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Effect of the honeycomb ceramics in the thermo-acoustic system
音響から熱への変換におけるハニカムセラミックスの影響

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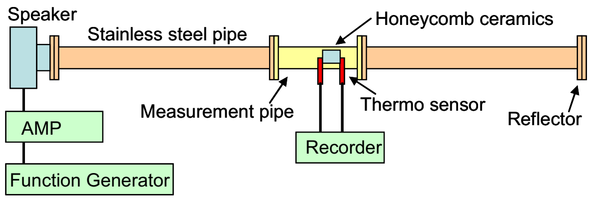
1. Introduction

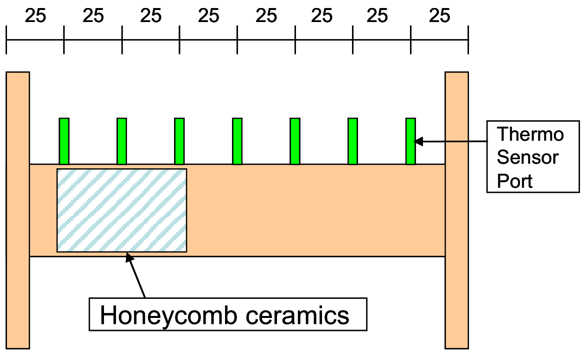
The effective use of the energy is demanded for energy saving. A thermoacoustic system can realize a cooling system using waste heat. Some research of the thermoacoustic have been conducted [1,2], but it is necessary to improve efficiency for the practical use. The authors have studied physical application of ultrasound using a standing wave field of ultrasound [3,4]. When there is a honeycomb ceramics which have a lot of slight narrow tubes in a standing wave field, difference of temperature occurs at the both ends of the pipes. The authors made a simple experimental system of the thermoacoustic using a straight pipe with honeycomb ceramics and a speaker. In the present paper, energy conversion from sound to heat is shown.

2. Experiment

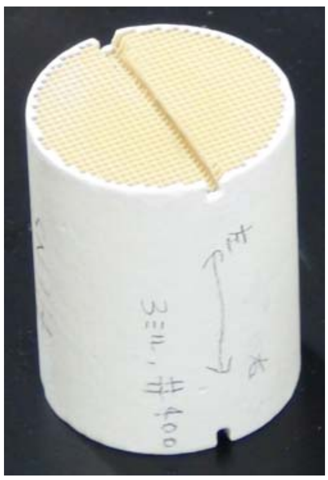
Figure 1(a) shows a basic experimental system. A stainless steel pipe is 42 mm inside diameter and 900 mm - 2,100 mm in length. The pipe is assembled by connecting plural short pipes and can adjust length by a 100 mm unit. There is a speaker (TOA, TU-750) at the left end and a stainless steel board was at the right end of the pipe. When the speaker is driven by a function generator and an amplifier, it radiates a sound wave into the pipe, and a standing wave field is generated in the pipe. The frequency was coordinated so that the wavelength equals the length of the pipe. Figure 1(b) shows a measurement pipe. The pipe is 200 mm in length, and it has seven thermocouple ports at each interval of 25mm. Figure 1(c) shows a honeycomb ceramics. The length of the ceramics is the multiple of 25mm and it is inserted into the measurement pipe. The temperature of both ends of the honeycomb ceramics was measured by the thermocouples through the thermocouple ports in the lateral wall of the measurement pipe.



(a) Basic experimental system.



(b) Measurement pipe.



(c) Honeycomb ceramics.

Fig. 1. Experimental setup.

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3. Experimental result and discussion

Figure 2 shows an experimental result. In this case, the pipe length is 1400 mm. The electric signal to drive the speaker is 239 Hz and 10 W. The honeycomb ceramics is 42 mm in diameter, 50 mm in length, #400 in hole size and 4 mil in wall size. The time for measurement was ten minutes. The speaker turned on after one minute from the start of the measurement and radiated the sound wave for five minutes. When the speaker turned on, the temperature of the honeycomb ceramics at the speaker side increased, and the temperature at the reflector side decreased. The temperature was saturated in about one minute. The temperature of both sides of the ceramics increased slowly together afterwards. This is the result of the thermoacoustic effect. In addition, the electric power to speaker heat up the whole honeycomb ceramics.

