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VISCOELASTIC ENERGY DISSIPATION OF DEPLOYABLE COMPOSITE STRUCTURES

Arafat Khan[1], Elisa Borowski[1], Eslam Soliman[2], Mahmoud Taha[1]

[1]University of New Mexico, United States of America
arkhan@unm.edu, eborowsk@unm.edu, mrtaha@unm.edu
[2]Assuit University, Egypt
eslam.soliman@eng.au.edu.eg

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Summary: Deployable aerospace structures made of fiber reinforced polymer (FRP) composites for space missions are of great interest to the aerospace community. The ability of folding and deploying these light weight composites without failure made them attractive materials for aerospace applications. A three-layer composite laminate tape spring made of (±45 plain weave, 0 unidirectional, ±45 plain weave) carbon fibers was recently suggested as an efficient deployment hinge. The rationale behind using the three layer composite laminate is that during the stowage (i.e. storage) period, the first and third ±45 plain weave lamina are subjected to pure shear stresses and thus their behavior will be dominated by the polymer matrix. Viscoelasticity of the polymer matrix can then be used to dissipate energy to control the deployment process.

In this paper, time dependent explicit finite element analysis in ABAQUS is used to simulate the viscoelastic energy dissipation of laminated composite tape spring. The challenge is related to modeling viscoelasticity of orthotropic materials. Most existing modeling techniques allow modeling viscoelasticity in isotropic but not orthotropic composite materials. We demonstrate the use of specifically designed user defined material subroutine (UMAT) to model viscoelasticity of the composite tape spring. The suggested UMAT was first validated using stress-relaxation tension test of ±45 plain weave carbon fiber coupons. The validated FE model was then used to simulate viscoelastic energy dissipation of CFRP deployable tape spring during stowage period. It is suggested that the proposed modeling approach can be extended to enable design of aerospace deployable composite structures for efficient deployment.