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Influence of external heat input by parallel plate fin heat exchanger on sound field of thermoacoustic system

平行平板フィン熱交換器による外部熱入力が熱音響システムの音場に与える影響

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1. Introduction

A thermoacoustic system[1)] is expected to be a means to suppress environmental burdens. A thermoacoustic phenomenon is the conversion of energy from heat and sound. Utilizing this phenomenon, both cooling and electric power generation haves been studied.[2-4)] A thermoacoustic system is driven by using waste heat and solar heat as a heat source. For this reason, effective utilization of unused heat is considered possible. However, heat input by electric heaters is used mainly in research on thermoacoustic systems. Regarding the influence of external heat input on the thermoacoustic system, there are yet many unexamined areas.

We conducted experiments with external heat input for the practical applications of thermoacoustic systems in this study. A heat exchanger with parallel plate fins was used as a means to input external heat to the system. In previous research, the thermoacoustic system using heat exchanger with parallel plate fins was proposed.[5)]

In this study, the heat input was from an electric heater wound in a spiral shape and a heat exchanger with a parallel plate fins to drive a straight-tube-type thermoacoustic system. Experimental studies were conducted on the influence of the heat exchanger with a parallel plate fins on the sound field by measuring and comparing the sound field in the tube in each heat input method.

2. Experimental method

The heat exchanger with a parallel plate fins is shown in **Fig. 1**. Inside the heat exchanger, 28 fins with a flow channel lengths of 10 mm and a plate thicknesses of 0.5 mm are arranged at intervals of 1.5 mm. The cartridge heater is inserted into the heat exchanger. In this experiment, electric power was supplied to the cartridge heater and heat was inputted through the fins. The schematic diagram of the system used for the experiments is shown in **Fig. 2**. Stainless steel was used for the resonance tube, and a straight-tube-type thermoacoustic system with a total length of 2000 mm was constructed. The inner diameter of the resonance tube is 42.6 mm. Atmospheric pressure air was used as the working fluid in the tube. The stack was made of honeycomb ceramics. It has a cell count of 600 channels/in^2 and a length of 50 mm. The installation position of the stack was 300 mm from the closed end of the tube. The sound pressure inside the tube was measured by a pressure sensor (PCB Piezotronics, 112A21). The installation position of the four pressure sensors were 0, 420, 1420, and 2000 mm from the closed

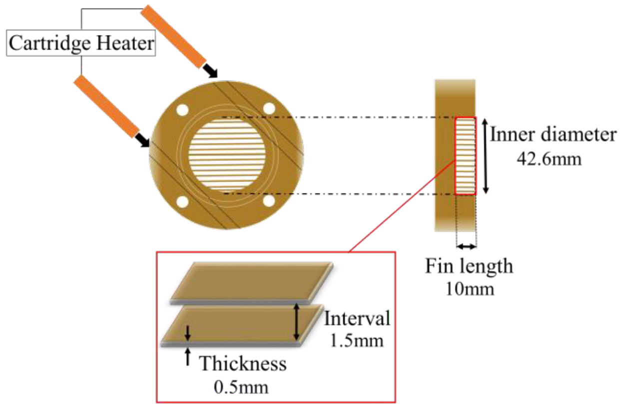

Fig. 1 Illustration of parallel plate fin heat exchanger.

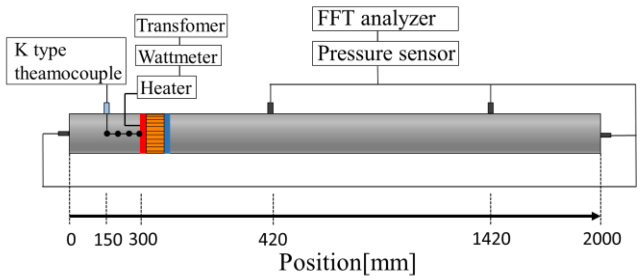

Fig. 2 Schematic illustration of experimental system.

