HOKKAIDO UNIVERSITY

Title	Research on Coupling Mechanism of Primary Acoustic Instability in Downward-Propagating Flames [an abstract of dissertation and a summary of dissertation review]
Author(s)	尹, 晟煥
Degree Grantor	北海道大学
Degree Name	博士(工学)
Dissertation Number	甲第12453号
Issue Date	2016-09-26
Doc URL	https://hdl.handle.net/2115/63328
Rights(URL)	https://creativecommons.org/licenses/by-nc-sa/2.1/jp/
Type	doctoral thesis
File Information	Youn_SungHwan_abstract.pdf, 論文内容の要旨

Hokkaido University Collection of Scholarly and Academic Papers : HUSCAP

学 位 論 文 内 容 の 要 旨

DISSERTATION ABSTRACT

博士の専攻分野の名称　博士（工学）　氏名　尹 晟煥

学 位 論 文 題 名

Title of dissertation submitted for the degree

Research on Coupling Mechanism of Primary Acoustic Instability in Downward-Propagating Flames
(下方伝播火炎における燃焼と音響学的不安定性の相互作用に関する研究)

The understanding of thermo acoustic instabilities caused by an effective interaction between the heat release by combustion and acoustic fluctuations are of fundamental importance because industrial applications such as gas turbines and rocket engines often suffer when strong pressure disturbances develop. It is therefore significant to suppress the instabilities by acoustically decoupled flame as much as possible for engine designs considering the safety of accidental explosions.

Recent experimental studies of such thermo acoustic instability have frequently been conducted in downward-propagating flames in a tube open at one end, and described the different types of the development of acoustic instability which are a primary acoustic instability evolving from a smooth curved shape to a flat flame and a violent secondary acoustic instability evolving from the flat flame to a corrugated structure. The secondary acoustic instability is caused by pre-existing finite-amplitude of the primary acoustic oscillations. Therefore, the primary acoustic instability is key feature of the whole process. However, an important unsolved problem is the generation mechanism of the primary acoustic instability because this instability is a major cause of flame instability initiation.

This paper is concerned with the coupling mechanism of primary acoustic instability of downward-propagating flames in a combustion tube. As tested gases, we selected ethylene/methane/propane premixed flames diluted with carbon dioxide or nitrogen. The flame front propagates from the open to the closed end of the tube, and, for a particular position, starts vibration under the presence of acoustic sound resonating at quarter wavelength. We call this phenomenon as the primary acoustic instability and focus on the growth mechanism responsible for acoustic sound amplification.

In Chapter 1, we elucidate premixed flame overview and intrinsic flame instabilities. Then, the potential coupling mechanisms of acoustic instability suggested by previous researchers are introduced, and our previous studies are briefly summarized. Finally, objective and scope of this study are presented.

In Chapter 2, the experimental setup and procedure are described. The propagation tube (transparent acrylic tube, 50-mm inner diameter and 511-mm length for Chapter 3 and 4; 50-mm inner diameter and 711-mm length for Chapter 5) is fixed vertically and charged with the tested gas at atmospheric pressure. The time-dependent behaviors of the downward-propagating flame are recorded by two high-speed cameras. The temporal variation of the primary acoustic pressure is measured at the bottom end of the tube.

In Chapter 3, the main focus is to establish the dominant onset mechanism of primary acoustic

instability between pressure coupling and acceleration coupling. To change the coupling constant, various gas compositions for lean ethylene flames diluted with carbon dioxide or nitrogen are used. Also, we utilize the CO2 laser irradiation method to alter the shape of the flame front. Finally, we also estimate the effects of acoustic losses on acoustic instability.

In Chapter 4, we describe the effects of the Lewis number on primary acoustic instability in non-equidiffusive flames based on pressure coupling which is more dominant mechanism as discussed in Chapter 3. In general, the chemical reaction rate becomes more sensitive to variations in gas temperature with decreasing Lewis number. This has a significant effect on the enhancement of acoustic sound, because gas temperature fluctuation is generated from acoustic pressure fluctuation under constant enthalpy.

In Chapter 5, the effect of the various fuels such as CH4, C2H4 and C3H8 diluted with N2 or CO2 on acoustic instability are discussed. Different fuels cause to change gas properties and Le. Therefore, the effects of fuel on generation mechanisms of the primary acoustic instability as well as the secondary acoustic instabilities are discussed following the previous Chapters 3 and 4.

In Chapter 6, conclusions of the present work are summarized.