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微小重力場における被覆導線の過電流着火に及ぼす周囲空間直径の影響に関する数値的検討

Numerical study on Effects of Confined Space Size on Overload Ignition of Polymer-Insulated Wire in Microgravity

八鍬凜太[1], 金野佑亮[1], 郭峰[2], 王強[1], 橋本望[1], 藤田修[1],
Rinta YAKUWA[1], Yusuke KONNO[1], Feng GUO[2], Qiang WANG[1], Nozomu HASHIMOTO[1] and Osamu FUJITA[1],
[1] 北海道大学工学研究院, Hokkaido University, Faculty of Engineering,
[2] 中国鉱業大学安全工学部, China University of Mining and Technology, School of Safety Engineering,

1. Introduction

Fire safety is one of the top priorities in manned space activities, and short circuiting of electrical wires is a most likely cause of fires in space. Therefore, experiments on overloaded wire ignition in microgravity have been conducted under a variety of conditions[1,2)]. On the other hand, the influence of confinement dimensions on the ignition characteristics of overloaded wires has not been investigated yet even though it is important from the practical view. In the present study, the effect of confined space diameter on the phenomena of overload ignition of insulated conductors was investigated based on experiments and numerical analysis.

2. Methods

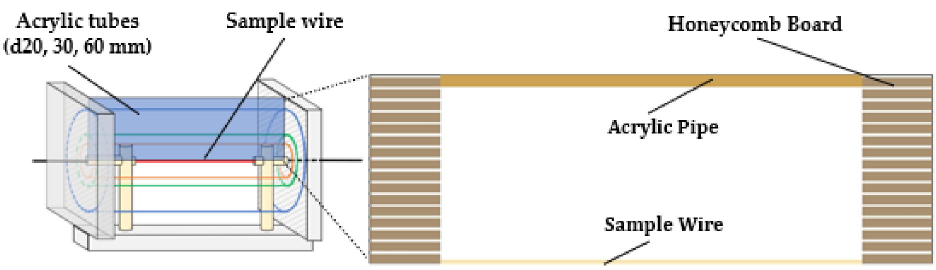

Figure 1. Schematic of 2-dimensional numerical model with different sizes of confined space

The 2D model is set up with a computational domain as shown in Figure1., with a mesh size of 0.1 x 0.1 mm 2D domain. We selected the same confinement variations with different diameters (20, 30, and 60 mm) as the microgravity experiments using drop tower. All the confinement walls and honeycomb board surface were set as inert boundaries at 293 K. Polyethylene insulated nichrome wire selected as test samples considering the availability of material properties and pyrolysis parameters[3,4)] and consistency with planned space experiments in ISS/KIBO module. The overloading was modeled as the volumetric Joule heat from the inner layer, which is controlled by the applied current value. The 2-step reaction of ethylene combustion was employed[5], and the ignition criterion was set as the critical local volumetric heat release of 32 MW/m^3.

3. Results and Discussion

Figure 2. shows the actual ignition and the numerical calculation of Heat Release Rate per unit volume for a 20 mm diameter confined space and 13 A supply current. From figures, it was confirmed that the ignition position could be reproduced and the ignition delay time is predicted to be close to the experimental results. It was also able to observe spontaneous ignition, which ignites at a distance from the core wire and the ignition position is not at the center of the core wire (right edge of the calculation domain), but at the edge where the density of oxygen is higher than that at the center of the wire.

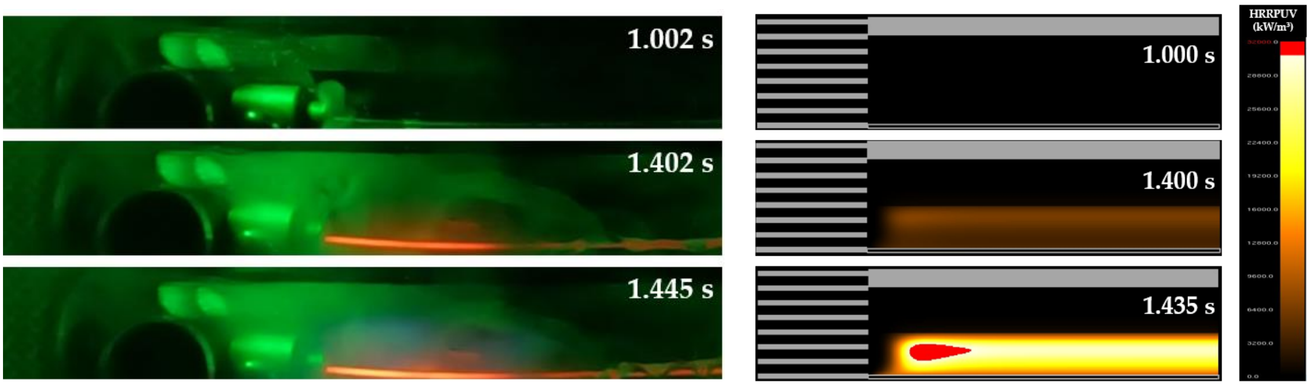

Figure 2. Comparison of actual experiments and numerical calculation of Heat Release Rate Per Unit Volume (Confined space diameter: 20 mm, Current supply value: 13A)

4. Conclusion

The numerical calculation model developed in this study has ability to predict the ignition position and ignition delay time, which could be applied to other conditions tested in the drop tower experiments and future space experiments planned in the scheme of FLARE project.

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