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Study of aerial standing wave field using ultrasonic sources formed by four striped mode vibrating plates with a jut driving point

4 枚の凸端駆動振動板から形成される空中強力定在波音場の検討

Koki NAITO[‡], Takuya ASAMI, Hikaru MIURA (Coll.of Sci. & Tech.,Nihon Univ.)
内藤広基[‡]，淺見拓哉，三浦　光（日大・理工）

1. Introduction

An ultrasonic source[1] using a stripe-mode rectangular transverse vibrating plate with a jut driving point outside the rectangular plate radiates strong acoustic waves in the air. The aim of this study was to demonstrate formation of a strong aerial standing wave field by using ultrasonic sources. In prior research, ultrasonic sources have been produced from a strong aerial standing wave field by using two vibrating plates[2]. In this report, a method for forming a stronger standing wave field by using four plates is proposed.

2. Ultrasonic Source

Figure 1 shows a schematic drawing of two sets of aerial ultrasonic sources formed by using two stripe-mode transverse vibrating plates with a jutting driving point. One of the ultrasonic sources consists of a 20 kHz bolt-clamped Langevin-type transducer with an exponential horn that has an amplitude expansion ratio of 4.6, and two vibrating plates and two washers connected with screws to interpose a resonance rod on the top. The dimensions of the vibrating plate are 1.2 mm in thickness, 90.8 mm on the narrow side, and 111.3 mm on the long side (see **Fig. 2**). The convex end has a narrow side of 12.0 mm and a long side of 48.0 mm. The plate acts as a stripe-mode transverse vibrating plate at 19.9 kHz. One of the ultrasonic sources is called ultrasonic source A and the other is called ultrasonic source B. The coordinate axis is defined as shown in Fig. 2.

3. Examination of the distance between two vibrating plates

Because the aerial standing wave field in this study is formed and surrounded by four plates, it is necessary to examine the length of one side of the aerial standing wave field that forms a square. Therefore, ultrasonic sources with one vibrating plate are prepared with three reflectors attached parallel with (1 reflector) and perpendicular to (2 reflectors) the vibrating plate (see **Fig. 3**). The

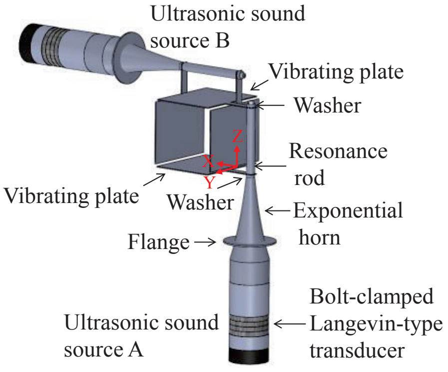

Fig. 1 Schematic drawing of the ultrasonic sound source with four vibrating plates.

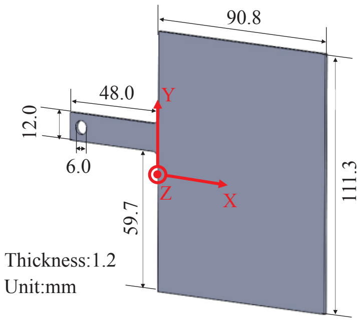

Fig. 2 Schematic drawing of the vibrating plate.

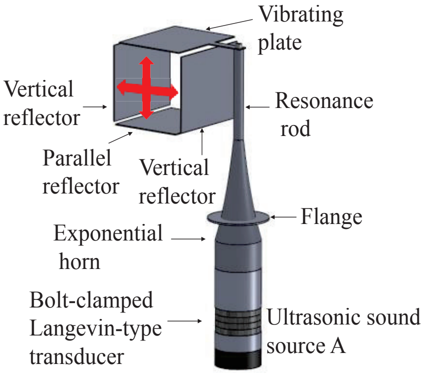

Fig. 3 Schematic drawing of the ultrasonic sound source with a vibrating plate and three reflectors.

