thinning area, and it can be confirmed that the defect is visualized. From the above, it is confirmed that by using harmonics, it is possible to visualize an elongated thinned area with a width of about 3 mm.



(a) 40 kHz

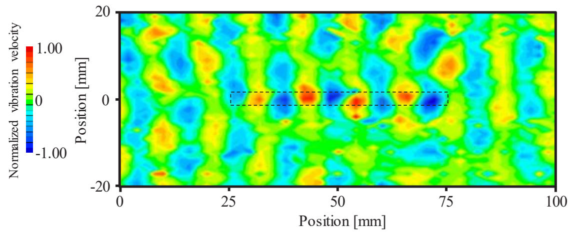


(b) 120 kHz

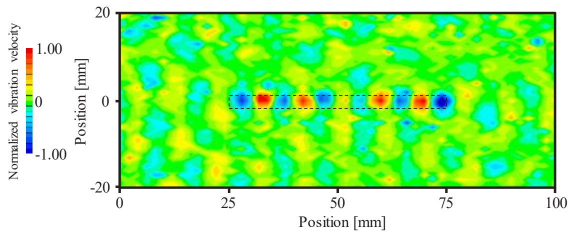


(c) 200 kHz

Fig.3 Imaging results (sample A)



(a) 160 kHz



(b) 200 kHz

Fig.4 Imaging results (sample B)

5. Conclusion

We attempted to image the thinned area in the metal flat plate using the harmonic multi beam due to the nonlinearity of high-intensity ultrasonic waves.

As the results, the propagated images of guided wave can be obtained by the proposed method, and the possibility of noncontact detection of thinned area with width of about 3 mm is obtained.

References

1.A.Osumi, Y.Asada, Y.Ito, USE2017, 2P2-1, (2017)
2. A.Osumi, M.Ogita, K.Okitsu, Y.Ito : Jpn. J. Appl. Phys. 56 (2017) 07JC12.