National Aeronautics and Space Administration

NASA Technology Infusion

Development of an Ablative 3D Quartz / Cyanate Ester Composite Multi-functional Material for the Orion Spacecraft Compression Pad

Technology Need

Vehicles re-entering Earth's atmosphere require protection from the heat of atmospheric friction. The Orion Multi-Purpose Crew Vehicle (MPCV) has more demanding thermal protection system (TPS) requirements than the Low Earth Orbit (LEO) missions, especially in regions where the structural load passes through. The use of 2-dimensional laminate materials along with a metal insert, used in EFT1 flight test for the compression pad region, are deemed adequate but cannot be extended for Lunar return missions.

Description

This multi-functional material technology provides an innovative, robust solution that will have the combined structural strength and thermal insulation properties needed for MPCV compression pad. It is based on 3-dimensional weaving and resin infusion approach for manufacturing a material that can function as a robust structure as well as a thermal protection system. The Orion compression pads serve as the interface between the Crew Module and Service Module. The Orion compression pads must carry the structural loads generated during launch, space operations and pyroshock separation of the two modules, and then must serve as an ablative TPS withstanding the high heating of Earth re-entry.

Infusion

Woven TPS received seed funding from the Center Innovation Fund. It graduated to the Game-Changing Development Program and is now being infused into the Orion vehicle in preparation for its 2018 flight.

Figure 1. Orion MPCV and compression pad

Solution

The 3-Dimensional Multifunctional Ablative Thermal Protection System (3D MAT) has been developed to meet the needs of Orion Exploration Mission compression pads. The 3D-MAT material derives structural robustness from the high fiber volume fraction of the 3D orthogonal weave and full resin densification at the large scale of 30 cm width by 7.6 cm thick and maintains a relatively low thermal conductivity via use of quartz fibers. This combination of properties is well suited for thermal protection system materials that also meet the structural requirements. New weaving and infusion technologies were developed in order to produce the 3D-MAT material. Continuous, automated 3D weaving of a preform of this type and at this scale has never before

been demonstrated, to the knowledge of the authors. Likewise, the full densification of large 3D preforms was also not well-established, and the RTM process developed herein is unique and enabling for the WQCE material.

Benefit

NASA is well on its way to sending humans into deep space with the asteroid retrieval mission (ARM) and the goal of putting astronauts on Mars in the 2030s. Orion's upgrades for its next launch in 2018 include a newly developed 3D quartz / cyanate ester composite material for the compression pad that will contribute to its long-term mission goals.

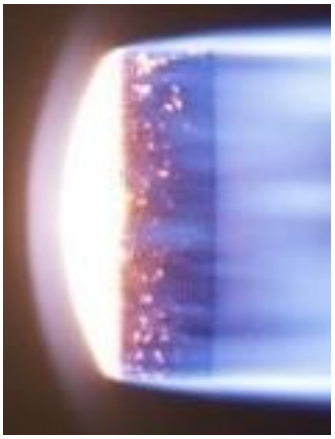

Figure 2. Arcjet test of 3D MAT

Figure 3. Orion

Development Team Leads

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