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STUDY ON VISUALIZATION OF BOUNDARY LAYER COMBUSTION OF WAX-BASED FUEL IN VERTICAL AND HORIZONTAL CONFIGURATIONS

Abstract

Hybrid rockets typically consist of a liquid oxidizer and solid fuel. Some advantages of hybrid rockets compared to solid rockets include: low cost, safety, throttling capability, however it has some problems. One of the most critical problems is low fuel regression rate is critical problem, and this decrease thrust and performance of hybrid rocket. In order to overcome this disadvantage, wax-based fuel has attracted researches' attention. These fuels provide large regression rates and, these are due to low melting points and low viscosity. Karabeyoglu et al., has revealed that the low viscosity of paraffin-based fuels enhances the Kelvin-Helmholtz instability between the liquefied fuel and the gaseous flow, and enables entrainment of a large number of droplets into the gaseous flow. Nakagawa et al. has visualized the generation of droplets in boundary layer combustion of a paraffin wax and gaseous oxygen. Though these researches have contributed to revealing mechanisms of boundary layer combustion of wax-based fuels, the experiments were all performed using the motors horizontally installed under the static environment. Contrary to these previous experiments, in practical use, a rocket motor operates under dynamic environments of axial acceleration, which may especially affect internal ballistics of films and droplets of liquefied fuels. Adachi and Shimada simulated characteristics of a supercritical flow of liquefying fuel with low viscosity under static acceleration environments, and they acquired an interesting result that even small axial acceleration strongly affects the velocity field. This result, which suggests that axial acceleration environment may strongly affect the flow of liquid film and the internal ballistics of droplets of liquefying fuels, is quite understandable because the liquefied fuels are about 1000 times more affected by body forces than the gaseous flow. The first step of our study is to figure out whether boundary layer combustion of wax-based fuels is actually affected by dynamic environments. In addition, if any significant such effects exist, our research will develop into investigating high-dynamic performances of wax-based fuels with experimental and theoretical approaches. This research will present the visualization of boundary layer combustion of a wax-based fuel and gaseous oxygen in a horizontally and vertically installed slab-burner. We have already succeeded to capture the high-speed video of the boundary layer combustion for the horizontally installed configuration. A mechanism, consistent with that predicted by Karabeyoglu was observed in the tests of wax-based fuels. Furthermore, these fuels showed a combustion oscillation typically observed in wax-based hybrid rocket propulsion.