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Proceedings of Symposium on Ultrasonic Electronics, Vol. 33 (2012) pp. 283-284
13-15 November, 2012

Effect of the interference of sounds by two sound sources in the thermoacoustic system

２音源による音響から熱への変換における音波干渉の影響

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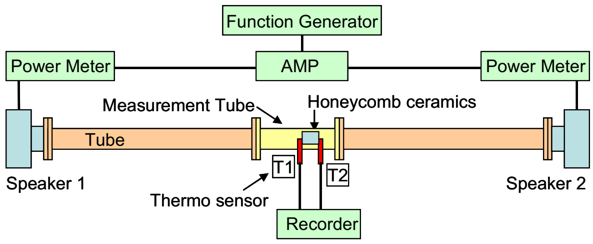
1. Introduction

A thermoacoustic system is a unique system. It realizes a cooling system using heat energy. The source energy can be taken from waste heat from a factory. In the previous paper [1], a standing wave field was formed by a speaker in a stainless steel pipe. When a honeycomb ceramics was set in the pipe, difference of temperature occurs at the both ends of the ceramics.

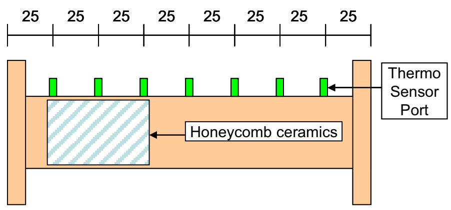
Some research of the thermoacoustic have been conducted [3,4], but it is necessary to improve the efficiency of thermoacoustic systems for the practical use. For improvement of the efficiency, a multi-stage transduction with plural elements is suggested. Furthermore, the distributed processing with plural loops is suggested, too. In the authors' system, if plural speakers are used, it is expected to provided difference of temperature that is higher than that with single speaker. In the present paper, the two speakers set in the both ends of the straight line pipe and examined the influence.

2. Experiment

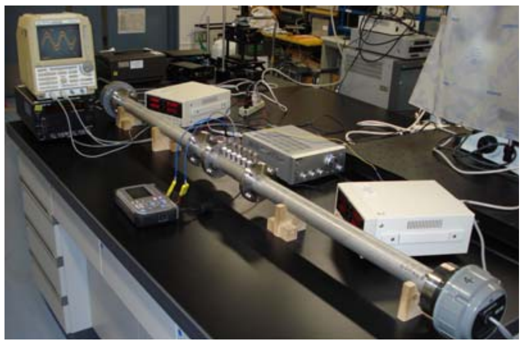
Figure 1(a) shows a basic experimental system. The stainless steel pipe consist of plural short pipes and the length can be adjust with 100 mm unit. A short pipe is 42.6 mm inside diameter and the both side flanged. There are two speakers (TOA, TU-750) at the both ends of the pipe. In addition, a measurement pipe was inserted as Fig. 1(b). The pipe is 200 mm in length, and it has seven thermocouple ports at each interval of 25 mm. A honycomb ceramics of 50 mm in length is inserted into the measurement pipe. The temperature of both ends of the honeycomb ceramics was measured by the thermocouples through the thermocouple ports. The basic tube length is 1500 mm which is 600 mm + 100 mm + 200 mm (measurement tube) + 600 mm, and the frequency was coordinated so that the wavelength equals the length of the pipe. Figure 1(c) shows a photograph of the experimental setup.



(a) Experimental system.



(b) Measurement tube part.


(c) Photograph of experimental system.
Fig.1 Experimental setup.

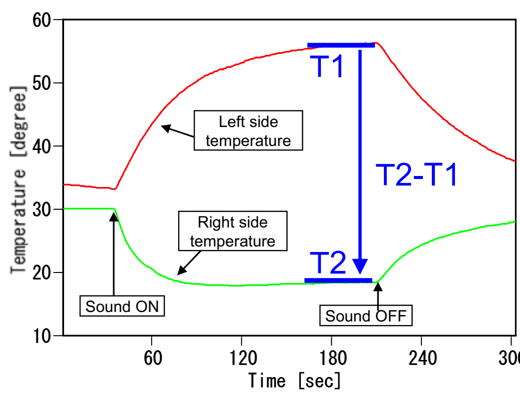


Fig. 2. Temperature-time curves (in experimental).

