Paper ID: 22223
oral
student

MATERIALS AND STRUCTURES SYMPOSIUM (C2)
Smart Materials and Adaptive Structures (5)

Author: Mrs. Marina Toropova
Univeristy of Toronto, Canada, toropova@utias.utoronto.ca

Prof. Craig Steeves
Univeristy of Toronto, Canada, csteeves@utias.utoronto.ca

ADAPTIVE BI-MATERIAL LATTICES TO MITIGATE THERMAL EXPANSION MISMATCH IN SATELLITE STRUCTURES

Abstract

Thermal strains and stresses due to temperature changes in satellite structures with adjoining parts made of materials with different coefficients of thermal expansion (CTE) present a serious problem due to thermal mismatch stresses and strains. To resolve it, it is possible to employ special composite adaptors with graded CTE configured as lattices made of two materials and empty space. The lattices consist of planar nonidentical anisotropic composite bi-material cells. Each cell is a generalization of the cell described in [Steeves et al. J. Mech. Phys. Solids, 2007, 55, 1803]: it is built based on an arbitrary virtual triangle and physically consists of two triangles connected to each other. An external skewed triangle is made of a material with lower CTE , and an internal unskewed triangle is made of a material with higher CTE. Different skew angles provide different CTEs along the sides of the virtual triangle in the cell. Such cells can be combined in a lattice in such a way that one edge of the lattice has CTE that coincides with the CTE of the first part of the structure, while the other edge of the lattice has CTE equal to the CTE of the second part of the structure. Differential thermal expansion can therefore be accommodate without generating thermal mismatch stresses. This paper presents a design algorithm for an individual cell, which requires the solution of nonlinear equations linking skew angles to three CTEs of the cell. The shape of each cell (the base triangle upon which it is built) is defined by the geometry of the adjoining parts of the satellite structure. Then, the cells are combined in one or more rows forming a planar or non-planar lattice. As an example, a polygonal ring connector to prevent lens misalignment is considered. The analysis shows that it is possible to design a bi-material lattice that connects structural elements with differing CTE without generating thermal stresses or unwanted thermal strains.