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PLASMA ASSISTED NITROUS OXIDE DIRECT THERMAL DECOMPOSITION AND COMBUSTION FOR HYBRID ROCKET

Abstract

Novel igniter for hybrid rocket motor (HRM) is studied, in which the nitrous oxide (N_2O) as an oxidizer is directly decomposed by the thermal effect of plasma. The N_2O based HRM has been widely studied due to advantages such as its self-pressurizing and safe handling. Many research groups have developed catalyst-based igniters to activate the N_2O. However, these approaches require the pre-heating sequence before firing so that they have relatively a long ignition delay time. In addition, the system performance is degraded by the deactivation of catalysts due to the repeated pre-heating and exposure to the high temperature. Therefore, the plasma assisted ignition system is proposed in this paper. In particular, an arc plasma generated in a low current less than 1 A was employed. In order to verify its applicability, the gas temperature was measured according to the mass flow rate and discharge current. The highest gas temperature was higher than $1,300\,^{\circ}$C in the condition of 0.7A and 0.5g/s. In the case of 1 g/s, all measured temperature was lower than $1,000\,^{\circ}$C. However, the voltage fluctuation was observed due to the high temperature environment around the inner electrode in 0.5g/s, which implies that the plasma was unstably generated because of the high temperature ablation effect on the inner electrode. The highest power consumption was 840W in 0.7A and 0.5g/s. In addition, PMMA was selected as a solid fuel for the hot-firing test. The 20N class thruster for HRM application of which the fuel grain was fabricated to set the initial O/F ratio of 6.5 was designed. The nozzle was also designed of which the throat diameter was 4.35mm. The test sequences were controlled by two stage ignition process. At the first stage, the initial ignition was performed with 1g/s. Once the ignition was activated, at the second stage, the main combustion was performed with 10 g/s that is the target mass flow rate. The plasma turned off after the combustion was stabilized. The ignition was empirically confirmed when the exit temperature of igniter increased up to $200\,^{\circ}$C. The initial ignition was achieved within 4 sec and the following main combustion was successfully operated. The measured average thrust was 16N and C^* efficiency was 70%. In this study, the plasma-assisted direct thermal decomposition of N_2O was carried out for HRM and the plasma discharge time to ignite the fuel was within 4 sec and total energy consumption was 1,780J.