When the speaker is driven by a function generator and an amplifier, it radiates a sound wave

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into the pipe, and a standing wave field is generated in the pipe. The electric power controled to 10 W with a wattmeter (HIOKI, 3332). The frequency was coordinated so that a power factor is the maximum. The frequency was 217 Hz for two speakers, 224 Hz for a speaker and a reflector in the ends of the pipe.

Figure 2 shows an experimental result. When the speaker was turned on, the temperature of the honeycomb ceramics at the speaker side (T1) increased, and the temperature at the reflector side (T2) decreased. The temperature was saturated in about one or two minutes. The maximum of temperature difference |T2-T1| was 35 degrees.

3. Result and Discussion

Figure 3 shows the dependence of the temperature difference T2-T1 between two ends of the honeycomb ceramics on the position of the sound source. A speaker and a reflector are in the left and right sides, respectivery. It shows a symmetric change. There are maximum and minimum points near the center position. When it was compared with the absolute value |T2-T1|, the value is biggest from a sound source at a position of 800 mm of the distant place than that at the other peak. In the following experiments are the temperature different was measured at around 800 mm.

Figure 4 shows the experimental result using single speaker. The speaker has a hole of 18 mm in diameter at the center. The area of the hole is 20 % of that of a pipe of 42 mm inside diameter. The hole disturbes the sound field when the standing wave field is formed. The resonance frequency with two speakers is different from that with one speaker and the reflector because the sound field is different. For latter case, stronger standing wave field is formed and the maximum temperature difference of 33 degrees was realized. When one speaker was at the right side, the peak in Fig. 4 corresponds to the other peak at around 700 mm in Fig. 3. Therefore the temperature difference for c) in Fig. 4 is lower than that for b).

Figure 5 is the experimental result with two speakers. The temperature difference is shown as a function of position for varius phase difference of sound between the two speakers. The maximum |T2-T1| was 38 degrees for the phase difference of 0 at 800 mm. The value exceeds the maximum one with one speaker. In addition, |T2-T1| was near zero for the phase difference of 180 degrees. In this case the sound waves from the two speakers was canceled each other.

4. Conclusion

In conclusion, a standing wave field was formed by two speakers in the both end of a stainless steel pipe. When the two speakers were drived in same phase, the maximum temperature difference exceeded that with one speaker.

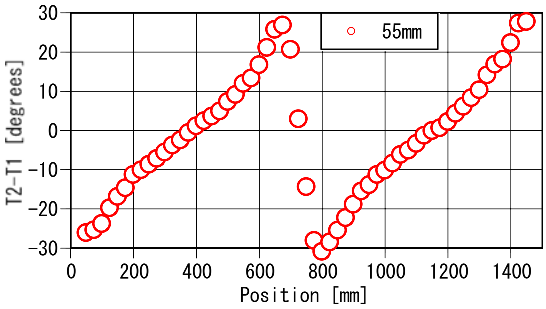

Fig. 3. Dependence of the temperature difference on the position from the sound source.

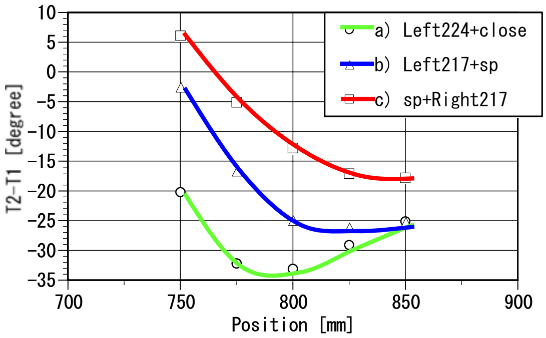

Fig. 4. Dependence of the temperature difference on the position for various conditions of the two ends.

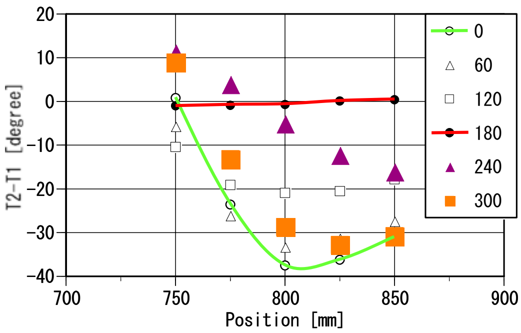

Fig. 5. Dependence of the temperature difference on the position for various phase differences.

Acknowledgment

This work was supported by a Grant-in-Aid for Scientific Research (24560281) from the Japan Society for the Promotion of Science.

References

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