LIGHT
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Technology Strategy Board
Driving Innovation

Demonstrator part: Thermal Protection System for Earth Re-Entry Capsule

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magnaparva™

End user

Magna Parva (http://www.scienceandtechnologyforhostileenvironments.com) has a strong heritage delivering engineering services, novel technologies and successful projects for hostile environments. They have developed strong partnerships with their clients and enjoy delivering a responsive, reliable and flexible resources, services and solutions. Their offices and labs in Leicester house design and analysis software, assembly integration and test equipment operated by highly skilled engineers and technologists who, cost effectively, work on numerous ESA projects and missions. Their Design, Management, Product and Quality Assurance systems have been developed with significant Space heritage and are now trusted by Agencies, Research Organisations, Large and Small Companies throughout Europe and beyond to meet even the most demanding of project requirements.

Description of the demonstrator part

The Thermal Protection System (TPS) for Earth Re-Entry Capsule (ERC) is a crushable lattice structure that is designed to protect a sensitive payload of planetary samples of the ERC by the management of thermal and mechanical energies imparted during mission phases such as atmospheric entry, descent and landing. The demonstrator is a small section (30 x 30 x 30 mm) of TPS 'material' which can appropriately represent the relatively large structure of the ERC (1.4 m diameter).

Figure 1 - Earth-Re-Entry Capsule

Objective of the demonstrator part

The TPS needs to exhibit bulk yield strength of 7.6 MPa +/- 10% using an additively manufactured (AM) titanium Ti-6Al-4V lattice. The bulk density must be less than 0.4 g/cm3. The challenge in engineering such a 'material' that is designed to crush at a certain load lies in the initial selection of lattice geometry and the subsequent addition and subtraction of material to nodes and elements. A solution for the TPS must be achieved with a density of less than 10% of the parent material.

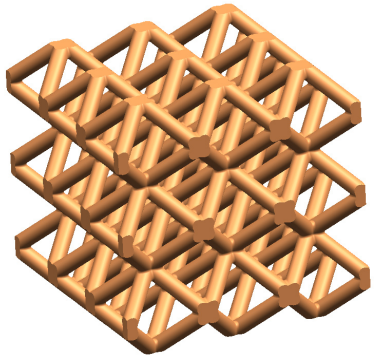

Figure 2 - Space Demonstrator Section of TPS Material

Description of the Research and Development approach to produce the final part

A baseline demonstrator is proposed which utilises a simple lattice consisting of four intersecting elements. Finite element analysis (FEA) was conducted on this component revealing crush strength of 8.2 MPa (meeting the requirement) with a density of 0.8 g/cm3. Initial results are unacceptable but show that a solution is feasible and help to define an approach to improve the part. The LIGHT software will be used to generate a library of lattice 'materials' which will undergo preliminary analysis for bulk properties. The most promising solution(s) will be improved in an iterative design-analysis phase until the component requirements can be demonstrated. Empirical testing of manufactured samples will correlate FEA studies and definitely establish a solution.

Benefits for Magna Parva Ltd

1. The ability to design and manufacture mass-optimised components is a key interest for Magna Parva, whose core business is mechanisms and structures for space and planetary exploration – An industry which typically imposes strict mass constraints. Further benefits are available where AM components may be designed with environment-tailored properties, such as optimised load paths. A software tool which assists the optimisation and design for manufacture of AM parts is an attractive proposition. Magna Parva is fortunate to be able to work with the partners of the LIGHT consortium and enjoys opportunities to expand industrial awareness and professional responsibility.

Project information

The LIGHT project (full title Inspiring New Design Freedoms and Light-Weight Solutions for Metal Additive Manufacturing) is funded by the UK's innovation agency, the Technology Strategy Board. Potential improvements in the economy and performance of Metal Additive Manufacture (MAM) components will be investigated by the use of specialised software. The LIGHT software tool, which will be developed throughout the project, allows the selective replacement of internal geometry by a lattice structure. Thus it is anticipated that the mass and material required to manufacture components will be reduced, whilst maintaining external geometry.

The LIGHT project is being undertaken by a consortium of seven organisations: Delcam Ltd, Bloodhound Programme Ltd, HiETA Technologies Ltd, CRDM/3DSystems Ltd, EOS Electro Optical Systems Ltd, Simpleware Ltd and Magna Parva Ltd.
The project runs from the 1st of December 2013 until the 31st of May 2016.

The consortium selected three demonstrator parts:

- *Air Brake Door Hinge (end user Bloodhound SSC)*
- *Thrust Nozzle (end user HiETA Technologies Ltd)*
- *Thermal Protection System for Earth Re-Entry Capsule (end user Magna Parva Ltd)*

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