JASMAC
Conference of the Japan Society of Microgravity Appllication

PS10

SAFを構成する直鎖炭化水素燃料の単一成分を用いた冷炎燃焼速度係数の測定

Measurement of cool flame burning rate constant using a single-component droplet of paraffin in SAF

小川　太新[1], 野村　浩司[2], 菅沼　祐介[2], 齊藤　允教[3], 田辺　光昭[3]
Taishin Ogawa[1], Hiroshi NOMURA[2], Yusuke SUGANUMA[2], Masanori SAITO[3] and Mitsuaki TANABE[3]
[1] 日本大学大学院生産工学研究科, Graduate school of Industrial Technology, Nihon University
[2] 日本大学生産工学部，College of Industrial Technology, Nihon University,
[3] 日本大学理工学部，College of Science and Technology, Nihon University,

1. Introduction

Recently global warming has progressed, and the movement to promote carbon neutrality has been spreading worldwide. The use of Sustainable Aviation Fuel (SAF) as an alternative aviation fuel has been considered. However, basic data on SAF has not been collected sufficiently. Therefore, we obtained experimental data on cool flame burning, which is expected to be used to improve the accuracy of future simulations. We focused on the straight-chain hydrocarbons which SAF consists of and will measure the cool-flame burning rate constant of them at microgravity. In this report, results of 1G preliminary tests to determine the experimental conditions for the microgravity experiment to be conducted in the future were presented.

2. Experimental apparatus

The employed experimental apparatus is almost identical to the one used by Nomura et al. in their previous study on droplet evaporation[1)]. There are some modifications, which will be noted below. **Figure 1** illustrates a droplet suspension system. The fiber that suspends a fuel droplet has been changed from alumina/silica fiber to SiC fiber to prevent fiber from melting. To observe the cool flame, the atmospheric gas was changed from nitrogen to dry air. The linear hydrocarbons used in the experiments were heptane, decane, and hexadecane. Ambient temperature was varied from 523 to 723 K with 50 K intervals. For each experimental condition, experiments were performed five times. The initial droplet diameter was set to 0.75 mm. A droplet was generated under the heated combustion chamber and inserted into it in 180 ms.

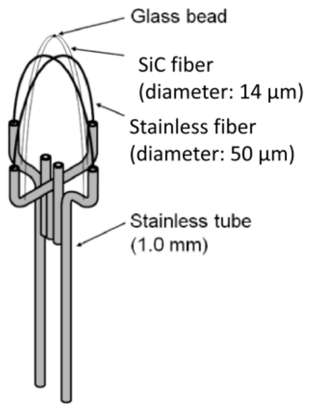

Figure 1. Droplet suspension system.

3. Experimental results

As a typical example, the squared droplet diameter history of hexadecane at the ambient temperature of 673 K is shown in **Figure 2.** The burning rate constant, k_b, was obtained from the solid straight line. The squared droplet diameter decreased linearly along the solid line. The time when the experimental data plots converge to the solid line is the ignition delay time. After ignition, the droplet burnt quasi-steadily. **Figures 3**, **4** and **5** show the cool flame burning rate constant and the hot flame burning constant for heptane, decane and hexadecane, respectively. In the case of hexadecane at an ambient temperature of 723 K, hot flame ignition occurred after cool flame ignition. The hot flame ignition was detected by a photodiode and the glow of the droplet suspension fiber. In the case of heptane and decane, no significant change in the slope after the initial heat-up period was observed. Since the slope after the initial heat-up period is much larger than in the case of droplet evaporation, it is considered that those fuels ignited during the initial heat-up period.

For all cases, the burning rate constant increased with increasing ambient temperature. All experiments were conducted on the ground and were affected by natural convection. Therefore, future experiments will be conducted at microgravity. Moreover, heptane evaporation experiments will be conducted to determine the evaporation rate constant to validate occurrence of a cool flame burning in the experiments conducted in this work for heptane.

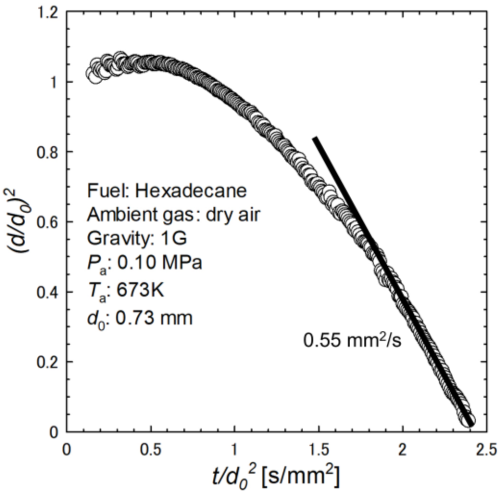

Figure 2. Squared droplet diameter history of hexadecane at an ambient temperature of 673 K.

