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HIGH DENSITY ABLATIVE THERMAL PROTECTION SYSTEMS FOR REUSABLE LAUNCH VEHICLES: PROCESSING, PROPERTIES AND THERMAL RESPONSE EVALUATION

Abstract

The aero heating encountered by reusable launch vehicles (RLV) warrants the use of a hot structures capable of withstanding the high temperature at the wing leading edge. Randomly oriented chopped silica fiber –phenolic resin ablative composites with varying fiber-resin compositions (70-90% by weight) were developed for this application. The density of the composites varied from 1.3-1.6g/cc depending on the fiber-resin ratio. Compositional dependency of the composites on their mechanical and thermo-physical properties was examined. As the silica fiber content increased, the density and mechanical properties decreased due to poor wetting of the fibers and compaction. Thus, compared to the composition with 70% fiber content, the tensile, compressive and flexural strengths reduced to nearly 50% at a fiber loading of 90%. Coefficient of thermal expansion, thermal conductivity and thermal diffusivity of the composites exhibited a decreasing trend with increasing silica fiber content whereas, specific heat capacity increased as expected. Thermal simulations were carried out to evaluate the performance of the materials for the simulated heat flux history at the wing leading edge. The peak heat fluxes simulated for RLV re-entering at an attitude of 70 km were 90 W/cm2 during ascent phase and 35 W/cm2 during descent phase. The thermal response was measured and the material surface behavior, mass-loss and flammability were studied. The mass-loss and back wall temperatures increased with increasing resin fraction in the composite. Ablation performance of the composites with higher silica content was superior, with diminished propensity for burning and formation of strong and intact char during kinetic heat simulation (KHS) tests. The mass-losses for compositions containing 80-90