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A Study of Detecting Internal Defect in Solid Material Using Nonlinear Aerial Convergence Ultrasonic Waves
非線形集束空中超音波を用いた固体材料内欠陥の検出

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1. Introduction

We considered a noncontact method that enables the detection of internal defect in solid materials by nonliner aerial convergence ultrasonic waves. That is, our method is the noncontact method that enables the detection of internal defect in solid materials by analyzing frequency information obtained from the vibration of an object excited with nonliner aerial convergence ultrasonic waves. In the past, this method is possible to detect internal defect in solid materials.[1)] In this report, we attempt to detect the depth of the internal defect by using this method.

2. Experimental set up and method

Figure 1 shows a schematic diagram of the experimental set up. A stripe-mode vibrating plate (frequency: 26.8 kHz) was used as a point-converging acoustic source[2)] to generate nonliner aerial ultrasonic waves. The ultrasonic waves radiated from this acoustic source are focused onto a circular area of 10 mm in diameter at a distance of 133.5 mm from the opening of the acoustic source.

Figure 2 shows, for a free field, the relationship between the sound pressure at the convergence point, analyzed using a fast Fourier transform spectrum analyzer, and the power input to the sound source. In this experiment, the surface of a sample vertically set to coincide with axis y. The sample was continuously irradiated with ultrasonic waves, and the vibration velocity on the surface of the irradiated sample was measured with a laser Doppler displacement meter located behind the acoustic source. The frequency of the measured vibration velocity was analyzed with a fast Fourier transform spectrum analyzer.

3. Experimental samples

Figure 3 shows the details of the sample. In the experiment, the sample is an acrylic plate. The 30-mm-thick acrylic plate had dimensions of 150 mm × 150 mm. We prepared the each sample which

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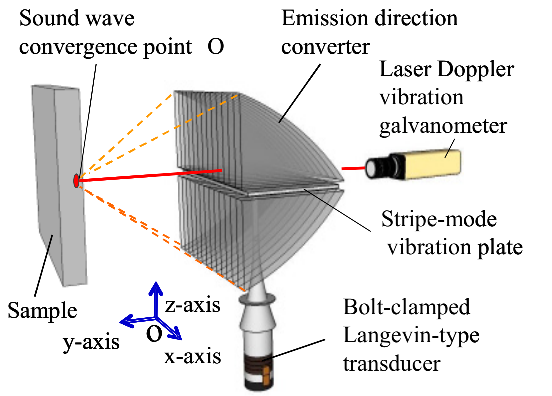

Fig. 1 Ultrasonic source for producing aerial convergent ultrasonic waves; schematic view of system used.

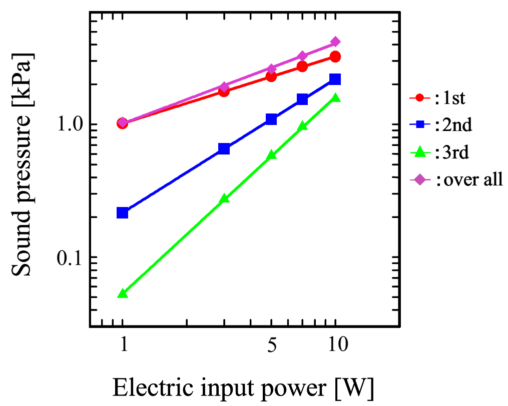

Fig. 2 Relationship between input power and sound pressure at the fundamental frequency and harmonic frequencies of the sound waves.

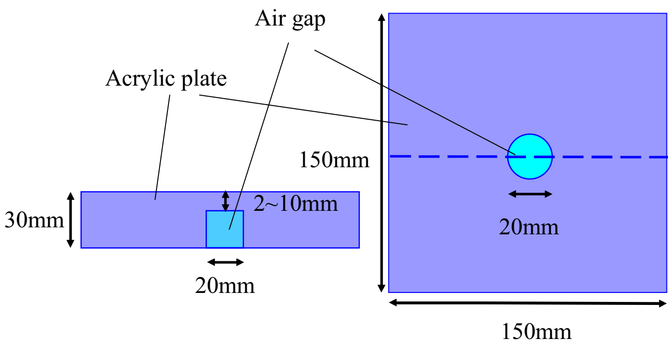

Fig. 3 Details of sample with artificial internal defect: (a) vertical sectional view (b) horizontal sectional view.

the depth from the surface of the sample to the artificial internal defect has been changed from 2 to 10 mm shown in Fig. 3.

