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微小重力環境を用いた複数液滴の冷炎ダイナミクスの解明 -PHOENIX2 プロジェクト進捗報告-

Elucidation of cool flame dynamics of multiple droplets under microgravity -PHOENIX2 project status report-

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1. Introduction

As fundamental research on spray combustion, the spontaneous ignition phenomenon is important, and research has been conducted by various approaches. The project will be conducted by the Japan-Germany international cooperation using a sounding rocket. A spontaneous ignition experiment of the fuel droplet array is performed under the gravity environment, and the location and occurrence timing of the cool flame is measured. In the future, this data will be used as reference data of a simplified reaction model for numerical calculation of combustion, so that it is useful for the modeling of combustion oscillation and development of diesel engines, etc. To clarify the generation timing and position of the cool flame that affects spontaneous ignition, an experimental apparatus for the fuel droplet array was developed. This report describes the development status of the experimental equipment and plans.

2. Experimental apparatus

The purpose of this project is to control natural convection and acquire reference data for cool flame generated from droplets in a microgravity environment using TEXUS rocket. To evaluate the effect of cool flame interference between droplets, experiments are carried out using droplet arrays. The cool flame can be observed by excitation light of formaldehyde, and we observe spontaneous ignition (position, timing), propagation (shape, velocity), and vibration phenomena clarified by calculation. Figure 1 shows a photograph of the experimental apparatus under assembly. The experimental apparatus consists of a combustion chamber with a shutter, a droplet array suspension system, a droplet array generator, a fuel feed pump, a droplet array elevator, CCD video cameras, a high-speed video camera, and LED backlights. All devices were controlled by a programmable sequencer. A droplet array is generated outside the combustion chamber and inserted into the combustion chamber through the slit at the bottom of the combustion chamber by the droplet array elevator just before observation. Liquid fuel is supplied from a Micro syringe to the droplet array generator by a stepper motor. Figure 2 shows the droplet array suspension system. The droplet array is generated by thin glass needles of the droplet array generator and suspended at the intersection point of the SiC fibers (diameter: 14 μm) of the droplet array suspension system. The assembly of the experimental apparatus is almost complete. A function verification test and a vibration test will be carried out in the future. After all tests, the experimental equipment is transported to the launch site.

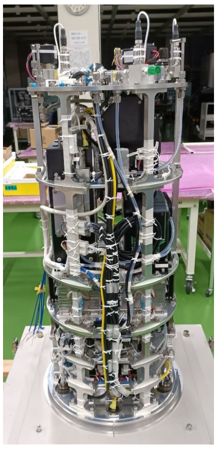

Figure 1. Droplet combustion experiment apparatus.

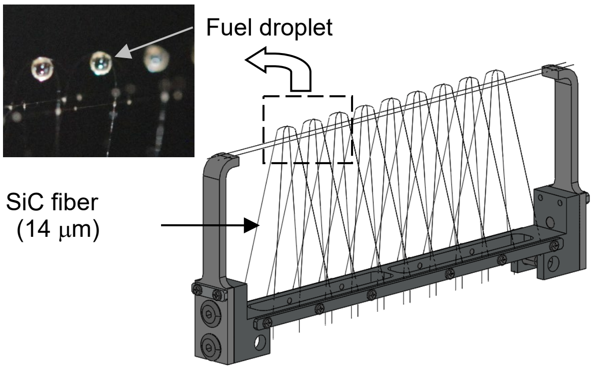

Figure 2. Droplet array suspension system.

3. Numerical analysis using deep learning

A method to analyze cool flame dynamics using deep learning has been developed. Figure 3 shows an example of the analysis results. The data of temperature and chemical species in cool flame vibration obtained by numerical analysis are reduced in dimension by deep learning and mapped onto a two-dimensional phase plane. Physical and chemical processes affect each other in a complicated manner. It shows that nonlinear dynamics can be specified in two dimensions.

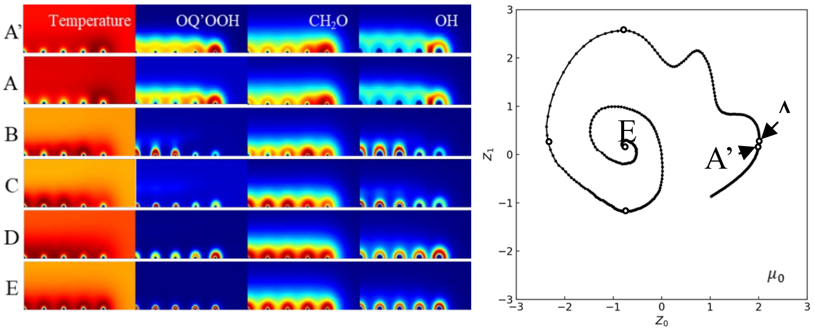

Figure 3. An example of numerical analysis results.

Acknowledgments

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