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Insulation Reformulation Development

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Sponsoring Program(s)

Human Exploration and Operations Mission Directorate
Space Launch System Advanced Development

Project Description

The current Space Launch System (SLS) internal solid rocket motor insulation, polybenzimidazole acrylonitrile butadiene rubber (PBI-NBR), is a new insulation that replaced asbestos-based insulations found in Space Shuttle heritage solid rocket boosters. PBI-NBR has some outstanding characteristics such as an excellent thermal erosion resistance, low thermal conductivity, and low density.

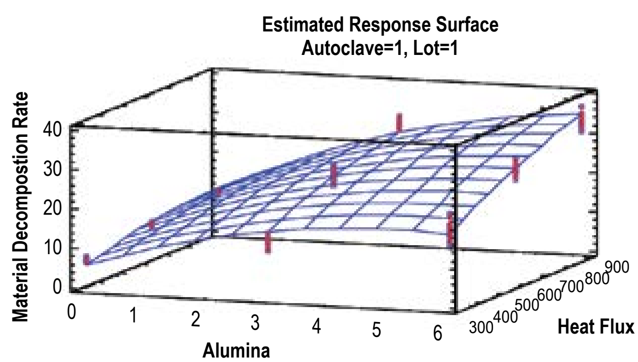
PBI-NBR also has some significant challenges associated with its use: Air entrainment/entrapment during manufacture and lay-up/cure and low mechanical properties such as tensile strength, modulus, and fracture toughness.

This technology development attempted to overcome these challenges by testing various reformulated versions of booster insulation. The results suggest the SLS program should continue to investigate material alternatives for potential block upgrades or use an entirely new, more advanced booster.

The experimental design was composed of a logic path that performs iterative formulation and testing in order to maximize the effort. A lab mixing baseline was developed and documented for the Rubber Laboratory in Bldg. 4602/Room 1178.

Rubber Lab mixer and control system.

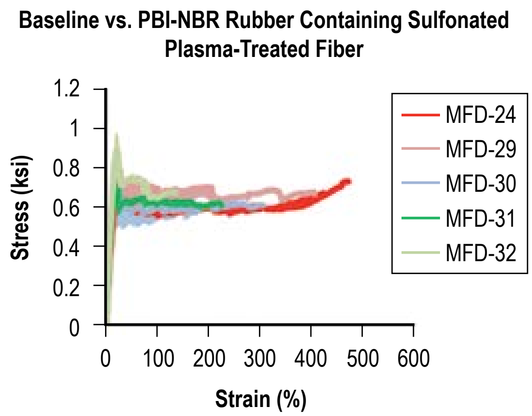
Rubber Lab mill and control system.



Contour plot of thermal erosion performance.

Comparative rheology, mechanical properties (tensile and elongation in different fiber directions), specific gravity, viscosity, scorch, Shore A hardness, and erosion performance were evaluated.

Formulations tested were derived from existing formulations: PBI-NBR and SFNBR (silica-filled acrylonitrile butadiene) and adjustments were made to fiber and fiber types, fillers, and processing aids.



Stress-strain of candidate formulations.

Anticipated Benefits

Improved understanding of the polymer chemistry of the raw ingredients and their direct effect on performance properties in extreme environments (e.g., solid rocket motors) will increase the options for material selection in future programs. The optimization of material selection for advanced booster programs within the constraints of weight impacts, mechanical performance, thermal performance, and manufacturability is key to affordable production of hardware for future missions.

Potential Applications

The better understanding of performance effects of constituents within polymers used in thermal insulation has the potential for broad industry application. Expansion of the supplier base via improved performance requirements will enable cost savings on multiple programs within defense, civilian, and commercial space programs that utilize solid rocket motors. Additional work by NASA could include development and formalization of standards for formulation methodology and test requirements for qualification.

Notable Accomplishments

Two formulations were selected for evaluation in a larger production mixer (outsourced for 100-lb batches). This allows additional test specimens and a scale-up formulation to be evaluated. Most lab scale mixes (6 lb) do not scale up equally. Properties should trend in the same fashion, but will not be exactly the same values.

Forward Work

Reformulation effort continues through FY 2015. The effort will include ethylene propylene diene monomer based formulation and alternate fibers.

References

EM41-TP063 SRM Insulation Reformulation. "SLS Booster Element Proposal for Motor Internal Insulation Development Effort," June 2013.