TECHNISCHE UNIVERSITÄT DRESDEN

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Wooden materials for space -

an insight into research on bio-based ablative thermal protection materials and their path to REXUS

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Motivation

Creation of long term sustainability in space by [1,2]:

→ Maximising the use of renewable resources

→ Minimising the environmental impact of manufacturing and launching space assets

Application of cork-based thermal protection system (TPS) in primary and secondary launch vehicle structures [3]

Research gap:

Bio-based thermal protection systems with the characteristics of current TPS and high mechanical performance.

Aim:

Utilise acceptance of a previously used TPS material of biological origin - cork.

→ Design an ablative TPS material made from preferably 100% renewable resources (especially wood and natural fibres)

→ Development of a dimensionally stable material withstanding high thermal <u>and</u> mechanical loads

Bio-based thermal protection material „TPSea“

Key design aspects:

→ Raw material screening and concept investigation

→ Development of recipe for TPSea

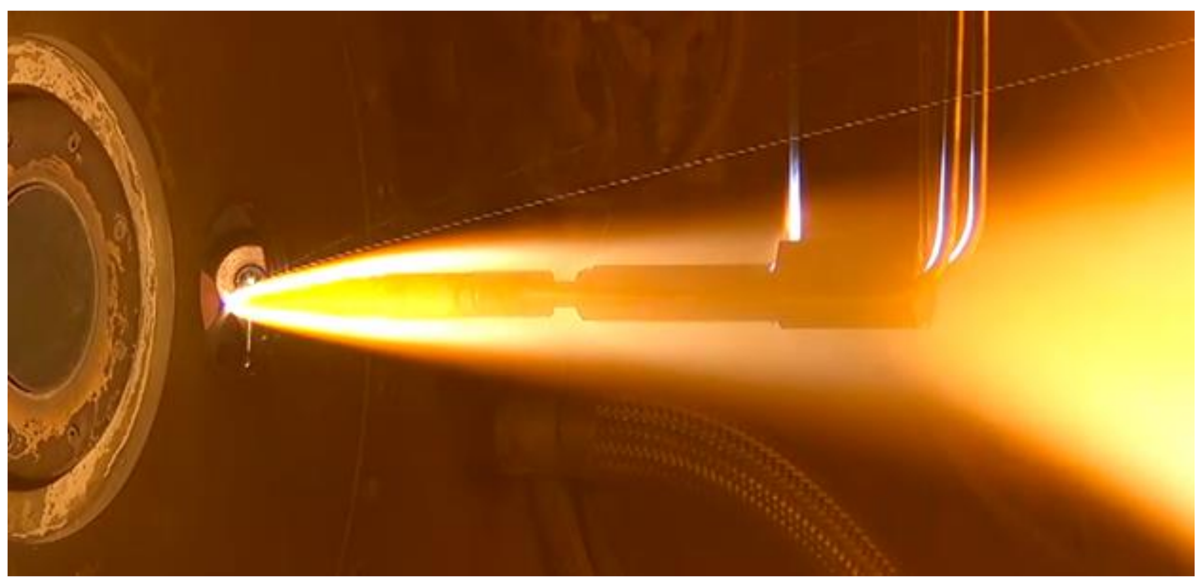
→ Optimisation of production process

From raw material to TPSea

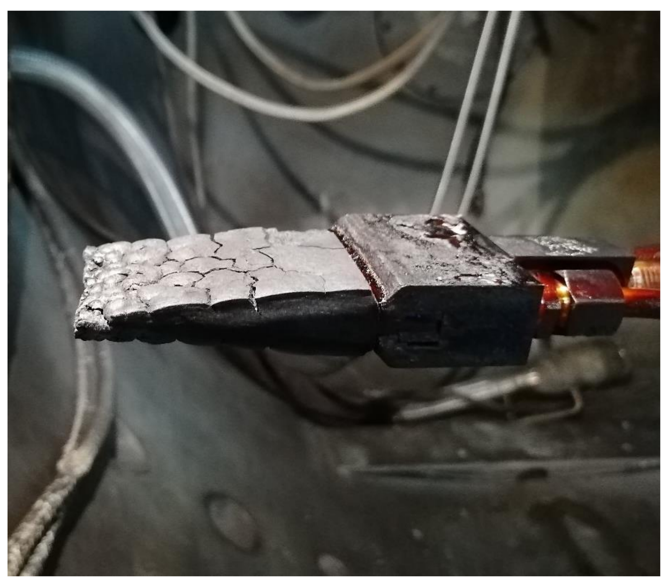
Evaluation and characterisation of TPSea by:

