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POWDERIZATION OF COMBUSTION PRODUCTS IN MAGNESIUM-WIRE AND WATER MICROPROPULSION SYSTEM: PROOF OF CONCEPT

Abstract

This study focuses on a hybrid micropropulsion system using water as an oxidizer and magnesium wire as a fuel. Water is considered a promising candidate as an oxidizer for a hybrid micropropulsion system due to its non-toxic, ready availability, and high installation density. In terms of fuel, magnesium as a fuel has a high chemical stability and energy density for chemical reactions with water. Commonly, metals are used in powder form to facilitate ignition, but there are concerns represented by dust explosion and the necessity of a high-pressure tank for powder supply. Despite the lower igniting properties, safety and installation density were prioritized, and the wire form was chosen over the powder form. In the previous studies, the applicability of magnesium wire combustion to a micropropulsion system was confirmed by measuring the reaction rate of a magnesium wire in water-vapor flow. Additionally, a breadboard model capable of feeding magnesium wire with a stepped motor was manufactured, and the concept of the propulsion system was verified by combustion experiments in air, not in water. However, during combustion experiment, combustion of a magnesium wire stopped, and failed to reignite. The main cause was combustion products (magnesium oxide) that grew to centimeter-class from the wire tip and accumulated in the combustion chamber. When combustion products float inside the combustion chamber by microgravity attach to a non-combusted magnesium wire, they can take away the heat required for combustion. And if combustion products attach to the combustion chamber wall, they may be taken away the heat that had to be transferred to the internal gas. Furthermore, there is a possibility that the nozzle or water-vapor inlet would be blocked by the combustion chamber, leading to deteriorate propulsion performance. Therefore, it is necessary to transfer heat more effectively to the non-combusted wire or internal gas and emit combustion products from the combustion chamber. The purpose of this study is to achieve efficient heat dissipation of combustion products and their discharge from the combustion chamber. As a method, the concept of powderizing combustion products on a sub-millimeter scale by vibrating the magnesium wire was proposed. For proof of concept, the possibility of combustion and powderization of vibrating magnesium wire was examined. At the conference, experimental results will be presented focusing on the size of combustion products and changes of temperature in the combustion chamber to verify the effects of the powderizing combustion product on propulsion performance.