Characterization of Hybrid Rocket Internal Heat Flux and HTPB Fuel Pyrolysis

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Statement of Problem

The broad objective of this work is to extend our understanding of the nature of the conventional or classical hybrid rocket combustion process (fuel decomposition, heat and mass transfer, and chemical reaction), and the critical engineering parameters that define this process,.

Objective of Work

As an assistance in the development and verification of CFD models of the hybrid rocket combustion process, specific objectives of the presented work were to bound the relative proportions of radiative and convective heat transfer to the solid fuel surface in the developed boundary layer region and to determine the pyrolysis law for hydroxyl-terminated polybutadiene (HTPB) under hybrid rocket heating conditions.

Approach Used

An existing hybrid slab window motor was instrumented with a total heat flux calorimeter and radiometer and with IR pyrometers for measuring the core gas temperature and combusting fuel surface temperature. Tests with a non-metallized HTPB fuel were carried out over a range of motor pressure and GOX oxidizer mass flux conditions. The time-averaged fuel regression rates were determined by both before and after measurement and weighing of the fuel slabs.

Conclusions

(1) Any model of the hybrid motor ignition process will have to be able to describe the progression of the fuel surface temperature-time profile, as observed in these experiments. (2) The c* efficiencies determined from the test results for this motor peaked near the stoichiometric O/F point. (3) The measured convective heat flux was in reasonable agreement with calculations based on the measured motor chamber gas temperature. (4) The measured radiation flux was considerably higher (factor of two) than predictions based on the measured gas temperature, This is believed to be due to the large, unaccounted for contribution from the cloud of fine, particulate free-carbon in the gas stream. (5) For a given regression rate, the measured fuel surface temperatures were somewhat higher, by approximately 12-130A, than literature pyrolysis data for HTPB. A possible explanation of this difference is the different concentrations of carbon powder tiller contained in the HTPB for the two studies, 0.25% and 3%, respectively. The higher literature value would provide greater assurance that the HTPB was opaque to radiation heat transfer,