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# 液滴列を燃え広がる冷炎の挙動観察用微小重力実験装置

# Microgravity experimental device for observing the behavior of cool flame spreading along droplet array.

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## 1. Introduction

Spray combustion is used for internal combustion engines such as a diesel engine and a rocket engine. To control the ignition and combustion, it is important to know a mechanism of the spray. An internal combustion engine using fuel spray happens the two-stage ignition which hot flame of about 2000 K occur after cool flame of about 1000K. The cool flame has a great effect on outbreak of the hot flame. Therefore, clarifying cool flame is important to elucidate combustion mechanism of spray combustion. The studies of ignition were conducted by many researchers. Moriue et al. compared the induction times of n-alkane droplets with different volatility[1]. Mikami et al. compared the influence of the flame spreading direction and the and local interactive effect[2]. In this study, the experiment is conducted using droplets with different diameters to observe the flame propagation behavior of cool flame. The ignition position is controlled by the difference in ignition delay due to the difference in droplet diameter. This experiment is carried out by using drop tower which can produce microgravity environment to disappears to the effect of natural convection. This report reports on the recent status of this research.

## 2. Experimental Apparatus and Procedure

Figure1 shows the experimental apparatus. The apparatus is composed of a droplet array holder, droplet array generation system, combustion chamber, fuel supply system, optical system. Figure2 shows the droplet array holder,

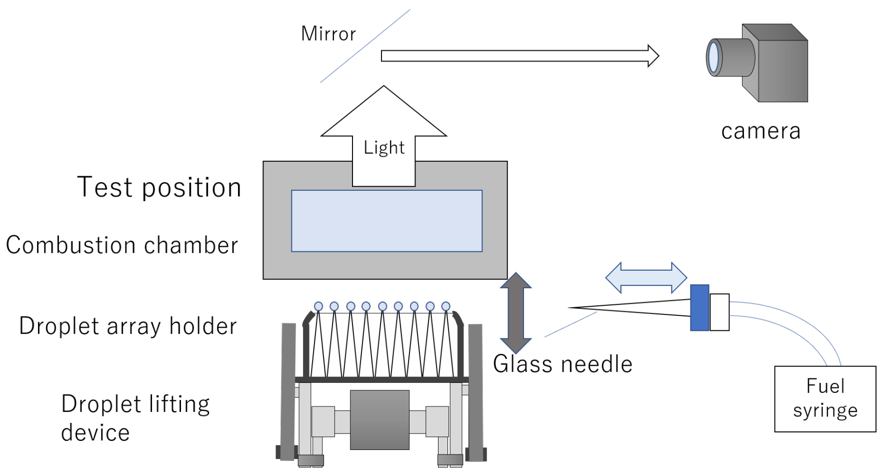


Fig. 1 Experimental apparatus

which is mounted on a movable arm of the droplet lifting device. The two arch shaped SiC fibers (diameter: 14 μm) are supported by two straight SiC fibers and a stainless steel frame. A Glass bead is fixed on the intersection point of the arch shaped two SiC fibers in order to prevent a droplet from falling down during the insertion of the suspended droplet into the combustion chamber. The maximum volume of glass bead is 3.75% of the initial droplet volume. The SiC fibers are adhered to the stainless-steel frame with a heat resistant inorganic adhesive. The heat resistant inorganic adhesive sintered doesn't change property during combustion. Since there are no components in the moving direction of droplets, the temperature decrease around the droplet in the combustion chamber is suppressed. Figure3 shows XY-axis traverse

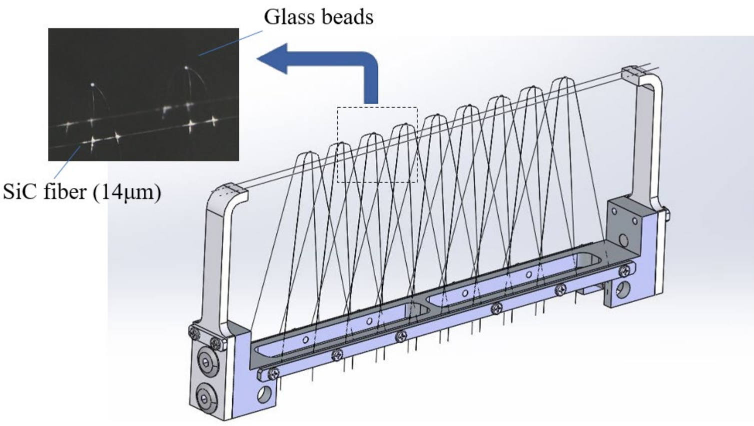


Fig. 2 Droplet array holder

device of the droplet array generation system. Droplet array generation system is composed of a glass needle, glass tube holder, PFA tube, three Linear ball stage, syringe and structures. The outer diameter of fine-drawn glass needle was about 40 μm. Since the two linear ball stages are vertically overlapped, the glass tube can be moved in two directions. The fuel is supplied to the glass needle tube connected to the PFA tube by the fuel supply device using a syringe and a stepper motor. Droplets are supplied at the tip of the glass tube after moving the glass tube to the generation position by the linear ball stage. In the experiment, the droplets are ignited in the combustion chamber to observe state of combustion.

