Elastomeric Thermal Insulation Design Considerations in Long, Aluminized Solid Rocket Motors

Heath T. Martin

An all-new sounding rocket was designed at NASA's Marshall Space Flight Center that featured an aft finocyl, aluminized solid propellant grain and silica-filled ethylene-propylene-diene monomer (SFEPDM) internal insulation. Upon the initial static firing of the first of this new design, the solid rocket motor (SRM) case failed thermally just upstream of the aft closure early in the burn time. Subsequent fluid modeling indicated that the high-velocity combustion-product jets emanating from the fin-slots in the propellant grain were likely inducing a strongly swirling flow, thus substantially increasing the severity of the convective environment on the exposed portion of the SFEPDM insulation in this region. The aft portion of the fin-slots in another of the motors were filled with propellant to eliminate the possibility of both direct jet impingement on the exposed SFEPDM and the appearance of strongly swirling flow in the aft region of the motor. When static-fired, this motor's case still failed in the same axial location, and, though somewhat later than for the first static firing, still in less than 1/3rd of the desired burn duration. These results indicate that the extreme material decomposition rates of the SFEPDM in this application are not due to gas-phase convection or shear but rather to interactions with burning aluminum or alumina slag. Further comparisons with between SFEPDM performance in this design and that in other hot-fire tests provide insight into the mechanisms of SFEPDM decomposition in SRM aft domes that can guide the upcoming redesign effort, as well as other future SRM designs. These data also highlight the current limitations of modeling elastomeric insulators solely with diffusion-controlled, gas-phase thermochemistry in SRM regions with significant viscous shear and/or condense-phase impingement or flow.

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