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REAL-TIME REGRESSION RATE MEASUREMENT OF AN ADDITIVE-MANUFACTURED FUNCTIONAL HYBRID ROCKET FUEL

Abstract

This paper presents efforts of a real-time regression rate measurement using an additive-manufactured hybrid rocket fuel with complex ladder-resistor structures of a conductive polymer in a electrically insulated polymer for the main solid fuel. The solid fuel is manufactured by a dual-head fused deposition modeling 3D-printer with high accuracy. The one head injects an electrically-insulated plastic filament sometimes used to manufacture solid fuel grains with complex shapes in the field of hybrid rocket propulsion, and the other does a filament including a conductive material like graphene. The combination of this type 3D-printer and the two type filaments enables us to manufacture a solid fuel with ladder resister structures normal to the grain surface. The resistance of the ladder-resistor structure decreases with the regression of the solid fuel during a burn, and the change in the resistance allows us to know real-time regression rates. This concept is based on the Miniature Resistive Regression and Ablation Sensor (MIRRAS) by ORBITEC, but we believe that our idea has a large advantage in the easiness of the manufacturing of the multipoint measurements of local regression rates. This type of fuels has the potential to realize a large number of real-time and local regression rates with a very small pitch. This is because the conductive filament functions as wires and resistors in addition to a role as a fuel, and the main plastic fuel also does as a board of an electric circuit so that this type of fuels do not need any materials to decrease performance as a solid fuel like adhesive agents or flexible boards. The purpose of this study is to demonstrate the concept of real-time measurement using this type of additive-manufactured fuels. Firing experiments are performed with a rectangular slab-fuel with a single structure of the ladder-resistor in a slab-burner with two observation windows. The results of real-time regression rate measurements with the ladder-resistor structure is validated with those of a high-speed video from the observation window. The presentation includes the results of manufacturing of prototype solid fuels, those of firing experiments, and the comparison of the real-time regression rates between the two measurement techniques.