National Aeronautics and Space Administration

NASAfacts

Space Technology
Game Changing Development
Woven Thermal Protection System

Overview
Woven Thermal Protection System (TPS) is a 14-month technology development project to prove the feasibility of woven material as a game changing approach for future planetary entry/return missions. Woven TPS can be rapidly manufactured at low cost, and could provide a sustainable, scalable and mission specific TPS solution. The woven carbon fabric, in combination with resin infusion through a resin transfer molding process, creates a TPS material capable of handling entry heating between 2,000 and 10,000 W/cm^2. Woven TPS material also exhibits greater structural capability making them suitable for multifunctional applications. One such application currently being investigated is the use of woven material in the design of compression pads for the Orion Multi-Purpose Crew Vehicle (MPCV).

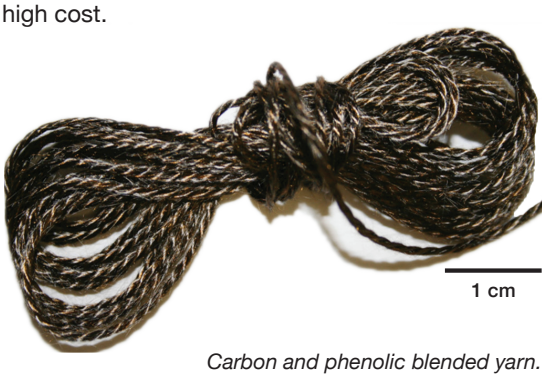
Project Description
Planetary entry and near-Earth object return missions with an anticipated heat flux between 1,500 and 10,000 W/cm^2 are currently limited to one viable TPS material—fully dense carbon phenolic (CP). However, high-density CP is only mass efficient at heat fluxes above 4000 W/cm^2. This mid-density TPS performance gap can be filled using cost-effective weaving technology to produce high-grade, conformal, mid- to high-density TPS. Woven TPS not only bridges this gap but also offers a superior performing replacement for heritage CP.

A woven TPS approach can result in TPS solutions that are optimized to a given mission's environments but with much-reduced costs compared to current TPS development and certification approaches. The woven TPS approach utilizes a stable U.S. weaving industrial base and processes that has a proven legacy and longevity in manufacturing commercial and advanced aerospace products. This industry has demonstrated capability to weave highly complex patterns in a 3D weave configuration for commercial applications.

The Woven TPS Project will demonstrate this concept in partnership with a reliable industrial weaver selected through a Request for Information process in a 14-month program. We will accomplish this by designing and manufacturing a series of low-, mid- and high-density samples of woven carbon fiber material of varying yarn compositions, weave architectures, and level of resin infiltration and by testing them at extreme conditions. It is the project's goal to develop a preliminary database, compare the performance of woven TPS against heritage fully dense CP, and raise the woven TPS from Technology Readiness Level (TRL) 2 at the start of the project to TRL 3 at project completion.

Direct Mission Infusion: 3D Woven Multifunctional Ablative TPS
It is recognized that woven technology developed and matured under the Woven TPS project has the potential for direct infusion into current NASA mission applications. 3D Woven Multifunctional Ablative TPS (3D MAT) is an approved new start project initiated in July 2012 to develop a multifunctional material solution (to TRL 4) using 3D weaving capability for Orion MPCV compression pads suitable for lunar return missions.

The six compression pads in the Orion heat shield serve as the interface between the service module and the crew module. The compression pads must carry the structural loads generated during launch and operations in space, and then must serve as an ablative TPS upon separation and entry, descent and landing. The current compression pad design for Orion is complex and limited to low-Earth orbit return missions. The baseline material in the current design is a 2D CP material, which has poor interlaminar strength. A metallic insert is required to handle mechanical loads. The combination of 2D CP and metallic insert is not suitable for meeting lunar return loads condition. Few existing options are available due to performance limitations and high cost.



Carbon and phenolic blended yarn.

3D MAT will leverage the efforts of Woven TPS to develop, manufacture, test and demonstrate a prototype material for Orion compression pads. The effort will combine 3D woven manufacturing techniques (using carbon, phenolic and/or quartz yarn) with resin infusion to develop a multifunctional material architecture capable of meeting both structural and thermal performance needs for lunar return. The end goal of 3D MAT is to deliver a prototype lunar return capable compression pad material for Orion MPCV flight testing in 2017.

Partnerships and Outreach

Woven TPS and 3D MAT are Game Changing Development Projects supported by NASA's Space Technology Mission Directorate. Rapid advancement in the Woven TPS effort was made possible by partnering with industrial textile manufacturer Bally Ribbon Mills of Bally, PA, and in teaming with other NASA centers including Johnson Space Center and Langley Research Center to provide needed expertise. In addition, Woven TPS has received support from student interns assisting with various aspects of material development from property testing to evaluating applicability of state-of-the-art modeling tools to guide in the Woven TPS design.

