3P2-5

Basic Study on Compact Airborne Ultrasound Emitter with Multiple Resonance Frequencies

Yusuke Miyasaka[1‡], Manaka Nagakita[2], Kyosuke Shimizu[1], Ayumu Osumi[2*], and Youicni Ito[2] ([1]Grad. of Sci. & Tech., Nihon Univ.; [2]Coll. of Sci. & Tech., Nihon Univ.)

1. Introduction

We have studied the high-speed non-contact and non-destructive testing method using scanning sound source technique[1-4)]. The ultrasound emitters that build up an Airborne Ultrasound Phased Array (AUPA) generally have narrowband frequency characteristics[5)]. Therefore, it is difficult for the ultrasound emitter to emit wideband sound waves such as chirp signals into the air[4)]. To solve this problem, the ultrasound emitter should have a wideband frequency characteristic.

We have proposed the ultrasound emitter with multiple resonance frequencies to realize wideband characteristics.

In this report, the numerical analysis using a Finite Element Method (FEM) was performed to verify the ultrasound emitter with three resonance frequencies.

2. Numerical analysis

The numerical analysis was performed using the FEM software COMSOL Multiphysics 6.1. **Figure 1** shows the analysis model of the ultrasound emitter and the dimensions of each resonator. Here, the analysis conditions of the numerical analysis are shown in **Table I**. A proposed ultrasound emitter has the structure in which a resonator is divided into nine parts. Note that the resonance frequency of the resonator is determined by the length and thickness of that resonator. In this report, we designed resonators as shown in Fig. 1 and placed them symmetrically. In the numerical analysis, the driving frequency of the ultrasound emitter was changed by 1 kHz in the range of 10 kHz to 80 kHz.

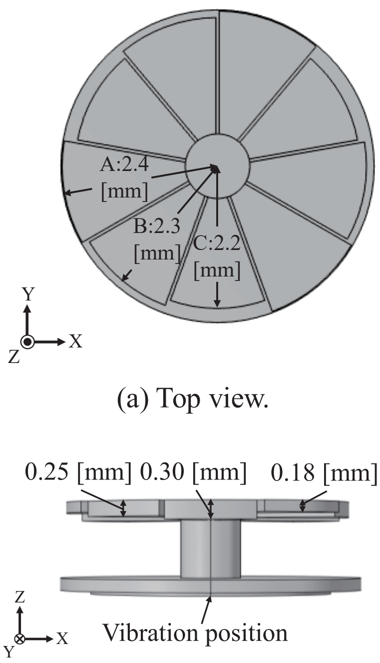


Fig. 1 Analysis model.

Table I Analysis conditions.

Materials	Duralumin, Iron, C-203, Air
Space dimension	3D
Mesh shape	Tetrahedron
Number of elements	About 140,000
Maximum mesh size [mm]	0.75
Voltage [V]	20
Time resolution [μs]	1

3. Results of analysis

3.1 Vibration of emitter

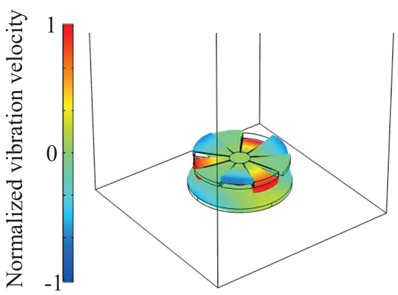
Figure 2 shows the analysis results of the vibration velocity. Fig. 2 (a) to (c) are the results of driving the ultrasound emitter at 40 kHz, 50 kHz, and 60 kHz, respectively. From the results, it can be confirmed that the entire ultrasound emitter vibrates at any frequencies.

E-mail: *osumi.ayumu@nihon-u.ac.jp

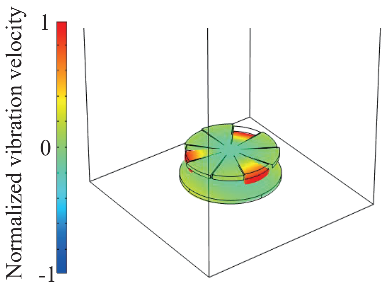
3.2 Sound field

Figure 3 shows the analysis results of the sound field when the ultrasound emitter is driven at (a) 40 kHz, (b) 50 kHz, and (c) 60 kHz. Each result shows the analysis result of the sound field indicated by the red plane in the figure (left figure). From the results, it can be confirmed that the sound waves are radiated in a form close to spherical waves at any frequencies.

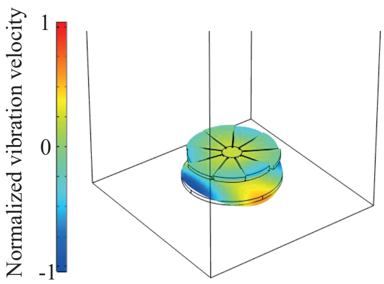
Figure 4 shows the frequency characteristic of the ultrasound emitter. The results are plots of the



(a) 40 kHz.



(b) 50 kHz.



(c) 60 kHz.

Fig. 2 Analysis results of vibration distribution.

maximum sound pressure at 10 mm on the center axis of the ultrasound emitter for each frequency. From the result, it can be confirmed that the maximum sound pressure of 26 Pa is generated at 46 kHz.

In addition, it can be confirmed that the half-value width of the frequency is the wideband of about 20 kHz (43 kHz to 62 kHz).

4. Conclusion

In this report, the FEM analysis of the ultrasound emitter with three resonance frequencies was performed for the purpose of realizing the wideband ultrasound emitter. As the results, we obtained the possibility of realizing the wideband ultrasound emitter with the bandwidth of 20 kHz.

Acknowledgment
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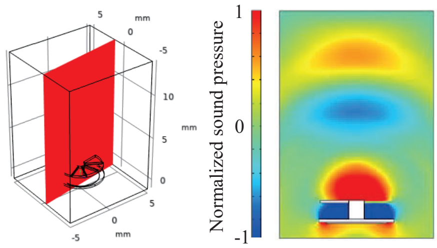
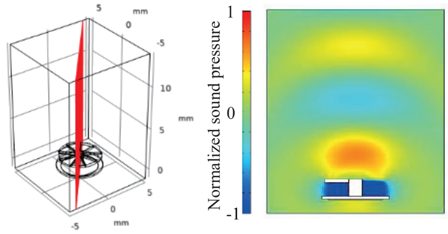
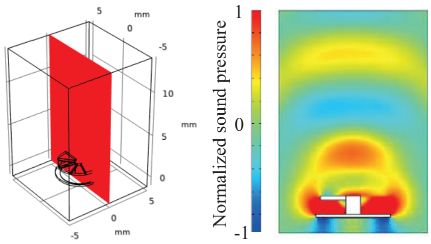


(a) 40 kHz.



(b) 50 kHz.



(c) 60 kHz.

Fig. 3 Analysis results of sound field.

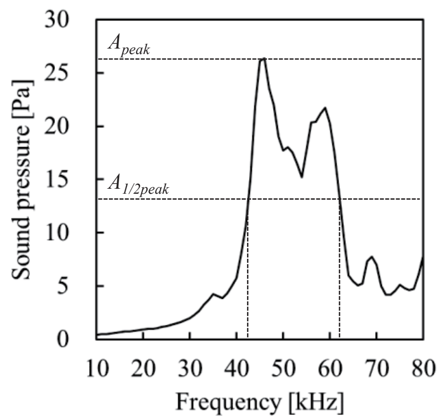


Fig. 4 Frequency characteristic.

References

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