1P4-7

# A prototype of a thermoacoustic prime mover of the full-length 29 m -Numerical calculation of system internal diameter and onset temperature-

## 全長 29m ループ管型熱音響プライムムーバーの試作 －内径と発振温度について数値計算－

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### 1. Introduction

A system applying thermoacoustic technology has many features that cannot be realized using existing systems[1-6]. For example, given that for an external combustion engine, there are many choices for the type of heat input; hence, it is possible to use waste heat effectively. Furthermore, the lack of moving parts and inexpensive construction are also advantages of such systems. Such systems are expected to have a wide range of applications.

Many researchers are working on the development and design of thermoacoustic systems[1-23].

However, only a few studies have focused on the shape of the thermoacoustic system[13-23]. Research on miniaturization of thermoacoustic systems was carried out in Symco[14], Penellet[15] and our group[16-18].

However, research on long or large thermoacoustic systems has not progressed much[19]. The frequency of the generated sound wave of the thermoacoustic system is inversely proportional to the total length of the system. Therefore, when the system is lengthened, the frequency of the generated sound waves are reduced. When the frequency is low, the energy conversion efficiency is expected to improve. On the other hand, in terms of effective utilization of waste heat, assuming that the heat is input from multiple remote heat sources, a long thermoacoustic system is considered to be effective. Also, the output increases as the inner diameter is increased.

In this study, we designed a prototype of a long loop-tube-type thermoacoustic prime mover. The onset temperature—the temperature at which the generation of thermoacoustic self-excited oscillation begins—of the thermoacoustic system was estimated using the stability analysis method proposed by Ueda et al.[13] The relationship between the inner diameter and the onset temperature was considered.

### 2. Numerical calculation of system

We have been conducting research using a loop-tube-type thermoacoustic prime mover of approximately 3.4 m in length. We designed a system with a total length of 29 m using the results and calculation methods obtained in previous studies[13, 22, 23]. We examined the inner diameter of the system. The onset temperature when the tube inner diameter $ID_{tube}$ was 0.1 to 0.8 m was calculated. A schematic of the model of the investigated loop-tube-type thermoacoustic prime mover is shown in Figure 1.

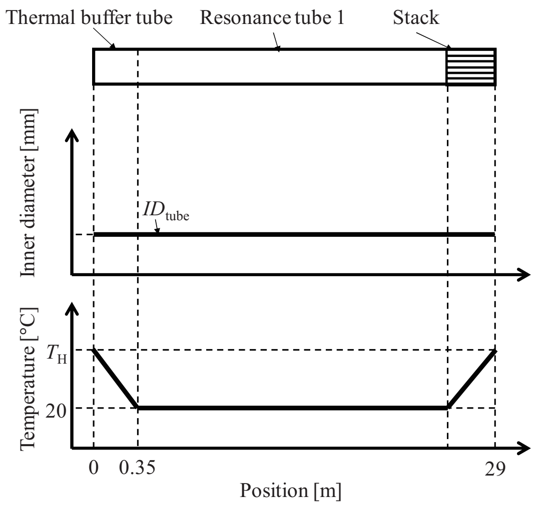


Figure 1 Analytical model for stability analysis, inner diameter, and temperature distribution.

The total length *L* of the system was 29 m. A Stack was honeycomb ceramic with a length of 50 mm. The stack channel radius was 0.635mm. The temperatures of the low-temperature side of the stack was kept at 20 ˚C (293.15 K) and the temperature gradients in the thermal buffer tube and the stack were assumed to be linear. Thermal buffer tube length was 350 mm. The working fluid in the system was atmospheric air.

The calculation results are shown in Figure 2. Based on the calculation results, it was confirmed that the onset temperature was very high. When the inner diameter was 0.5 m, the onset temperature was found to be approximately 900 ˚C. It was also found that the onset temperature was approximately 400 ˚C, even when the inner diameter was 0.8 m.

We considered that at such a high onset temperature, the same inner diameter thermoacoustic system is not suitable for practical applications. These results indicated that PA[21] or other methods need to be used to design long thermoacoustic systems.

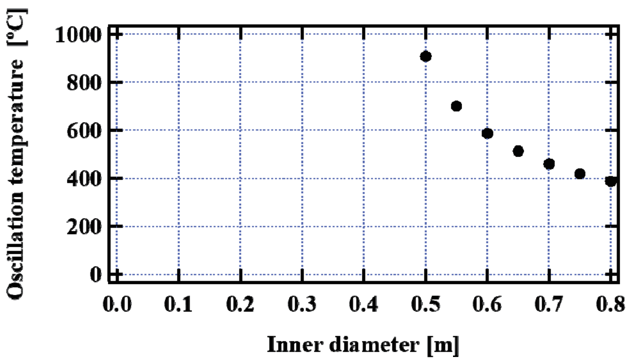


Figure 2 Calculation results of the onset temperature with the inner diameter of the tube from 0.1 to 0.8 m.

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