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Sound pressure distribution in a wet cloth sample in a standing wave sound field formed by two intense aerial ultrasonic sources

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1. Introduction

In our previous work, a standing wave sound field was formed using two intense aerial transverse vibrating plate ultrasonic sources, and wet cloth samples placed in the sound field were dried. We showed that drying was enhanced at the sound pressure node position (the particle velocity anti-node position) in the standing wave sound field.[1)]

In this paper, to understand the effect of the sample moisture content on the sound field, we examine the sound pressure distribution when the wet samples were placed at the sound pressure anti-node or node position.

2. Intense aerial ultrasonic sources and experimental apparatus

Figure 1 shows a schematic of the intense aerial transverse vibrating plate ultrasonic sources used in the study. The ultrasonic source consisted of a 20 kHz bolt-clamped Langevin ultrasonic transducer, an exponential horn for amplitude expansion, a transmission rod for adjusting longitudinal vibration resonance frequency, all screwed together, and a rectangular stripe-mode transverse vibrating plate (A2017) screwed to the end of the transducer. The driving resonance frequency was 20.3 kHz.

Figure 2 shows a schematic of the experimental setup. Two ultrasonic sources were installed with their vibrating plate surfaces parallel and facing each other with a spacing of 38 mm (two wavelengths) to form a standing wave sound field between the plates. A sample and a sample holder for fixing the sample were also installed.

3. Sound pressure distribution in the standing wave sound field

Figure 3 shows the measured sound pressure near the center between the vibrating plates with no sample. A probe microphone with a diameter of 1.5 mm was used for the measurements. The color bar indicates the value normalized by the maximum sound pressure. The figure shows that a standing wave sound field of two wavelengths in the *z*-axis direction and two wavelengths in the *x*-axis direction was formed within the measurement range. The sound pressure was uniform in the *y*-axis direction because of the stripe-mode vibration displacement.

4. Sound pressure distribution with dry sample

Cotton cloth (Kanakin No. 3; size: 44 (*x*-axis direction, about 1.2 times the wavelength) × 84 × 0.5 mm) was used as the sample to be dried. The sound pressure distribution in the sample was examined by measuring the sound pressure with a microphone.

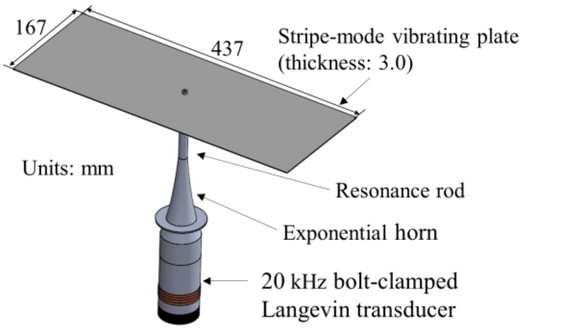

Fig. 1 Aerial ultrasonic sound source.

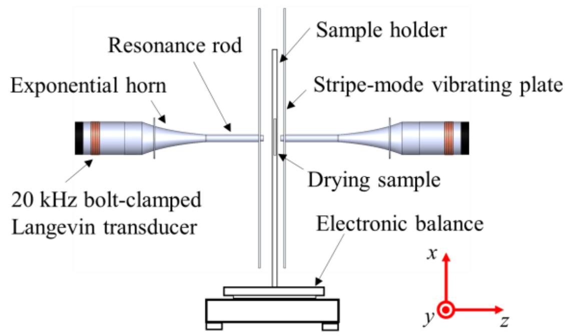

Fig. 2 Outline of experimental equipment.

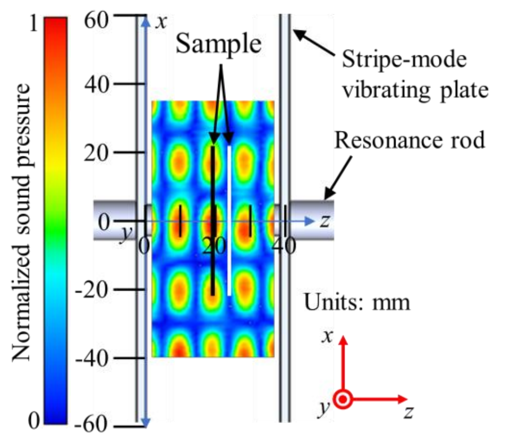

Fig. 3 Measured sound pressure distribution of standing wave sound field with no sample plate.