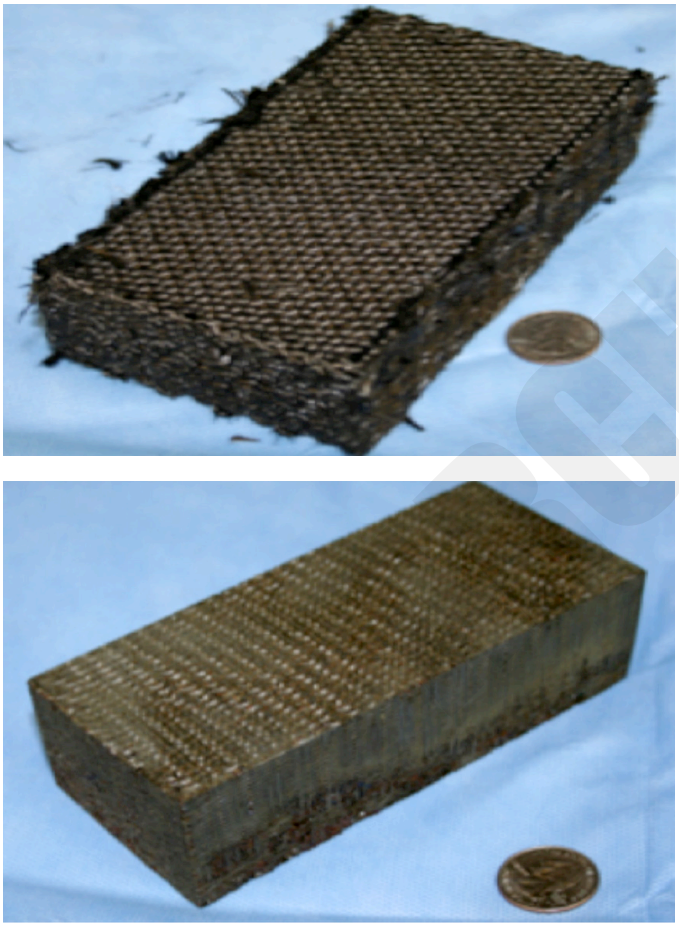
Principal Investigator:
Ethiraj Venkatapathy, NASA's Ames Research Center

For more information:
http://www.nasa.gov/centers/ames/cct/technology/stp/gamechanging/woven_tps.html

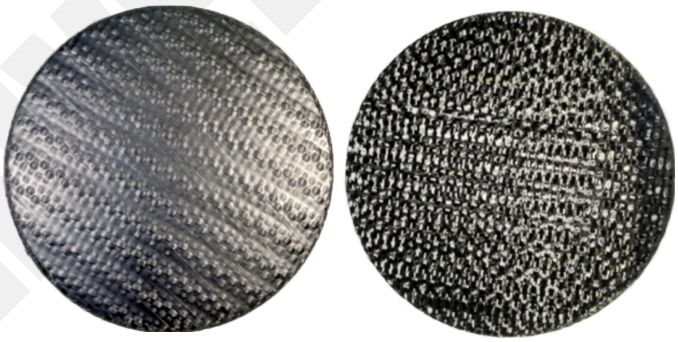
To see a video about Woven TPS:
http://gcd.larc.nasa.gov/media-center/

The Game Changing Development (GCD) program investigates ideas and approaches that could solve significant technological problems and revolutionize future space endeavors. GCD projects develop technologies through component and subsystem testing on Earth to prepare them for future use in space. GCD is part of NASA's Space Technology Mission Directorate.

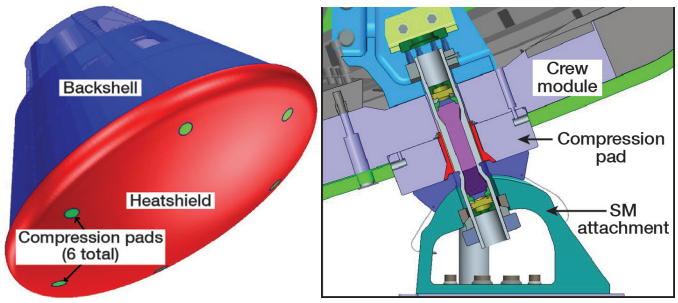
For more information about GCD, please visit
http://gameon.nasa.gov/



Woven perform (preinfusion), top, and resin infused woven TPS.



Woven TPS test article pretest, left, and posttest.



Crew module, left, and expanded view of the crew module, compression pad and the explosive bolt and service module (SM) attachment (SM not shown).

National Aeronautics and Space Administration

Ames Research Center
Moffett Field, CA 94035

www.nasa.gov

FS-2012-10-200-LaRC