1P4-11

Study of electric power generation by a thermoacoustic engine
熱音響エンジンを用いた発電の検討

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1. Introduction

In recent years, the maintenance of the global environment is needed, because there are problems of the global warming and decreasing energy resources. A thermoacoustic system is a unique system for conversion of heat into acoustic energy, and vice versa. Unused heat such as waste heat from a factory, the solar heat etc. could be used as the source energy in a thermoacoustic engine. It is expected in future as energy reuse and energy saving. Many researchers have conducted such researches [1-3].

The simplest thermoacoustic engine is Rijke tube which converts heat into sound. Moreover, it is disirable to convert the acoustic energy into electric power. Because it is easy to transport it to a distant place through an electric wire. In addition, if the energy is electrical, it can be utilized in various existing electric apparatus. In the present paper, the energy conversion is studied from sound generated by a thermoacoustic engine into electric power.

2. On the standing wave field

An experiment was conducted to generate a standing wave field using a speaker and a tube. A piezoelectric element was inserted into the sound field. Figure 1 shows a basic experimental setup. An acrylic tube is 40 mm in inner diameter and 1,000 mm in length. There is a speaker (TOA, TU-730A), at the left end and a reflector which is an acrylic board is at the right end of the tube. When the speaker is driven by a function generator (NF, WF1946B) and an amplifier (YAMAHA, A-S301), it radiates a sound wave into the tube, and a standing wave field is generated in the tube. The frequency was coordinated so that the half wavelength equals the length of the tube. Figure 2 shows the sound pressure distribution of the tube when the speaker was driven at 161 Hz and 10 W. The maximum pressure was observed at the both ends of the tube. The minimum pressure was at the center of the tube. It shows a standing wave field generated in the tube.

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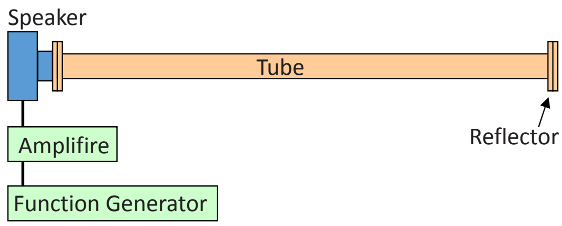

(a) Experimental system.

(b) Photograph.
Fig. 1. Experimental setup.

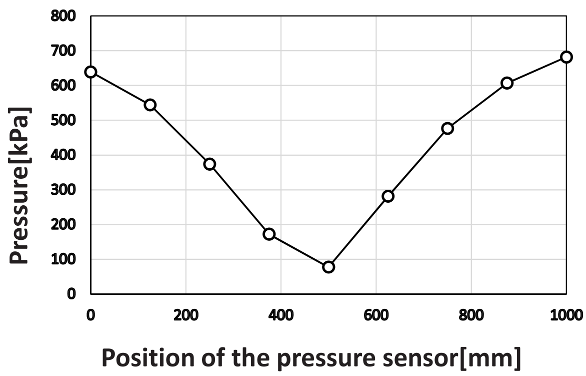

Fig. 2. Sound pressure distribution on the tube.

Fig. 3. Photograph of the transducer.

Figure 3 shows a piezoelectric element (Akizukidenshi, FGT-31T-3.7A1), it was inserted in the tube. Figure 4 shows the experimentally measured voltage generated by the piezoelectric element as a function of the position. In this experiment, the driving electric power to the speaker was 3 W or 10 W. The generated electric voltage is higher in the center area of the tube in the each cases. Figure 5 shows wave form of the voltage. It shows that there are two frequency components; the fundamental frequency (161 Hz) and the third harmonics (483 Hz). When the voltage was maximum, the light emitting diode (LED) lighted with connected electric circuit.

3. On the thermoacoustic engine

Next, a similar experiment was conducted using a thermoacoustic engine with a straight tube. The thermoacoustic engine is made of a glass tube with a honeycomb ceramics at an appropriate position to convert heat into sound. The length of the thermoacoustic engine is 1,000 mm. The both side is closed. The edge face of the honeycomb ceramics was twined with nichrome wire which is electric heater. When the heater is on, the temperature difference between the both sides of the honeycomb ceramics increases and it generates beep sound. Figure 6 shows the experimentally measured temperature-time curves between the both ends of the honeycomb ceramics and the signal of a microphone. It shows that when the temperature difference is over 90 degrees, the sound is generated.

Figure 7 shows the voltage by the piezoelectric element in the sound field. Although a complicated change is seen, the maximum is around the center. Under this condition, the LED did not light.

4. Conclusion

A thermoacoustic engine converts heat into sound. Moreover, it is desirable to convert the acoustic energy into electric power. When a standing wave field was generated using a speaker, the electrical power was generated using a piezoelectric element. When a thermoacoustic engine was used, the electrical power was also generated.

References

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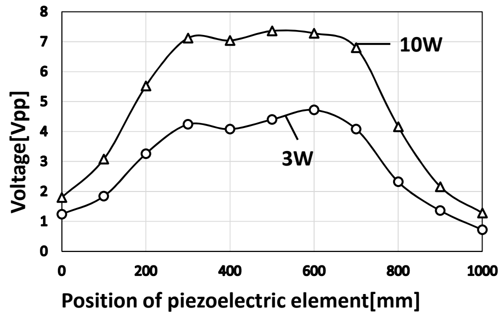

Fig. 4. Generated voltage of the transducer.

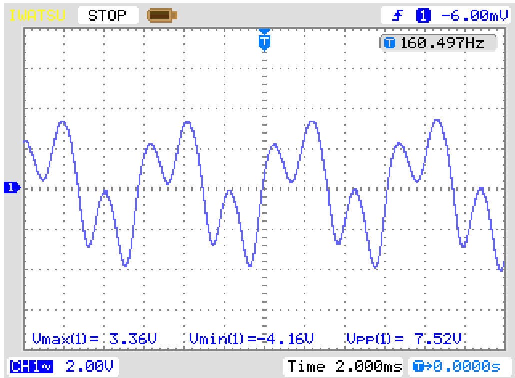

Fig. 5. Waveform of the voltage.

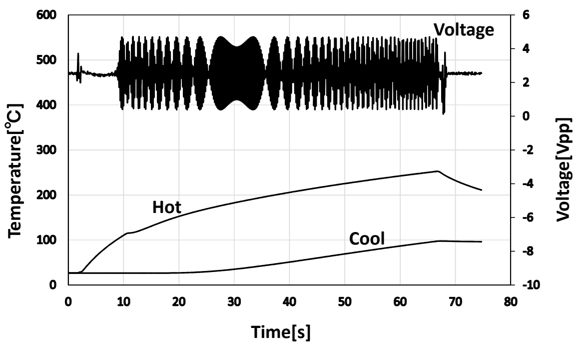

Fig. 6. Result of the experiment.

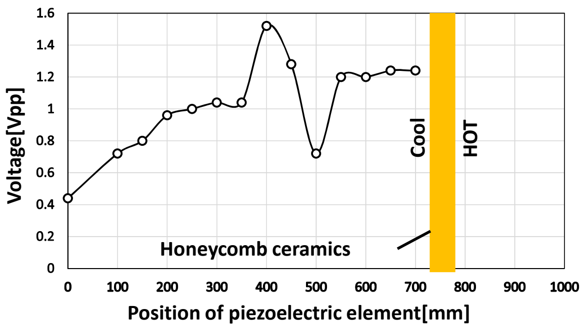

Fig. 7. Generated voltage of the transducer on the thermoacoustic engine.