- Bulk density profile
- Spec. heat capacity and thermal conductivity
- Thermogravimetric analysis (TGA)
- Bending and tensile strength
- Testing in arc-heated wind tunnel L2K with peak temperatures of ~2200° C

Test specimen of TPSea before and after TGA



Investigation of ablation characteristics of a TPSea sample in the arc-heated wind tunnel L2K of the German Aerospace Center (DLR) [4]



Carbonised test specimen after testing in L2K

Results and potential advantages

→ Patenting of TPSea: DE 10 2022 132 031 A1

→ Density of ~ 0.7 - 0.9 g/cm³ ; Bending strength of 5 - 15 N/mm²

→ Consistent thermal resistance due to similar spec. heat capacity

→ Strength: 6-20 times higher tensile strength compared to ablative cork-TPS

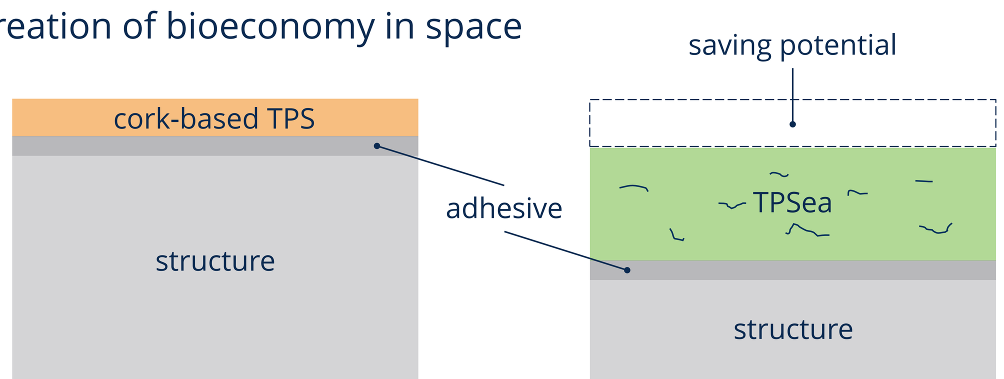
Potential advantages of wooden materials in space:

→ Easy handling and moulding

→ More energy- and cost-efficient, local manufacturing

→ Utilisation of readily available, renewable resources

→ Creation of bioeconomy in space



→ Design rethinking by TPSea withstanding thermal <u>and</u> mechanical loads

→ Lighter overall design by reducing the thickness of metallic base structure

SHAMA Experiment on REXUS 34

SHAMA - **S**ustainable **H**eat-protective **A**blative **MA**terial

→ Understand TPSea material behaviour in relevant environments during REXUS 34 flight

During flight:

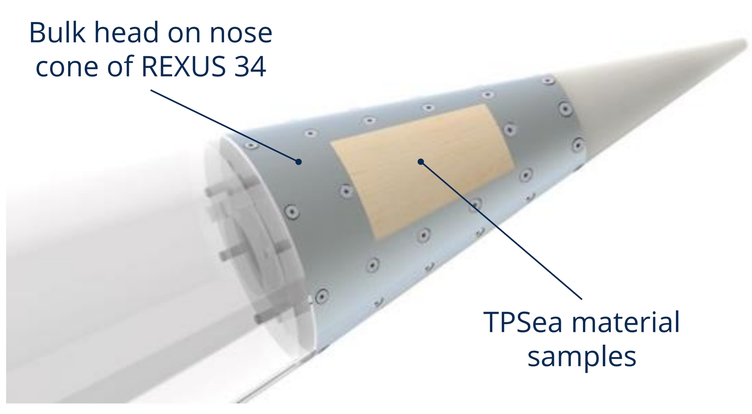
→ Measurement of temperatures at various points

→ Measurement of material thickness to in-situ record material ablation via ultrasonic sensors

Post-flight:

→ Visual and analytical examination of surface and core material

→ Analysis and evaluation of measurements



Experiment design of nose cone bulk head for REXUS 34

Flight components of SHAMA experiment

References:

[1] United Nations Office for Outer Space Affairs Guidelines for the Long-Term Sustainability of Outer Space Activities of the Committee on the Peaceful Uses of Outer Space; United Nations, 2022; ISBN 978-92-1-002185-2.

[2] ESA The ESA Green Agenda Available online: https://www.esa.int/About_Us/Climate_and_Sustainability/The_ESA_Green_Agenda (accessed on 13 September 2024).

[3] O. Drescher, M. Hörschgen-Eggers, G. Pinaud, and M. Podeur, 'Cork Based Thermal Protection System For Sounding Rocket Applications-Development And Flight Testing', 2017.

[4] German Aerospace Center - Deutsches Zentrum für Luft- und Raumfahrt (DLR), Institut für Aerodynamik und Strömungstechnik.

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