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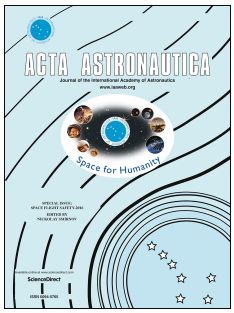

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PII: S0094-5765(17)31306-1

DOI: 10.1016/j.actaastro.2018.01.048

Reference: AA 6678

To appear in: *Acta Astronautica*

Received Date: 18 September 2017

Revised Date: 1 December 2017

Accepted Date: 23 January 2018

Please cite this article as: Y. Guan, J. Li, Y. Liu, T. Xu, Influence of different propellant systems on ablation of EPDM insulators in overload state, *Acta Astronautica* (2018), doi: 10.1016/j.actaastro.2018.01.048.

Influence of Different Propellant Systems on Ablation of EPDM Insulators in Overload State

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Abstract:

This study examines the propellants used in full-scale solid rocket motors (SRM) and investigates how insulator ablation is affected by two propellant formulations (A and B) during flight overload conditions. An experimental study, theoretical analysis, and numerical simulations were performed to discover the intrinsic causes of insulator ablation rates from the perspective of lab-scaled ground-firing tests, the decoupling of thermochemical ablation, and particle erosion. In addition, the difference in propellant composition, and the insulator charring layer microstructure were analyzed. Results reveal that the degree of insulator ablation is positively correlated with the propellant burn rate, particle velocity, and aggregate concentrations during the condensed phase. A lower ratio of energetic additive material in the AP oxidizer of the propellant is promising for the reduction in particle size and increase in the burn rate and pressure index. However, the overall higher velocity of a two-phase flow causes severe erosion of the insulation material. While the higher ratio of energetic additive to the AP oxidizer imparts a smaller ablation rate to the insulator (under lab-scale test conditions), the slag deposition problem in the combustion chamber may cause catastrophic consequences for future large full-scale SRM flight experiments.

Key words:

Solid Rocket Motor (SRM); Propellant; Insulator; Ablation; Slag Deposition;

1. Introduction

The thermal protection systems of the inner combustion chamber of modern large-scale solid rocket motors (SRM) directly affect the success and reliability of the launch. Owing to the ever-increasing demands in working pressure and combustion temperature, a high-aluminum propellant, containing 17–20% aluminum powder (Al), is widely used, which aims to increase the combustion stability and maximize the specific impulse. However, the use of a high-aluminum propellant, in conjunction with restrictions on the overall size of the SRM, can expose the insulator