

## Probabilistic Prediction of Lifetimes of Ceramic Parts

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ANSYS/CARES/PDS is a software system that combines the ANSYS Probabilistic Design System (PDS) software with a modified version of the Ceramics Analysis and Reliability Evaluation of Structures Life (CARES/Life) Version 6.0 software. [A prior version of CARES/Life was reported in "Program for Evaluation of Reliability of Ceramic Parts" (LEW-16018), *NASA Tech Briefs*, Vol. 20, No. 3 (March 1996), page 28.] CARES/Life models effects of stochastic strength, slow crack growth, and stress distribution on the overall reliability of a ceramic component. The essence of the enhancement in CARES/Life 6.0 is the capability to predict

the probability of failure using results from transient finite-element analysis. ANSYS PDS models the effects of uncertainty in material properties, dimensions, and loading on the stress distribution and deformation. ANSYS/CARES/PDS accounts for the effects of probabilistic strength, probabilistic loads, probabilistic material properties, and probabilistic tolerances on the lifetime and reliability of the component. Even failure probability becomes a stochastic quantity that can be tracked as a response variable. ANSYS/CARES/PDS enables tracking of all stochastic quantities in the design space, thereby enabling more precise

probabilistic prediction of lifetimes of ceramic components.

*This work was done by Noel N. Nemeth and John P. Gyekenyesi of Glenn Research Center, Osama M. Jadaan and Tamas Palfi of Ohio Aerospace Institute, Lynn Powers of Case Western Reserve University, Stefan Reh of ANSYS Inc., and Eric H. Baker of Connecticut Reserve Technologies, LLC. Further information is contained in a TSP (see page 1).*

*Inquiries concerning rights for the commercial use of this invention should be addressed to NASA Glenn Research Center, Innovative Partnerships Office, Attn: Steve Fedor, Mail Stop 4-8, 21000 Brookpark Road, Cleveland, Ohio 44135. Refer to LEW-17682-1/4-1.*

## STRANAL-PMC Version 2.0

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Version 2.0 of the Strain Rate Dependent Analysis of Polymer Matrix Composites (STRANAL-PMC) software has been released. A prior version was reported in "Analyzing Loads and Strains in Polymer-Matrix Composites" (LEW-17227), *NASA Tech Briefs*, Vol. 26, No. 11 (November 2002), page 36. To recapitulate: Modified versions of constitutive equations of viscoplasticity of metals are used to represent deformation of a polymeric matrix. The equations are applied in a micromechanical approach, proceeding upward from slices of unit cells, through the ply level, to the laminate level. The constitutive equa-

tions are integrated in time by a Runge-Kutta technique. To predict the ultimate strength of each composite ply, failure criteria are implemented within the micromechanics. The inputs to STRANAL-PMC are the laminate geometry, properties of the fiber and matrix materials, and applied stress or strain versus time. The outputs are time-dependent stresses and strains at the slice, ply, and laminate levels. The improvements in version 2.0 include more rigorous representation of hydrostatic-stress effects in the matrix, refinement and extension of ply failure models, and capabilities to analyze transverse shear

stresses. Version 2.0 can be implemented as a material-model code within transient dynamic finite-element codes.

*This program was written by Robert Goldberg and Kelly S. Carney of Glenn Research Center, Wieslaw Binienda of the University of Akron, and Aditi Chattopadhyay of Arizona State University. Further information is contained in a TSP (see page 1).*

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## Micromechanics and Piezo Enhancements of HyperSizer

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The commercial HyperSizer aerospace-composite-material-structure-sizing software has been enhanced by incorporating capabilities for representing coupled thermal, piezoelectric, and piezomagnetic effects on the levels of plies, laminates, and stiffened panels. This enhancement is based on a formulation similar to that of the pre-existing HyperSizer capability for representing thermal effects. As a result of this enhancement, the electric and/or magnetic response of a material or structure to a mechanical or thermal load, or its mechanical response to an applied electric or magnetic field can be predicted. In

another major enhancement, a capability for representing micromechanical effects has been added by establishment of a linkage between HyperSizer and Glenn Research Center's Micromechanics Analysis Code With Generalized Method of Cells (MAC/GMC) computer program, which was described in several prior *NASA Tech Briefs* articles. The linkage enables HyperSizer to localize to the fiber and matrix level rather than only to the ply level, making it possible to predict local failures and to predict properties of plies from those of the component fiber and matrix materials. Advanced graphical user interfaces

and database structures have been developed to support the new HyperSizer micromechanics capabilities.

*These enhancements were made by Steven M. Arnold of Glenn Research Center, Brett A. Bednarczyk of Ohio Aerospace Institute, and Phillip WA. Yarrington and Craig S. Collier of Collier Research Corp. Further information is contained in a TSP (see page 1).*

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