Next, the influence of the pipe length, position and length of honeycomb ceramics was studied. The studied pipe length were 900 mm, 1500 mm, and 2100 mm. The position of the honeycomb ceramics was varied with every 25 mm step. Its length was changed for three cases; 25 mm, 50 mm, and 75 mm. Figure 3 shows the difference of temperature T2-T1 between two ends of the honeycomb ceramics. All results showed a similar curve. Maxima in |T2-T1| appeared at the both ends of the pipe and near its center. In this experiment, the maxima value of |T2-T1| was observed at the pipe length of 1500 mm. For each length, |T2-T1| was larger for longer honeycomb ceramics.

4. Conclusion

In conclusion, 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. The influence of pipe length, position and length of honeycomb ceramics was studied. The difference of temperature between two ends of the honeycomb ceramics varied with position of honeycomb ceramics in a similar way for all the conditions. Maxima in |T2-T1| was observed at the both ends of the pipe and its center.

References

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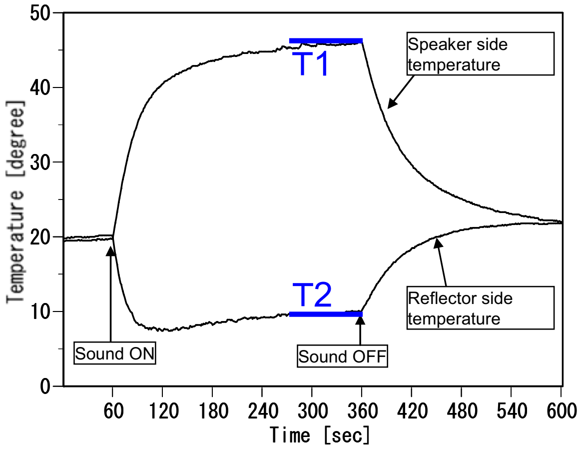
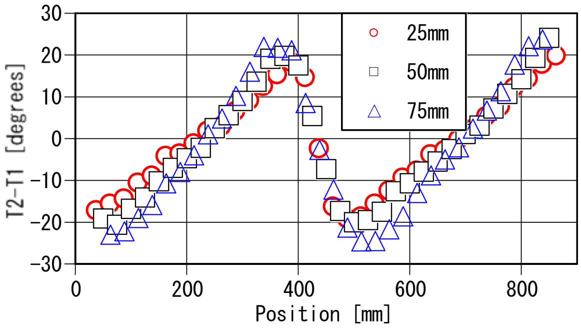
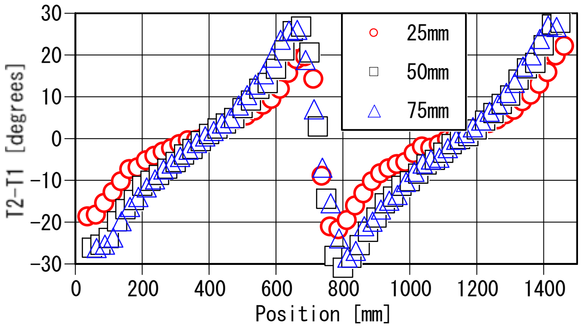


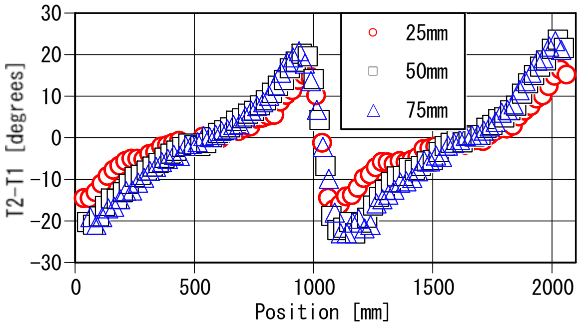
Fig. 2. An experimental result.



(a) The pipe length is 900 mm (374 Hz).



(b) The pipe length is 1500 mm (226 Hz).



(c) The pipe length is 2100 mm (163 Hz).

Fig. 3. Dependence of the temperature difference on position for various length of ceramics.