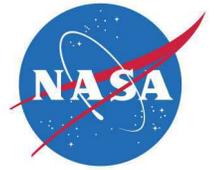




National Aeronautics and
Space Administration



Materials and Coatings

Toughened Uni-piece Fibrous Reinforced Oxidation-Resistant Composite (TUFROC)

Light weight, low cost, reusable thermal protection
systems for 1650 degree C

This invention is available for licensing from NASA's space program to benefit U.S. industry. The Toughened Uni-Piece Fibrous Reinforced Oxidation-Resistant Composite (TUFROC) represents an exciting leap in reusable thermal protection systems (TPS) technology that allows for much more affordable and sustainable operations involving Space Launch Services and other systems that utilize Earth re-entry vehicles. TUFROC has an exposed surface design and appropriate materials combination for a space vehicle that will survive the mechanical stresses induced in the initial ascent and will subsequently survive the extreme heating and mechanically stressful environment of re-entry. It provides a thermal protection tile attachment system, suitable for application to a space vehicle leading edge and for other uses in extreme heating environments (up to 3600 degree F., and possibly higher, for short time intervals).

BENEFITS

- Flight tested
- Survives high heat fluxes 3600 F. and above
- Light weight
- Modular, therefore easily replaceable
- Low cost to fabricate and maintain
- Easier to design - can be fabricated and tested in various configurations
- Reusable thermal protection system
- Provides a composite insulating structure

technology solution



NASA Technology Transfer Program

Bringing NASA Technology Down to Earth

THE TECHNOLOGY

The invention includes an exposed surface cap having a specially formulated coating, an insulator base adjacent to the cap with another specially formulated coating, and one or more pins that extend from the cap through the insulator base to tie the cap and base together through ceramic bonding and mechanical attachment. The cap and insulator base have corresponding depressions and projections that mate and allow for differences in thermal expansion of the cap and base. The cap includes a high temperature, low density, carbonaceous, fibrous material whose surface is optionally treated with a HETC formulation, the fibrous material being drawn from the group consisting of silicon carbide foam and similar porous, high temperature materials. The insulator base and pin(s) contain similar material. The mechanical design is arranged so that thermal expansion differences in the component materials (e.g., cap and insulator base) are easily tolerated, and is applicable to both sharp and blunt leading edge vehicles. This extends the possible application of fibrous insulation to the wing leading edge and/or nose cap on a hypersonic vehicle. The lightweight system comprises a treated carbonaceous cap composed of Refractory Oxidation-resistant Ceramic Carbon Insulation (ROCCI), which provides dimensional stability to the outer mold line, while the fibrous base material provides maximum thermal insulation for the vehicle structure. The composite has graded surface treatments applied by impregnation to both the cap and base. These treatments enable it to survive in an aero-convectively heated environment of high-speed planetary entry. The exact cap and base materials are chosen in combination with the surface treatments, taking into account the duration of exposure and expected surface temperatures for the particular application.



Various configurations of TUFROC



Toughened Uni-Fibrous Reinforced Oxidation-resistant Composite (TUFROC)

APPLICATIONS

The technology has several potential applications:

- Reentry vehicles
- Spacecraft
- Race cars
- Heating elements for furnaces
- Aircraft
- Turbine engines
- Automobiles

PUBLICATIONS

Patent No: 7,381,459; 7,314,648

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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.

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