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ANALYSIS AND EXPERIMENT ON THE SUSTAINED COMBUSTION PHENOMENON OF HAN/PVA-BASED ELECTRICALLY CONTROLLED SOLID PROPELLANT

Abstract

Electrically controlled solid propellant (ECSP) is a solid propellant of which the ignition, extinguishment, and the thrust can be controlled by electric energy. Many studies have been conducted to apply ECSP to various propulsion systems, but additional research is needed to improve the performance of propellant and to overcome the persistent combustion phenomenon that was observed during the combustion experiment for applying to the propulsion system in the basic research stage. This phenomenon is the continuous combustion even after the electric energy is cut off. To verify this phenomenon, TGA analysis was performed on ECSP with PVA contents of 15 wt%, 18 wt%, and 25 wt% under heating conditions of 5 K/min, 10 K/min, and 15 K/min. The TGA analysis results confirmed the thermal decomposition temperature according to the PVA content, and the decomposition temperature of ECSP increased with the heating rate, and the persistent combustion phenomenon was confirmed to be greatly affected by the thermal energy. In addition, the thermal decomposition temperature of HAN and ECSP were very similar. ECSP underwent a phase transition from solid state to liquid state as the temperature rised, and a conductive molten layer was formed. It was judged that the persistent combustion phenomenon occured when a large amount of thermal energy accumulated in the conductive molten layer. The temperature at which the conductive molten layer was formed, that is the glass transition temperature, and the specific heat of the propellant were additionally measured by DSC analysis. Based on the glass transition temperature and specific heat of ECSP collected through DSC analysis, the minimum ignition energy required for propellant ignition was calculated. Based on the calculated minimum ignition energy, the combustion experiment of ECSP was performed, and the difference between the measured data and the calculated minimum ignition energy was analyzed. As a result, it was possible to control ECSP efficiently by minimizing the thermal energy accumulated in the conductive molten layer and applying strong electric energy for a short time to apply ECSP to the propulsion system.