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end of the tube. The K-type thermocouple was used to measure the high-temperature side of stack and on the inside of the tube. The installation position of the K-type thermocouple was in four places: 150, 200, 250, and 300 mm (the high-temperature side of stack) from the closed end of the tube. The sound field distribution on the low-temperature side of the stack was calculated using the two-sensor method.[6,7] the sound field distribution on the high-temperature side of the stack was obtained from the measured sound pressure.

The input power to the electric heater and the cartridge heater was 140, 160, 180, and 200 W, respectively. First, 140 W was charged to the heater. The input electric power was kept constant, and the sound field with the sound wave inside the tube, which reached steady state, was then measured. After that, the same measurement was carried out at 160, 180, and 200 W.

3. Experimental results

The change of the sound intensity before and after the stack due to the increase of input power is shown in **Fig. 3**. It was confirmed that the sound intensity increased with the increase of the input power in both of the heat input methods. In addition, it is confirmed that the increment of the sound intensity showed a larger value for the electric heater than the heat exchanger with parallel plate fins. Increase in the sound intensity depends on the increase in the input power. The gradient of increasing sound intensity in the electric heater and the heat exchanger with parallel plate fins were similar. The temperature distribution inside the tube at 200 W of input power is shown in **Fig.4**. At the same input power, it is confirmed that the electric heater has a higher temperature at the high-temperature end of the stack. This is thought to be because in the heat exchanger with parallel plate fins, the supplied heat was transferred to the tube wall and air. For that reason, it is thought that the amount of heat flowing into the stack is lesser than that of the electric heater, and the amount of the increase in intensity is reduced.

4. Conclusion

In this study, the sound intensities were compared with an electric heater and a heat exchanger with parallel plate fins for heat input. It was confirmed that the increase in the sound intensities in the tube was larger for the electric heater. The sound intensity increased similarly with the increase of input power. In the future, it is necessary to study the influence of the change in the shape of the fin on the increasing trend of the intensity.

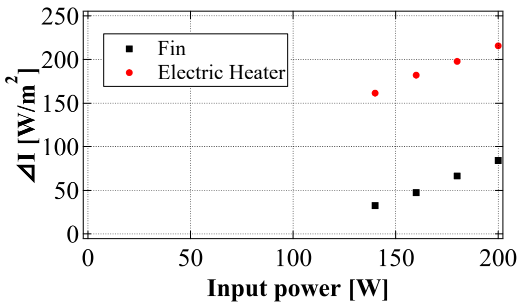

Fig. 3 Change of the sound intensity before and after the stack due to the increase in input power.

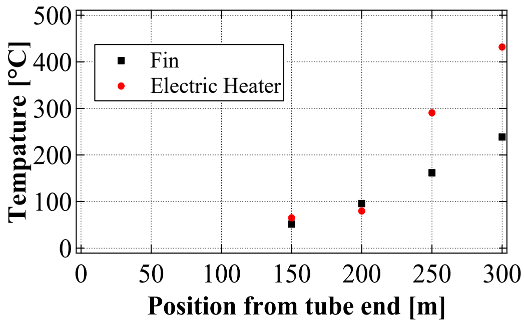

Fig. 4 Temperature distribution inside the tube at 200 W.

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References

1. A.Tominaga: Fundamental Thermoacoustic, (Uchida Rokakuho, Tokyo, 1998), pp. 9-30, [in Japanese].
2. T.Yazaki, *et al.*: Appl. Phys. Lett, **80** (2002) 7.
3. S. Backhaus, *et al.*: Appl. Phys. Lett, **85** (2004) 9.
4. S.Ueno, *et al.*: J. Appl. Phys. **56** (2017) 07JE07.
5. G.W. Swift, Thermoacoustic engines, J. Acoust. Soc. Am., **84** (1988) 1145-1180.
6. A.Fusco, *et al.*: J. Acoust. Soc. Am., **91** (1992) 1.
7. T. Biwa *et al.*: J. Acoust. Soc. Am., **124** (2008) 1584-1590.