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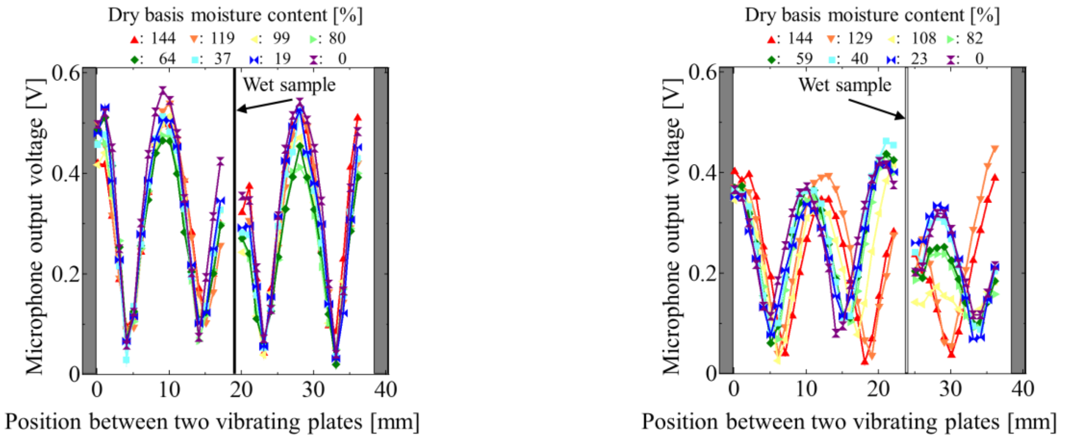
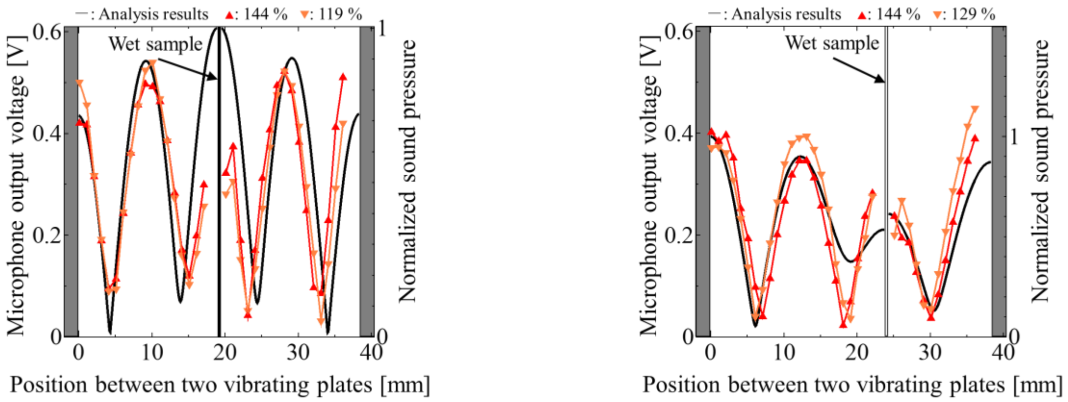


(a) Placed at sound pressure anti-node position. (b) Placed at sound pressure node position.

Fig. 4 Sound pressure distribution in a wet sample.



(a) Placed at sound pressure anti-node position. (b) Placed at sound pressure node position.

Fig. 5 Sound pressure distributions of a wet cloth sample and a polypropylene plate sample.

The measurement range was 0 mm in the *x*-axis direction, 70 mm from the vibrating plate end face in the *y*-axis direction, and 0–36 mm in the *z*-axis direction.

Figures 4 (a) and (b) show the sound pressure distribution with the sample placed parallel to the vibrating plate; the vibrating plate is shown on the left and right of the figures. In Fig. 4 (a), the sample was placed at the anti-node position of the sound pressure (black line in Fig. 3), and the sound pressure distribution did not depend on the moisture content of the sample. In Fig. 4 (b), the sample was placed at the node position of the sound pressure (white line in Fig. 3). When the moisture content of the sample was high, the sound pressure near the sample was the anti-node position, and the sound pressure anti-node or node position was different compared with when there was no sample present. However, as the moisture content of the sample decreased, the sound pressure node position became the same as that without the sample, indicating that the standing wave sound field approached the field with no sample present.

Figures 5 (a) and (b) show the sound pressure distributions of a wet cloth sample with a high moisture content (shown in Fig. 4) and a plate-shaped polypropylene sample. In Fig. 5 (a), the sample was placed at the sound pressure anti-node position. The distribution of the sound pressure anti-node and node positions in the analysis and measurement results were similar. In Fig. 4 (b), the sample was placed at the sound pressure node position. The distributions of the sound pressure anti-node and node positions of the in the analysis and measurement results were similar.

5. Conclusions

These results show that when a sample with a high moisture content was placed at the sound pressure node position, the standing wave sound field was disturbed because the sample reflected the sound waves. However, as the moisture content decreased, the standing wave sound field approached that obtained with no sample.

References

1) C. Owada, T. Asami, and H. Miura, Proc. 2024 Spring Meet. Acoustical Society of Japan, 2024, pp. 23-24 [in Japanese].