MECHANICAL AND THERMAL PROPERTIES OF CHIRAL HONEYCOMBS

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The multifunctional properties of cellular solids have generated great interest for their application in ultra-light structures. Their characteristics are highly dependent on the cell geometry, which can be in principle designed to enhance mechanical, electromagnetic and thermal performances. The application of stronger and lighter structural assemblies and materials is particularly relevant to the aerospace and aircraft industries. Ongoing interests in such structures and improvements in manufacturing processes have contributed to the study and development of cellular solids of innovative shapes and topologies. Much interest has recently centered on cellular assemblies featuring a negative Poissons ratio behavior, also known as "auxetic" [1]. Materials having auxetic characteristics include special subsets of foams, long fiber composites, microporous polymers, as well as honeycombs [1,2]. In honeycombs, the negative Poissons ratio behavior implies a stiffening geometric effect, which leads to increased in-plane indentation resistance, shear modulus and compressive strength [2]. An analytical analysis of deformation of these honeycombs [3] allows prediction of the mechanical properties. Among the topologies with negative Poisson's ratio, the chiral layout has some interesting features, which are explored in this paper. In particular, the potential of chiral honeycombs to be applied as load carrying thermal protection systems (TPS) are investigated. A variety of TPS concepts, currently being considered for future space transportation systems, involve the use of honeycombs as heat-shielding and load-carrying structural components. The honeycomb construction provides low density and low thermal conductivity through the TPS thickness. Significant advantages over current TPS may be obtained if multiple tasks can be carried out by the same structural component: a multifunctional honeycomb TPS, for example, will be subjected to aerodynamic pressure loading, in addition to high temperatures. Cell walls must withstand air loads without buckling, or undergoing deformations which may affect the aerodynamic performance of the vehicle they are employed on. To this end, previous work [4] has shown that honeycombs with chiral core possess significantly higher flat-wise compressive strength than hexagonal configurations. The current study focuses on the mechanical properties of chiral honeycombs, as well as the effect of honeycomb cell geometry on the heat-shielding performance. The performance of chiral honeycombs as TPS is evaluated in comparison with that of hexagonal honeycomb. The comparison is carried out while taking weight into consideration, so that a normalized performance index is obtained. Results of numerical simulations show that chiral honeycombs provide better thermal insulation, in addition to higher structural strength, which suggest the application of the proposed configuration as an alternative to current designs.

References

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