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Advanced Ablation Characterization and Modelling

Results in Brief

Advanced methods for characterization and modelling of ablative materials

Because of the absence of validated predictive models, today most ablation materials are developed by an iterative trial-and-error process and are not in line with the latest safety rules. An EU-funded project develops key technologies for improvements in efficiency and cost for a new generation of high temperature materials.

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One of the biggest challenges of space transportation is bringing back a spacecraft to Earth or achieving safe entry and landing on other planets. During the atmospheric entry phase of the flight the vehicle is exposed to extreme thermal loads. In the dense atmosphere of a gas giant like Jupiter or Saturn these loads can be two or even three orders of magnitude larger than those of an Earth re-entry. The development of more efficient materials is essential for interplanetary missions like ExoMars or sample return missions.

One way of managing thermal loads on a spacecraft, caused by the enormous speed of re-entry, is to protect its structure with a sufficient thermal protection material. The most efficient method is the thermal ablation process, which blocks the heat transfer due to the phase transformation from solid state to liquid and gas. Gaseous ablation products remove heat from the surface during the outgassing process.

However, most ablation materials currently available are the results of research carried out more than 20 years ago. Recently Europe intensified the effort for the development of new generation ablation materials. Main objectives of the EU-funded project 'Advanced ablation characterization and modelling' (ABLAMOD) are better material characterization, improvements in physical modelling and measurement techniques.

The ABLAMOD team investigated three main ablators based on carbon phenolic, silica phenolic composites and cork. Novel spectroscopic techniques are used to characterise the high enthalpy flow properties and material behaviour under extreme aerothermal environments. Complementary measurement techniques allow the determination of material properties like density, thermal conductivity, heat capacity and thermal expansion at different levels of the ablation process.

The collected experimental data serves as a starting point for the development and validation of realistic models for ablation processes. ABLAMOD researchers develop modules for gas-surface interaction, transport phenomena and radiation. The modularity of the coupling tool of these modules and the main ablation code allow very flexible simulation with different time scales. ABLAMOD's approach for ablation modelling is unique in Europe. Through a better understanding of the underlying physics, a significant step is expected to be made towards a predictive ablation modelling framework, allowing the tailoring of materials for a specific mission.

Keywords

Thermal protection · ablation material · extreme temperatures · re-entry · material characterization · ablation modelling

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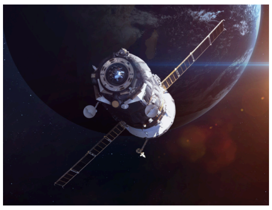

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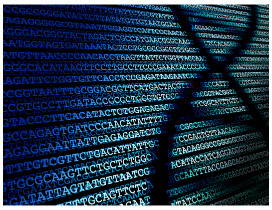

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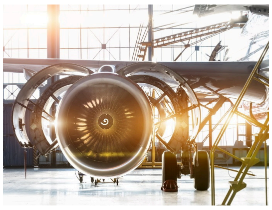

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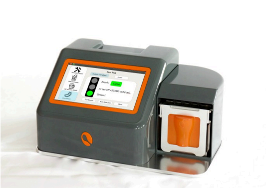

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