Prediction of creep performance during long-term storage of composite directors based on nonlinear viscoelasticity

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Introduction

- In order to further improve the mobility and rapid response capability of MLRS and achieve the goal of "multi-skill and multi-purpose", a modular launch canister, clustering of E-glass fiber/ epoxy composite(GFRP) directors, is generally equipped[1].
- Polymeric composites are known to exhibit a time-dependent behavior due to the viscoelastic properties of the polymers, and there a stress threshold beyond which the polymer and polymeric composites exhibit nonlinear viscoelastic characteristics[2].
- GFRP directors undergoes creep deformation during 15 years stacking storage. Deformation of the director has a negative impact on launch safety and firing dispersion.

Fig.1 Multiple launch rocket system (MLRS)

Objectives

- **The Nonlinear viscoelasticity of unidirectional E-glass/epoxy 6509 composite.**
    - Experimental characterization
    - Numerical simulation
- **Predict the long-term storage creep response of GFRP directors.**

Experimental

- The 60/60-minute creep/creep-recovery tests were carried out for $[90]_{16}$ and $[\pm 45]_{4S}$ specimens at room temperature.
- The recorded strain data has seven stress levels for $[90]_{16}$ specimens ranging from 17MPa to 35MPa, and eight stress levels for $[\pm 45]_{4S}$ specimens from 9MPa to 30MPa.
- **Schapery's Nonlinear parameters[3]**

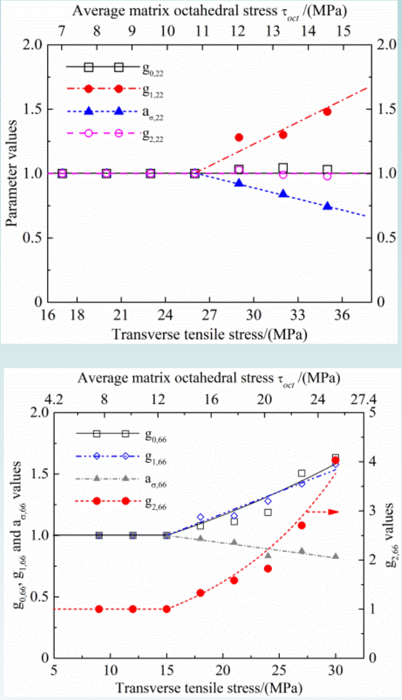

Fig.2 Schapery's nonlinear parameters as a functions of the applied stress and the average matrix octahedral shear stress

Numerical simulation

- The stacking sequence of GFRP director is $[90/(\pm 53.7)/90]$.
- A UMAT in the Fortran code was implemented to define the nonlinear viscoelastic properties of the GFRP director.
- The total step time for the creep model was 15 years.

Results

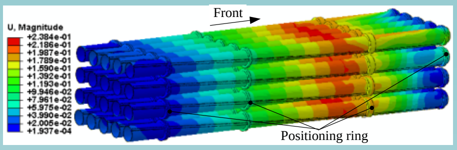

Fig.3 Residual creep deformation of director bundle after 15 years storage

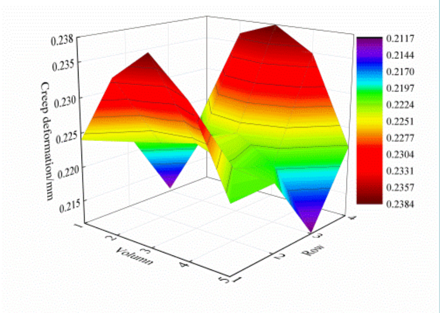

Fig.4 Saddle-shaped distribution in three-dimensional space of the maximum creep deformation for all 20 directors

Conclusion

- After 15 years of stacking storage, the maximum residual deformation of all GFRP directors presents a saddle-shaped distribution in three-dimensional space.
- The two directors in the middle of the upper and lower rows show a maximum residual deformation of 0.24 mm, and the two directors in the middle of the left and right columns show a minimum residual deformation of 0.22 mm.

References

[1]Yu, C.G., Li, Z.G. 2012. Analysis of rocket launching system. National Defence Industry Press, Beijing.

[2]Guedes, R.M. 2010. Nonlinear viscoelastic analysis of thick-walled cylindrical composites pipes. Int. J. Mech. Sci. 52(8):1064-1073.

[3]Schapery, R.A. 1969. On the characterization of nonlinear viscoelastic materials. Polym. Eng. Sci. 9(4):295-310.