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On the Thermoacoustic Phenomena Caused by the Heat Phase Adjuster.

ヒートフェーズアジャスタ設置に起因する熱音響現象について

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1. Introduction

An energy conversion efficiency of thermoacoustic engine was improved by many researches.[1)] Proposed improvement methods by our group were a phase adjuster (PA)[2,3)] and expanding phase adjuster (EPA)[4)] devices, both methods have partially reduced or expanded the inner-diameter path. When PA or EPA is set on the thermoacoustic system, it acts as an amplifier and stabilizer of the system oscillation. As the results, the efficiency of energy conversion improved steeply, and the stabilized resonant oscillation are also observed. We are researching about these phenomena which are affected by the position and length of PA. However, these mechanisms are not clear yet, and there are some problems for these devices. Because PA is a solidified device and is located in the thermoacoustic tube, it is difficult to tune and move them to the best setting position while the system is running. Therefore, it is necessary to find easier methods that produce the same effects of PA and EPA as the amplifier and stabilizer.

In the previous study, an easy method to get the high efficiency and the stable oscillation was proposed. This method is based on a local heating technique, the acoustic tube was partially heated by an electric heater. We called it heat phase adjuster (HPA).[5)]

In this study, we put the HPA on the position where can change to multiple resonant mode to discuss the relationship between temperature of the HPA position and acoustic field.

2. Experimental Method

Figure 1 shows the schematic illustration of the experimental system. Experiments were carried out using the loop-tube-type thermoacoustic system. The total length of the system was 3300 mm and the inner diameter of the tube was 42 mm. The thickness of the prime mover stack and the channel radius was 50 mm and 0.45 mm (900 cells/inch^2), respectively. The internal fluid of the experimental system was air, and the temperature gradient of the stack was formed by an electric heater and circulating *water as shown. The high temperatu*re end of the stack was heated up using the electric heater with 330 W. The position of the HPA was 650 mm from the high heat temperature end, in a clockwise direction. The HPA was set outside of the acoustic tube, the width of the coiled HPA was 50 mm and the heat input quantity of the HPA Q_{HPA} was changed from 0 to 240 W. Firstly, only the prime mover was driven, and the HPA started 600 seconds after.

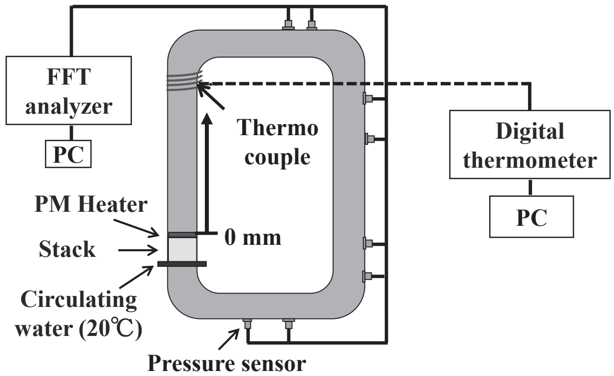

Fig.1 Schematic of experimental system.

The sound pressure fluctuation in the system was measured using pressure sensors (PCB Piezotronics Inc.). Temperatures of the stack ends and HPA position were measured by K-type thermocouples.

3. Experimental Results and Discussion

Figure 2 shows temperature changes on the stack both ends and inside air of the HPA position. The numbers of wattage in this figure show Q_{HPA}.

First, the prime mover stack is heated up, few seconds after thermoacoustic phenomena is occurred. When a Q_{HPA} is 0 W, 2-wavelength resonant mode is observed as shown in **Fig.3**. In our experiments, 2-wavelength resonant mode is usually observed without HPA condition. Temperatures of the stack hot end T_{H} and cold end T_{C} are stable in this condition.

After 600 seconds, a Q_{HPA} is supplied with 40 W, though resonant mode is same as 0 W conditions, T_{H} increases with increasing temperature of the HPA T_{HPA}. Therefore, it is estimated an energy conversion from heat to sound is not active.

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At the beginning of 80 W, T_H increases same as 40 W conditions. However, T_{HPA} reaches to 55 ℃, resonant mode changed to 3-wavelength as shown in **Fig.4**. Temperature of the stack both ends changed significantly. It may because of the heat flow change with the shift of resonant mode.

At the beginning of 160 W, T_{HPA} is fluctuating hardly. Additionally 1-wavelength and 2-wavelength resonant mode is appeared, and acoustic field is unstable. However, T_{HPA} reaches to 70 ℃, resonant mode changed to 1-wavelength as shown in **Fig.5**. T_{HPA} also becomes stable.