4. Irradiation condition of sound waves

Figure 4 shows relationship the radiation resistance of the ultrasonic sound source and the surface of the sound pressure when the distance between the ultrasonic sound source and the acylic plate changed. In this experiment, the supplied power is held constant at 5W. For the compasion, these results normalized. As a results, maximum and minimum value of the radiation resistance and the sound pressure of the surface are same positions. Above the results, we put the sample on the position which maximum value of the radiation resistance and the sound pressure. That is, the sample set 137.5 mm from the ultrasonic sound source.

5. Detection of internal defect

Figure 5 shows the characteristics of vibration velocity for each sample. Fig. 5 shows the result for each sample which the depth of the internal defect is 2, 6, and 10mm. In addition, **Fig. 6** shows the vertical axis of Fig. 5 converted to distortion rate. The distortion rate is defined as the ratio of the square root of the sum of the vibration velocities of second and third harmonic components to the vibration velocity of the fundamental frequency in this experiment. In both figures, a blue square indicates the area of the artificial internal defect. Measurements were taken along the dashed blue line shown in Fig. 3, and the supplied power was held constant at 5 W.

As a results, the vibration velocity and the distortion rate for the sample differed between the area with the internal defect and the area without the internal defect. In addition, the vibration velocity and the distortion rate are different depending on the depth from the surface of sample to the artificial internal defect.

6. Conclusion

We attempt to detect the depth of the internal defect in solid materials by using nonliner aerial convergence ultrasonic waves. As a results, it is found that the vibration velocity and the distortion rate for the sample differed depend on the depth from the surface of the sample to the artificial internal defect. Therefore, it is possible to detect the depth of the internal defect by using this method.

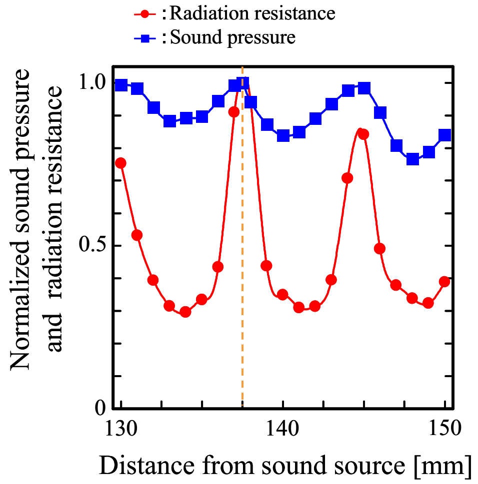

Fig. 4 Relationship sound pressure of surface and radiation resistance of ultrasonic sound source when distance between ultrasonic sound source and sample changed.

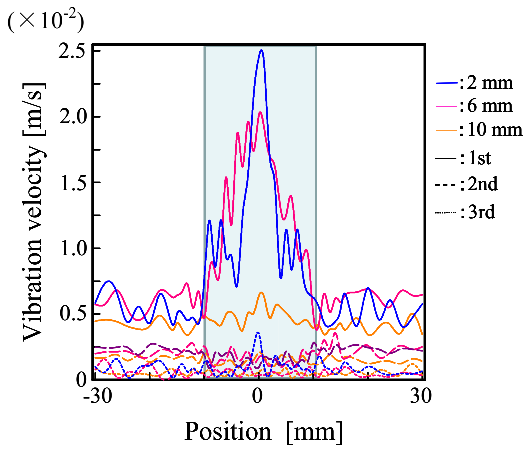

Fig. 5 Distribution of vibration velocity for each sample. (measured along dashed blue lines in Fig. 3)

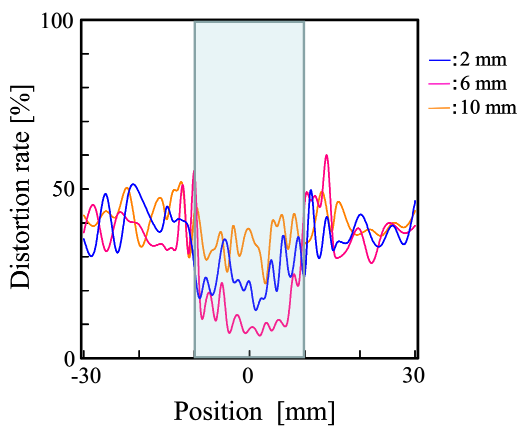

Fig. 6 Distribution of distortion rate for each sample. (measured along dashed blue lines in Fig. 3)

References

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