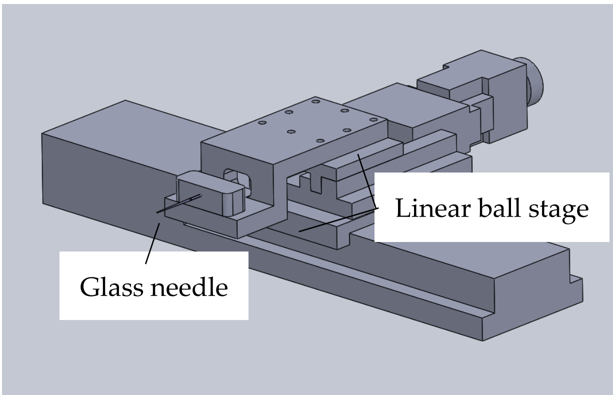


Fig. 3 Droplet array generation system

The internal dimensions of the combustion chamber are W42 mm × D42 mm × H120 mm, and it has a cartridge heater and five K-class thermocouples. The temperature inside the combustion chamber is raised by the cartridge heater, and the average value of the two thermocouples near the center of the combustion chamber is controlled as the experimental condition temperature. The combustion chamber has an observation window on the side and an opening for the drop array holder passing through on the bottom.

*n*-decane ($C_{10}H_{22}$) is employed as a liquid fuel. The initial droplet diameters are varied from 0.6 mm to 1.0 mm. Experiments is performed at atmospheric pressure. The combustion chamber internal temperature is varied from 570 K to 600 K. This temperature is near the cool flame generation limit[3]. The droplet array generation system is moved to the generation position by the XY-axis traverse device. After that, fuel is supplied from the syringe and droplets are generated by the tip of the glass needle and suspended at the intersection point of two arch SiC fibers. After generation, the shutter under the combustion chamber opens and the droplet array holder is moved into the combustion chamber. Then, Observe the combustion.

### 3. Function verification test of droplet array holder

It is necessary to know whether the glass beads can hold the droplets because data cannot be obtained if the droplets fall during the droplet ascending motion of the experiment. In order to investigate the maximum diameter of the droplets that the glass beads can hold, the droplet lifting device was operated under the condition that the droplet diameter was changed. This experiment was performed with glass bead diameters of 0.228 mm and 0.276 mm. The diameter of the glass beads of the former assumes that the initial droplet diameter is 0.8 mm, and that of the latter is 1.0 mm. The diameters of the droplets and beads were measured by a scale from the image projected on the CCD camera using the buck light. Figure 4 shows the droplet supported by the SiC fibers. In this experiment, the droplet was vertically moved 5 times for each diameter of the droplet. It defined as success if the droplets could be held. The motor and a crank mechanism were used for vertical movement. It takes about 215ms to move up.

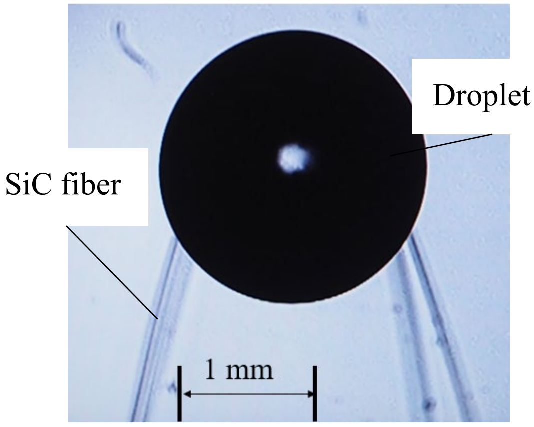


Fig. 4 Droplet supported by the SiC fiber

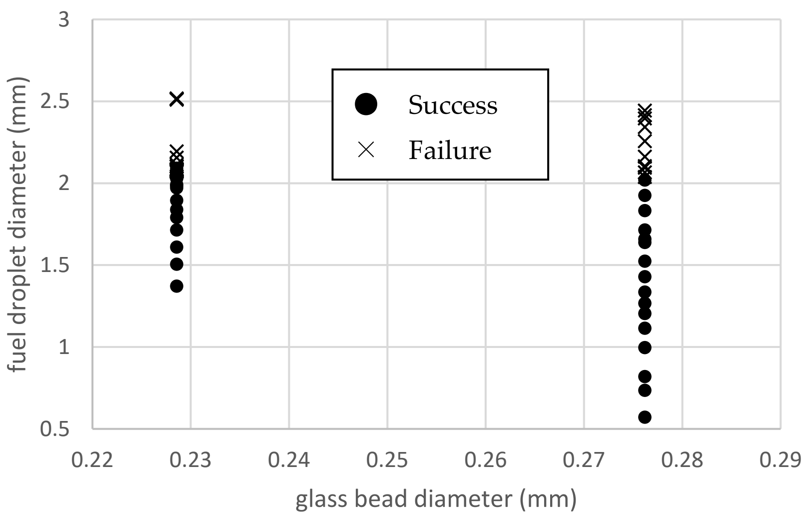


Fig. 5 Droplets of function verification of the droplet array holder

Figure 5 shows the success or failure of movement of the droplet. In the case of the bead diameter in this experiment, the upper limit of the droplet diameter that can be moved was about 2 mm. This result suggests that it is possible to move the droplets in a shorter time. In a short-time microgravity experiment using a drop tower, it is desirable that the movement time is short in order to obtain time for observing the phenomenon. In the future, we will proceed with the optimization of movement parameters.

## 4.Conclution

The experimental apparatus was developed to observe the cool flame spreading along a fuel droplet array. The functional verification test of the droplet array holder was conducted. It was confirmed that it is possible to move a droplet with a diameter of 2 mm.

## References

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