When a Q_{HPA} is 240 W, resonant mode is same, and temperature of the stack both ends changed gradually with changing T_{HPA}. And energy conversion efficiency was improved more than 160 W under same resonant mode.

From these results, existence of the threshold of T_{HPA} to change resonant mode is estimated.

By the measuring temperature the acoustic impedance Z is obtained. When a Q_{HPA} was 0 W, Z of the HPA position was 410 Pa・s/m^3, and Z when resonant mode changed from 2 to 3-wavelength and from 3 to 1-wavelength was 388, 380 Pa・s/m^3, respectively. It is estimated that partial Z change affects to acoustic field of the system.

4. Conclusion

In this study, the HPA was placed on the position where can change to 1 or 3-wavelength resonant mode. As the results, it was found that the resonant mode can change depending on temperature of the HPA. We consider that this method is useful to drive this system steadily. Further studies are needed in order to make the system practicable using this method.

Acknowledgments

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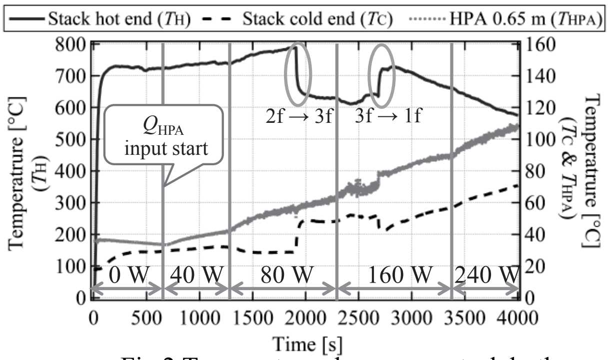

Fig.2 Temperature changes on stack both ends and inside air of the HPA position.

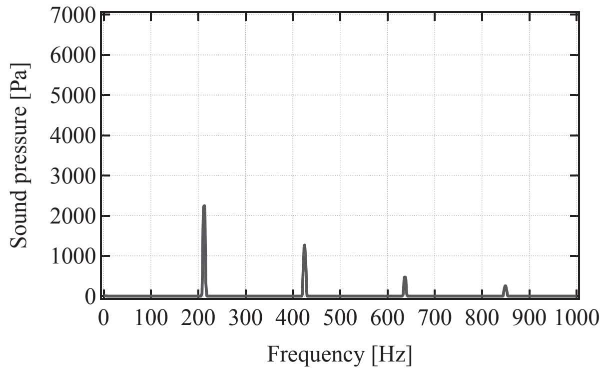

Fig.3 Sound pressure spectrum, when the Q_{HPA} was 0 W.

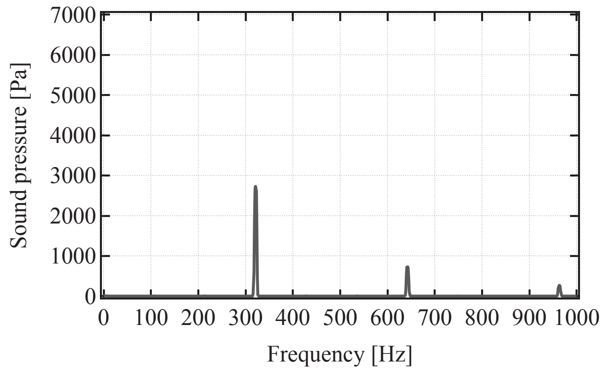

Fig.4 Sound pressure spectrum, when the Q_{HPA} was 80 W.

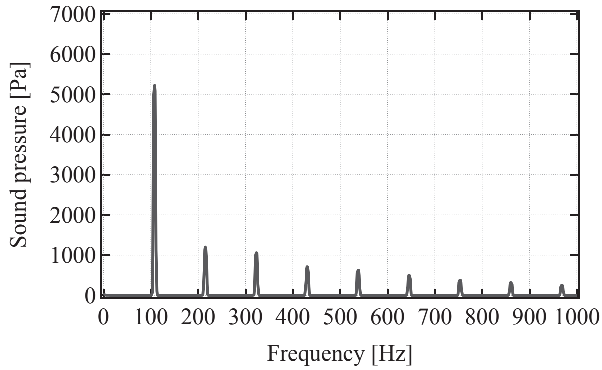

Fig.5 Sound pressure spectrum, when the Q_{HPA} was 160 W.