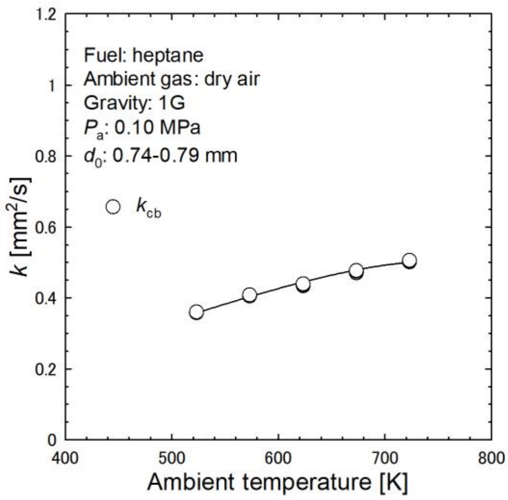

Figure 3. Effect of ambient temperature on the cool flame burning rate constant of heptane.

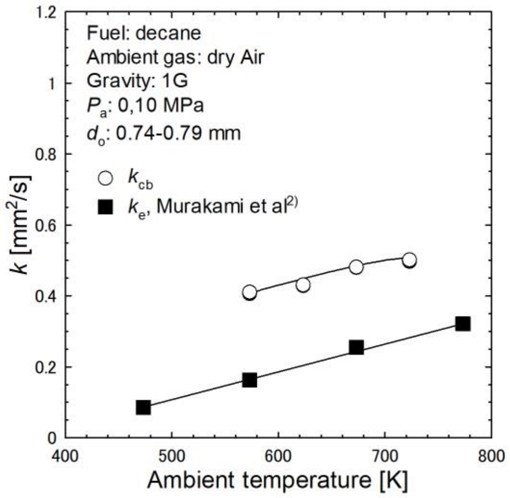

Figure 4. Effect of ambient temperature on the evaporation rate constant and the cool flame burning rate constant of decane.

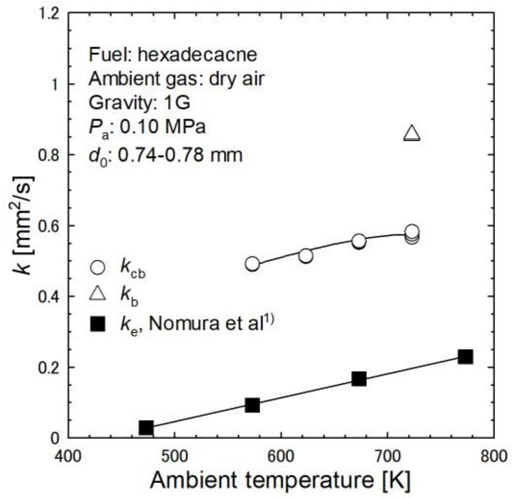

Figure 5. Effect of ambient temperature on the evaporation rate constant, the cool flame burning rate constant, and the hot flame burning rate constant of hexadecane.

4. Conclusion

To determine experimental conditions of microgravity experiments which will be performed, cool flame combustion experiments were conducted for heptane, decane and hexadecane at normal gravity. Ambient pressure was set at 0.10 MPa and ambient temperature was varied from 523 to 723 K. From the squared droplet diameter histories, cool flame burning constants were measured for all fuel.

Acknowledgments

This study was supported by the Feasibility Study Phase for Flagship Mission of JAXA and the JSPS KAKENHI Grant (JP24K07887). We express our gratitude for all support.

References

1) H. Nomura, T. Mura Koshi, Y. Suganuma, Y. Ujiie, N. Hashimoto, H. Nishida: Microgravity experiments of fuel droplet evaporation in sub- and supercritical environments, Proc. Combust. Inst., **36** (2017) 2425, http://dx.doi.org/10.1016/j.proci.2016.08.046 .
2) Y. Murakami, H. Nomura and Y. Suganuma: Experimental study on unsteadiness of n-decane single droplet evaporation and effect of natural convection on droplet evaporation at high pressures and temperatures, Trans. JSASS Aerospace Tech. Japan, **19** (2021) 647, DOI: 10.2322/tastj.19.647.