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miura.hikaru@cst.nihon-u.ac.jp, asami.takuya@nihon-u.ac.jp, csku13023@g.nihon-u.ac.jp

dimensions of the parallel and vertical reflectors are the same as those of the vibrating plate. The change in electric impedance is measured when the distance between the vibrating plate and the reflectors is changed. The measurement range is 95–105 mm, chosen to be greater than the dimension of the vibrating plate, 90.8 mm. The input voltage is fixed at 5 V and the resonance frequency is fixed at 19.9 kHz. **Figure 4** shows the result. In the figure, the vertical axis is the electric impedance and the horizontal axis is the distance to the reflectors. The figure shows that the maximum value of the electric impedance occurs when the distance between the vibrating plate and the parallel and perpendicular reflectors is 99.4 mm. The higher electric impedance is, the higher radiation impedance is. Therefore, the distance is set as 99.4 mm.

4. Sound pressure distribution of the aerial standing wave field

4.1 Sound pressure distribution of the XY- and the YZ- plane

A microphone with a probe is used to measure the sound pressure distribution over the XY- and YZ-planes of the ultrasonic sources shown in Fig. 1. For this test, the input power is fixed at 1 W and the resonance frequency is fixed at 19.9 kHz. **Figure 5** shows the result as the sound pressure distribution in the XY- and the YZ-planes. The color shows the value of the sound pressure normalized by the maximum value of the microphone output voltage. The figure shows that the aerial standing wave field is formed symmetrically toward the X-axis and Z-axis at evenly spaced intervals.

4.2 Sound pressure distribution of the XZ- plane

The sound pressure distribution in the XZ-plane is measured in the same way as the distribution in the other planes. The input power is fixed at 1 W and the resonance frequency is fixed at 19.9 kHz. **Figure 6** shows the result as the sound pressure distribution in the XZ-plane. The color shows the value of sound pressure normalized by the maximum value of the microphone output voltage. The figure shows that aerial standing wave field is formed symmetrically toward the X-axis and Z-axis at evenly spaced intervals.

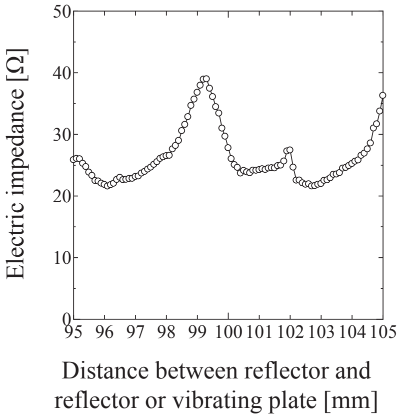

Fig.4 Relationship between distance from the reflector to another reflector or vibrating plate and electric impedance.

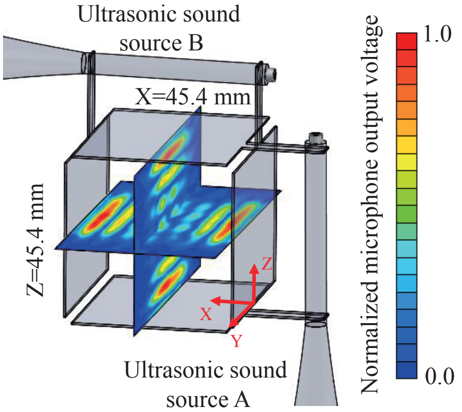

Fig. 5 Sound pressure distribution in the XY-and YZ-planes in the case of four vibrating plates.

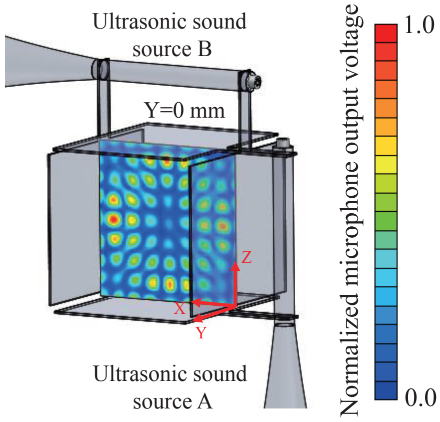

Fig. 6 Sound pressure distribution in the XZ-plane in the case of four vibrating plates.

5. Conclusions

In this study, ultrasonic sources with four vibrating plates were produced and examined. As a result, a strong aerial standing wave field was formed in the enclosure formed by four vibrating plates.

References

[1] H. Miura and H. Ishikawa, J. J. Appl. Phys., 48 , 07GM10, 2009.
[2] K.Naito, T.Asami, H.Miura, Nihon Onkyo Gakkai-Shi, pp.1265-1266, 2014.3.