Characterization, Operation and Analysis of Test Motors Containing Aluminized Hybrid Fuels

Timothy P. Kibbey
Jacobs ESSSA Group, Huntsville, AL 35812

Andrew C. Cortopassi and J. Eric Boyer
Pennsylvania State University, University Park, PA 16802

NASA Marshall Space Flight Center's Materials and Processes Department, with support from the Propulsion Systems Department, has renewed the development and maintenance of a hybrid test bed for exposing ablative thermal protection materials to an environment similar to that seen in solid rocket motors (SRM). The Solid Fuel Torch (SFT), operated during the Space Shuttle program, utilized gaseous oxygen for oxidizer and an aluminized hydroxyl-terminated polybutadiene (HTPB) fuel grain to expose a converging section of phenolic material to a 400 psi, 2-phase flow combustion environment. The configuration allows for up to a 2 foot long, 5 inch diameter fuel grain cartridge. Wanting to now test rubber insulation materials with a turn-back feature to mimic the geometry of an aft dome being impinged by alumina particles, the throat area has now been increased by several times to afford flow similarity. Combined with the desire to maintain a higher operating pressure, the oxidizer flow rate is being increased by a factor of 10. Out of these changes has arisen the need to characterize the fuel/oxidizer combination in a higher mass flux condition than has been previously tested at MSFC, and at which the literature has little to no reporting as well.

Testing for fuel regression rate comprised a two-level, full factorial design available over Aluminum loading level, mass flow rate, pressure, and diameter.

The data taken significantly surpasses the previous available data on regression rate of aluminized HTPB fuel burning with gaseous oxygen. It encompasses higher mass fluxes, and appears to generate more consistent data. The good test article and facility design and testing work of the Penn State HPCL combined with careful analysis of the data and good planning has made this possible. This should be able to assist with developing rate laws that are useful both for research planning and for developing flight system sizing relationships that can help optimize hybrid rocket concepts for trade studies. The successful approach of this DOE and test setup is applicable to other propellant combinations as well.