known and predictable. Control electronics can also be implemented so that a closed-loop feedback can be maintained. Changing the contents of the chalcogenide memory cells can compensate for any change in environmental effects that might cause a change in optical path. This real-time control provides significant control and stability in use conditions.

This work was done by Karl F. Strauss and Douglas J. Sheldon of Caltech for NASA's Jet Propulsion Laboratory. For more information, contact iaoffice@jpl.nasa.gov. NPO-46891

Reliability-Based Design Optimization of a Composite Airframe Component

This methodology accommodates uncertainties in load, strength, and material properties.

John H. Glenn Research Center, Cleveland, Ohio

A stochastic optimization methodology (SDO) has been developed to design airframe structural components made of metallic and composite materials. The design method accommodates uncertainties in load, strength, and material properties that are defined by distribution functions with mean values and standard deviations. A response parameter, like a failure mode, has become a function of reliability. The primitive variables like thermomechanical loads, material properties, and failure theories, as well as variables like depth of beam or thickness of a membrane, are considered random parameters with specified distribution functions defined by mean values and standard deviations.

The cumulative distribution concept is used to estimate the value of the response parameter like stress, displacement, and frequency for a specified reliability. This solution for stochastic optimization also yields the design and weight of a structure as a function of reliability. Weight versus reliability is traced out in an inverted S-shaped graph. The center of the graph corresponds to 50-percent probability of success, or one failure in two samples.

A heavy design with weight approaching infinity could be produced for a near-zero rate of failure. Likewise, weight can be reduced to a small value for the most failure-prone design. Reliability can be changed for different components of an airframe structure. For example, the landing gear of an airliner can be designed for very high reliability, whereas it can be reduced for a raked wingtip.

The design capability is obtained by combining three codes: MSC/Nastran code (the deterministic analysis tool), the fast probabilistic integration or the FPI module of the NESSUS software (the probabilistic calculator), and NASA Glenn's optimization testbed CometBoards (the optimizer). For the raked wingtip structure of the Boeing 767-400ER airliner, the stochastic optimization process redistributed the strain field and reduced weight by 17 percent over the traditional design.

This work was done by Shantaram S. Pai and Rula Coroneos of Glenn Research Center and Surya N. Patnaik of Ohio Aerospace Institute. 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-18497-1.

Zinc Oxide Nanowire Interphase for Enhanced Lightweight Polymer Fiber Composites

This technique can be used in applications requiring reduced structural mass, such as in aircraft, missiles, rockets, and balloons.

NASA's Jet Propulsion Laboratory, Pasadena, California

The objective of this work was to increase the interfacial strength between aramid fiber and epoxy matrix. This was achieved by functionalizing the aramid fiber followed by growth of a layer of ZnO nanowires on the fiber surface such that when embedded into the polymer, the load transfer and bonding area could be substantially enhanced. The functionalization procedure developed here created functional carboxylic acid surface groups that chemically interact with the ZnO and thus greatly enhance the strength of the interface between the fiber and the ZnO.

The matrix-ZnO interface is enhanced through increased surface area (>1,000 times), mechanical interlocking, and the creation of a functional gradient between the nanowires and matrix, which has been shown to improve the interface strength of a carbon fiber composite by well over 100 percent. The composite compressive strength, shear strength, shear modulus, interlaminar shear strength, and interfacial shear strength should all be enhanced because the graded interface reduces the stress concentration at the discrete fiber-to-matrix boundary.

The first milestone of the project was to develop the functionalization procedure to enhance the attachment of the ZnO nanowires to the aramid fiber. This was achieved with carboxylic acid groups that split the peptide bond, catalyzed by a strong base, and created a carboxylate and a primary amine functional group. Carboxylic acid groups are specifically chosen because they often discharge a proton leading to charge coordination between the negative oxygen atoms and the positive zinc ions. Furthermore, the bond angles of carboxylic acid functional groups are