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MATERIALS AND STRUCTURES SYMPOSIUM (C2)
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ANALYTICAL STUDY OF THERMAL AND MECHANICAL PROPERTIES OF SYNTACTIC FOAMS FOR SPACE APPLICATIONS

Abstract

A critical factor required for the sustained extraterrestrial presence of humans in the solar system is the ability to provide durable, lightweight, structural, thermal insulation composites (STICs) that can be inexpensively manufactured and transported. This work aligns with NASA's grand challenge of Space Colonization and technology roadmap areas TA14 (Thermal Management Systems) and TA12 (Materials, Structures, Mechanical Systems and Manufacturing). The primary objective is to develop composite materials having a thermal conductivity below 50 mW/(m-K) and mechanical properties suitable for extraterrestrial habitat construction. This study focuses on the optimization of syntactic foams incorporating hollow glass spheres in an epoxy matrix. Previous work has investigated thermal properties and mechanical properties of syntactic foams independently without consideration for how these properties change in relationship to one another. This work looks at the relationship between thermal properties and mechanical properties as a function of the volume fraction of hollow glass spheres, packing arrangement, and size distribution to optimize the thermal and mechanical properties for extraterrestrial habitat requirements. Three dimensional finite element modeling, using a representative volume element, was performed to predict both thermal and mechanical properties of hollow glass syntactic foams. The study considers the effects of three different packing patterns and size distributions over a volume fraction range from 0 to 72%. It was found, as expected, that the effective thermal conductivity and strength of the syntactic foam decreased with increased volume fraction of hollow spheres. It was also shown that the packing pattern and size distribution of spheres has little effect on the effective thermal conductivity but may be more influential on the mechanical properties of the foam such as the magnitude and location of stress concentrations developing within the epoxy matrix. The results from this study will be used in the design of syntactic foams of which thermal and mechanical properties will be experimentally measured.