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液滴群要素の着火・燃え広がりの数値シミュレーション

Numerical simulation of ignition and flame spread of droplet-cloud elements

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Spray combustion is used in many combustors such as jet engines, oil-fired furnaces, and diesel engines, and is a complex phenomenon in which liquid fuel atomization, droplet dispersion, fuel evaporation, and chemical reactions proceed at the same time. In order to control the spray combustion continuously and stably, it is necessary to excite a phenomenon called group combustion, which is seen at the base of the spray flame, in which multiple spray droplets burn as a whole, but the detailed excitation mechanism is still elucidated. There is a big gap between the findings of droplet combustion and spray combustion. In 2017, the first droplet combustion experiment was conducted to elucidate the mechanism of group combustion of randomly dispersed droplets at kibo on the ISS, which is expected to extend the experiment time under microgravity conditions.[1)] In the group combustion experiment, a study using the droplet-cloud element[2)] and a study using the randomly distributed droplet clouds[3-5)] were conducted to investigate the effects of the droplet interaction of the randomly distributed droplet clouds. The large-scale ignition phenomenon was observed in which multiple unburned droplet clouds burned at the same time near the group-combustion-excitation limit of the randomly distributed droplet clouds. It was hypothesized that the cool flame and flammable mixture might have contributed to the large-scale ignition phenomenon. The effects of the vaporization characteristics of a single unburned droplet outside the flame-spread limit due to cool flame and the flame propagation behavior due to the premixture formed around the preheated droplet cloud elements were verified.[6)]

The purpose of this study is to elucidate the ignition and spread of droplets without gravity by direct numerical simulation. N-Decane is used as the liquid fuel. Reaction of n-Decane consists of 73 species and 277 elemental reactions. The non-equilibrium Langmuir-Knudsen model[7)] is used for the evaporation model of the droplet, and the discrete ordinate method[8)] is used for the radiation model. Figure 1 shows the droplet placement in this study. Two cases were examined and compared, one was when the cluster L with a diameter of 1 mm was preheated by the cluster H with a diameter of 2 mm and then the droplet I was ignited, and the other was when the droplet I was ignited without preheating. We will evaluate the excitation of cool flame and the behavior of flame propagation and report the results. Figure 2 shows the temperature in the case without preheating.

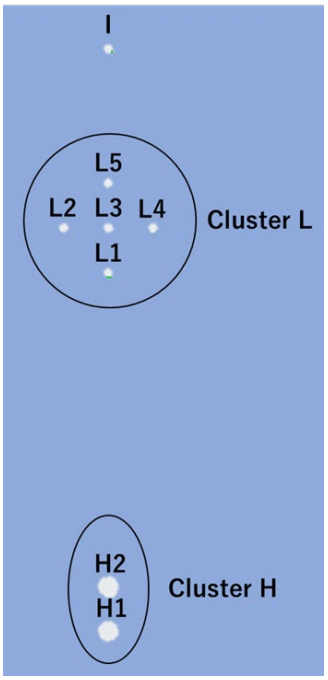
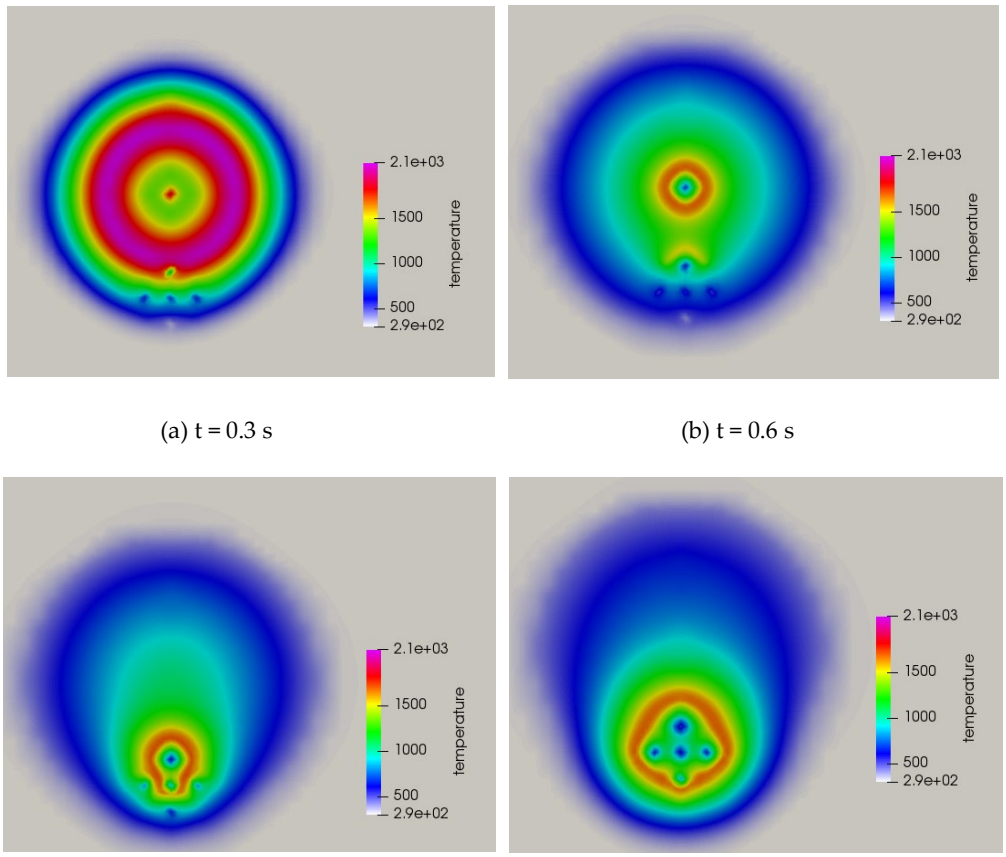


Figure 1. Placement of droplet-cloud element to simulate the large-scale ignition.



(a) t = 0.3 s

(b) t = 0.6 s

(c) t = 0.9 s

(d) t = 1.2 s

Figure 2. Flame propagation behavior without preheating.

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