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ACTIVE COOLING CONCEPT FOR HIGH-TEMPERATURE APPLICATIONS USING LIGHTWEIGHT ADDITIVELY MANUFACTURED LATTICE CORE STRUCTURES

Abstract

In the last decade, reusability of launchers first stages boosted the necessity for high temperature structures and materials. Thermal Protection Systems and rocket propulsion components shall be able to survive severe thermal and mechanical environments, while still having minimal possible mass. The exploitation of the Additive Manufacturing (AM) of metallic components offers a wide potential for the generation of geometries which allow one to reach an optimum between the load carrying capability, their thermal protection performance and systems mass. This paper proposes a concept for actively cooled lightweight structures capable of withstanding both mechanical and thermal loads. Five types of viable open cell lattice cores for sandwich structures are analysed and compared. This is done numerically by simulating the flow of cooling medium through an externally heated pipe embedding such cores. Numerical results are verified by comparing them with available literature. Each lattice specimen is analysed at constant heat load and varying coolant mass flow rates. These lattices are compared in terms of their permeability, pressure drop, heat transfer rate and mechanical strength. The best performing specimen provides the lattice core type that shall deliver the best overall performance depending on the coolant type, available pumping power, thermal and structural loads. These structures can be used to increase the thermomechanical performance of various heat exchanger applications, while reducing their weight and exploiting modern AM capabilities to the fullest. Applications where lattice core sandwich structures can be utilized include active cooling of heatshields for re-entry vehicles and rocket engines. Lastly, to showcase their potential, an exemplary actively cooled aerospike nozzle with a porous lattice core for a hybrid sounding rocket is designed and its thermomechanical performance numerically analysed.