IAF SPACE PROPULSION SYMPOSIUM (C4)
Solid and Hybrid Propulsion (2) (4)

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ABLATION RESISTANCE ASSESSMENT OF GRAPHITE AND CARBON-CARBON COMPOSITES UNDER HYBRID PROPELLANT ROCKET FREE-JET EXPOSURE

Abstract

High temperature ablative material selection in hybrid propellant rockets differs from solid and liquid propellant rockets. Carbon-carbon ceramic composites and graphite perform unique durability under high temperatures and pressure around the nozzle region of hybrid rockets. Carbon-carbon composite manufacturing has multiple densification and graphitization processes. Each stage extends the manufacturing process and contributes to ablation resistance. The purpose of this paper is to test and discuss the ablation behaviour of graphite and differently processed carbon-carbon ceramic composites under hybrid rocket motor free-jet exposure. Since carbon-based materials are exposed to thermochemical ablation under high temperature, pressure, and oxidative combustion gases; the free-jet test would perform flight-like test for hybrid rocket motors with its similar gas composition. The ablation rate and behaviour of selected materials are tested under free-jet of gaseous oxygen-paraffin based hybrid rocket motors that have 2.1, 2.6 and 3.0 different oxygen to fuel (OF) ratio. The flow field around ablative material samples were simulated with Computational Fluid Dynamics (CFD) method, and CFD simulation result is compared with the measured surface temperature from the sample surfaces by IR spectrophotometer. Depending on the hot-gas exposure of samples for different OF ratios, carbon-carbons and graphite's ablation resistance are compared. It is observed that the heat treatment temperature and number of densification cycles in carbon-carbon composites have significant effect on ablation performance. Even if graphite performed better ablation resistance than differently processed carbon-carbon composites, carbon-carbons mechanical performance could be preferred especially in the nozzle region. Therefore, it is important to understand the effect of manufacturing process on the ablation performance in carbon-carbon composites.