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COMBUSTION CHARACTERISTICS OF THE END-BURNING HYBRID ROCKETS AT LAMINAR FLOW

Abstract

Recently, hybrid rocket has been paid to attention while the demand for the scientific missions, such as the upper air sampling, the zero-gravity experiment, and the orbit injection of the micro satellite, that need a small rocket increase. Because hybrid rocket does not need gunpowder, it is cheaper, safer and cleaner than the solid rocket. However, as mixing of the fuel and the oxidizer does not progress completely in the hybrid rocket, that results decreasing of the combustor efficiency and the lower specific impulse. For this reason, the traditional hybrid rocket had not been becoming practical use. We proposed the end-burning hybrid rocket which employ the combustion at the edge of the solid fuel in order to improve a these disadvantages. This is a new combustion system in which oxidizer flows through the porous solid fuel and burns at the exit edge side of fuel. Because the flame is formed at the end face of the solid fuel, the decreasing of the specific impulse and combustion efficiency resulted from O/F shift are improved dramatically. In this combustion system, two patterns of combustion are observed, i.e., the spreading combustion and the stable combustion. Although there are a lot of researches on spreading combustion on the solid surface, there are only a few examples which studied combustion of the solid fuel duct. Therefore, the elucidation of mechanism of this combustion form obtains an important finding in perspective of combustion engineering. We have studied the spreading combustion and the stable combustion at turbulent flow to reveal the mechanism of the end burning. As a result, at turbulent flow the boundary condition which decides the combustion pattern depend on the friction velocity of oxidizer at the fuel surface. However, the boundary condition in laminar flow has not been understood yet. In this study, we aim to clarify the combustion mechanism at laminar flow in the present study. We observed the changes of flame spread rate at various oxidizer mass flow rate (Reynolds number < 2300). At laminar flow, the velocity gradient at the fuel surface might dominate the combustion patterns. This is because that in laminar region momentum transport is dominated by velocity gradient of the oxidizer at the wall. This results is coincides with the results in turbulent region. This result is also important finding for basic combustion engineering, because examples about the elucidation of mechanism of this combustion hardly exist. In addition, this result might be expected to apply for practical use of the end-burning hybrid rocket.