Additive Manufacturing of Actively Cooled Thermal Shields

Pedro Miranda[1 *], Joel Andersson[2], David Linder[3], Ludovic Charpentier[4]

[1] Departament of Mechanical, Energy and Materials Engineering, University of Extremadura, Badajoz, Spain.

[2] Department of Engineering Science, University West, Trollhättan, Sweden.

[3] QuesTek Europe AB, Solna, Sweden.

[4] PROMES-CNRS, Font-Romeu Odeillo, France.

* presenting author e-mail: pmiranda@unex.es

High-temperature Thermal Protection Systems (TPS) that are critical in many industrial applications (aerospace, energy generation, etc.) typically rely on passive thermal insulation, which is limited by the oxidation and ablation resistance of their constituent materials. In the AM-ACTS project we develop novel high-performance thermal shield elements that can be actively cooled by circulating an appropriate fluid through a bioinspired internal microchannel network created by additive manufacturing (AM) within the TPS elements.

Sustainable and flexible fabrication routes based on direct and/or indirect AM and low-energy sintering processes like spark plasma sintering (SPS) for improved sustainability has been successfully applied to the production of these actively cooled thermal shields (ACTS) from ultra-high temperature ceramics and refractory metals. Reliable UHTCs (ZrB_2, TiB_2, ZrC) feedstocks for DIW, with and without the incorporation of BN reinforcing platelets, have been developed and used in the fabrication of ACTS. Methods for combining refractory alloys like Inconel 718 with UHTCs in multi-material AM constructs have also been explored experimentally, as well as numerically, and the microstructure and performance of the resulting multi-materials have been analyzed.

Experimental and computational results to be presented orally and in the poster, indicate that the proposed designs and processing routes offer suitable solutions for the sustainable and environmentally friendly production of thermal shields for atmospheric re-entry in reusable spacrafts, turbine blades, rocket engines, reactor walls or solar receivers with improved maximum service temperature and/or service lifetime at a given temperature. All of which will have a major impact in terms of energy efficiency, sustainability and maintenance costs reduction in these and many other industrial applications.

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