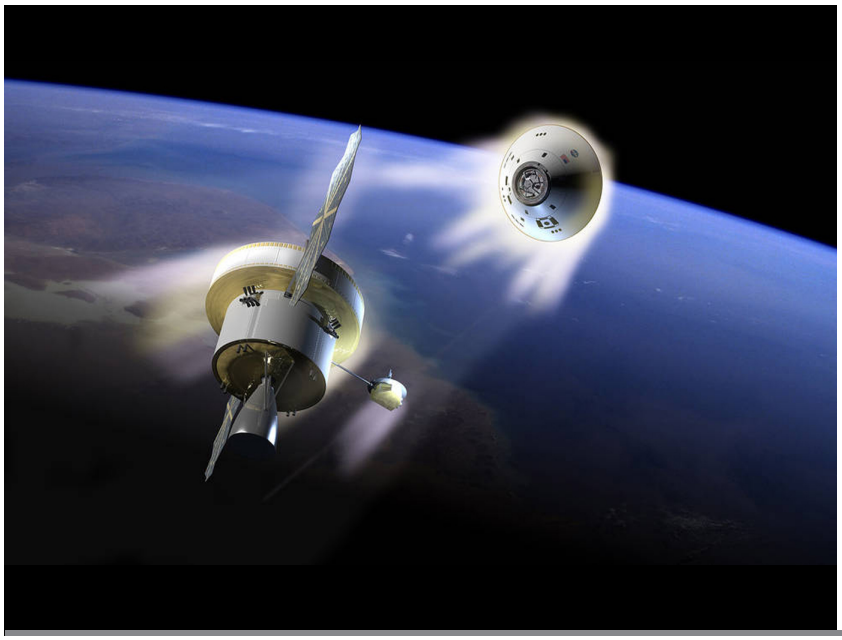


National Aeronautics and Space Administration

TECHNOLOGY SOLUTION

Materials and Coatings

Multifunctional Ablative Thermal Protection System

3-Dimensional Multifunctional Ablative Thermal Protection System (3DMAT)

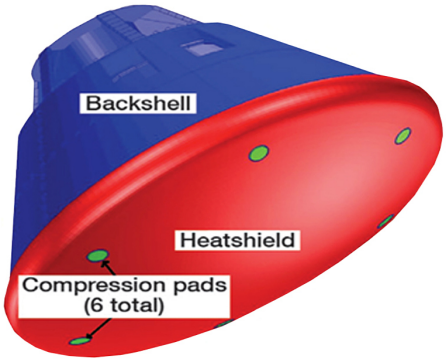
NASA has developed a unique and robust multifunctional material called 3DMAT that meets both the structural and thermal performance needs for a lunar return mission and beyond. The 3DMAT Thermal Protection System (TPS) uses a game-changing woven technology tailored to the needs of the Orion Multi-Purpose Crew Vehicle (MPCV) compression pad in order to support the lunar return mission, EM-1, and beyond. Compression pads serve as the interface between the crew module and service module of the Orion MPCV. The compression pads must carry the structural loads generated during launch, space operations, and pyroshock separation of the two modules. They must also serve as an ablative TPS withstanding the high heating of Earth re-entry. 3DMAT leverages the NASAs investment in woven TPS to design, manufacture, test, and demonstrate a prototype material for the Orion compression pads that combines the weaving of quartz yarns with resin transfer molding.

BENEFITS

- Significantly enhanced composite z-direction (inter-layer) strength relative to a 2D laminate material
- Well suited for structural components requiring 3D reinforcement in a large size
- Larger part cross-section compared to any previous continuously woven material
- Robust aerothermal performance, tested up to 700 W/cm2

THE TECHNOLOGY

The initial compression pad design for Orion was complex and limited to Earth orbit return missions, such as the 2014 Exploration Flight Test-1 (EFT-1). The 2-D carbon phenolic material used for EFT-1 has relatively low interlaminar strength and requires a metallic sheer insert to handle structural loads. There are few options for materials that can meet the load demands of lunar return missions due to performance or part-size limitations. The 3DMAT material is a woven fiber preform fully densified with cyanate ester resin. It produces a large composite with significant structural capabilities and the ability to withstand high aerothermal heating environments on its outer surface while keeping the inner surface cool and protected from the aerothermal heating. The robustness of the 3DMAT material is derived from high fiber volume (>56%), 3-D-orthoganol architecture, and low porosity (0.5%). Orion has adopted 3DMAT for all future MPCV missions, including EM-1 schedule to launch in 2018.



Orion crew module highlighting the compression pads in the heat shield

APPLICATIONS

The technology has several potential applications:

- Material handling
- Aerospace systems
- Manufacturing
- Thermal Protection Systems

PUBLICATIONS

Patent No: 10,105,909

https://ntrs.nasa.gov/citations/20150011678
https://ntrs.nasa.gov/citations/20190002016

technology.nasa.gov

NASA's Technology Transfer Program pursues the widest possible applications of agency technology to benefit US citizens. Through partnerships and licensing agreements with industry, the program ensures that NASA's investments in pioneering research find secondary uses that benefit the economy, create jobs, and improve quality of life.

ARC-17602-1, TOP2-244

More Information

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