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CARBON FIBER REINFORCED PLASTICS WITH ALUMINUM HONEYCOMB CORE DESIGN METHODOLOGY FOR SPACE AND SURFACE MINING APPLICATIONS

Abstract

The space mining market is expected to grow in the future with water, gold, and platinum as just a few of the resources that could be accessible in the Moon or in near-Earth asteroids. In order to achieve this mining capability, sandwich composites offer an optimum structure for space mining vehicles due to their relatively high strength and stiffness compared to their weight. Expanding the use of composite material systems into the space and surface mining industries requires design charts that fully define the material system for a design engineer. Currently, there is no methodology that systematically allows a design engineer to define a sandwich composite material system that consists of carbon fiber reinforced plastics with aluminum honeycomb cores. This paper introduces design charts and tables generated using a combination of Classical Lamination Plate Theory and Honeycomb Mechanics that allows an engineer to specify all parameters that make up this type of material system. These parameters include 1) number of plies 2) stacking sequence 3) core thickness 4) core density. Analytical models developed here were further validated by experimental analysis using appropriate ASTM standards with good correlation. Use of these design charts will help facilitate wider use of sandwich composites into the space and surface mining industries as a replacement to typical monolithic materials.

Along with development of design charts using analytical and experimental methods, a novel technique for modeling sandwich composites using finite elements is introduced. This approach uses 3D elements and is conducive to rapid design iterations when topological changes are occurring, such as in a Research and Development environment. Numerical techniques and algorithms were developed to allow an engineer to solve and post-process hundreds of load cases for the purpose of verifying the sandwich composite parameters that were selected from the previously discussed design charts. Numerical results are validated with analytical models.

This methodology uses both analytical and numerical models to specify all parameters of a sandwich composite material system consisting of carbon fiber reinforced plastics with aluminum honeycomb cores. First, all parameters can be initially selected using design charts developed with analytical models. Second, the material system can be verified using the numerical techniques and algorithms used in this research.