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Sprayable Phase Change Coating Thermal Protection Material

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ABSTRACT

NASA has expressed a need for reusable, environmentally friendly, phase change coating that is capable of withstanding the heat loads that have historically required an ablative thermal insulation. The Space Shuttle Program currently relies on ablative materials for thermal protection. The problem with an ablative insulation is that, by design, the material ablates away, in fulfilling its function of cooling the underlying substrate, thus preventing the insulation from being reused from flight to flight.

The present generation of environmentally friendly, sprayable, ablative thermal insulation (MCC-1), currently use on the Space Shuttle SRBs, is very close to being a reusable insulation system. In actual flight conditions, as confirmed by the post-flight inspections of the SRBs, very little of the material ablates. Multi-flight thermal insulation use has not been qualified for the Space Shuttle. The gap that would have to be overcome in order to implement a reusable Phase Change Coating (PCC) is not unmanageable. PCC could be applied robotically with a spray process utilizing phase change material as filler to yield material of even higher strength and reliability as compared to MCC-1. The PCC filled coatings have also demonstrated potential as cryogenic thermal coatings.

In experimental thermal tests, a thin application of PCC has provided the same thermal protection as a much thicker and heavier application of a traditional ablative thermal insulation. In addition, tests have shown that the structural integrity of the coating has been maintained and phase change performance after several aero-thermal cycles was not affected. Experimental tests have also shown that, unlike traditional ablative thermal insulations, PCC would not require an environmental seal coat, which has historically been required to prevent moisture absorption by the thermal insulation, prevent environmental degradation, and to improve the optical and aerodynamic properties.

In order to reduce the launch and processing costs of a reusable space vehicle to an affordable level, refurbishment costs must be substantially reduced. A key component of such a cost effective approach is the use of a reusable, phase change, thermal protection coating.