Using a nonlinear thermo-viscoelastic constitutive model for the design and analysis of ETFE structures

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Abstract

A nonlinear, time dependent thermo-viscoelastic material model has been developed at Caltech [1] to represent thin polyethylene based films, typically used as the shell for high altitude balloons. This material model has been implemented in the aerospace industry for several years in support of the design and analysis of stratospheric balloons. Viscoelastic material models have already been successfully applied in a finite element (FE) environment [2] for modelling of such balloons.

Ethylene tetrafluoroethylene (ETFE) is fluorine-based plastic which also shows a significant time-dependent and temperature-dependent response under load. The Caltech material model can therefore be factored and calibrated in order to be used for the design and analysis of ETFE films. In doing this a more precise and controlled analysis of this type of structures can be achieved. The most remarkable advantage of having such a complete tool is how the design process gets simplified on one hand but at the same time better understood and more accurate. This gained precision may be critical for some extreme cases, as will be exemplified in this paper. This comprehensive approach can also dispense the designer with some of the factors currently required to account for biaxial stress, temperature variation and long-term effects. A yield locus can be also defined [3] to aid in the design and analysis tasks.

References

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[3] F. Bosi, S. Pellegrino, "Molecular based temperature and strain rate dependent yield criterion for anisotropic elastomeric thin films", *Polymer*, vol. 125, pp 144-153, 2017