Fatigue Performance of High Fiber Content T1000G/RS-14A Graphite/Cyanate Ester Composite Materials

J. Michael Starbuck, Barbara J. Frame
Oak Ridge National Laboratory*

Abstract

For rotating energy storage devices, such as flywheels, the energy stored is proportional to the mass of the rotor and to the square of the rotational velocity. Therefore, the energy stored can be maximized by either increasing the rotating mass and/or by increasing the rotational velocity. In applications where overall weight reductions are critical requirements, high strength, low-density materials, such as graphite/cyanate ester composites, are ideal material systems. However, these materials require high hoop strengths in order to withstand the higher rotational velocities needed to compensate for the reduced mass of the rotor. One means for increasing the hoop strength of the composite is to increase the fiber volume fraction in the hoop direction of the composite. However, in doing so it is important that the other significant material properties for this application, including the composite's cyclic fatigue strength, not be compromised. Previous researchers have demonstrated that graphite fiber-reinforced composites have excellent fatigue performance. However, most of the existing database is for lower fiber content composites and the fatigue performance of high fiber content systems has not been demonstrated.

To evaluate the performance of high-fiber content graphite/cyanate ester composites, T1000G/RS-14A composite rings were tested under both static and fatigue loading conditions. The rings were wet-filament wound with the fibers all oriented in the hoop direction, and with a nominal fiber content of 78-80 vol. %. A 14-inch diameter hydroburst test fixture was developed for conducting all of the tests and the static strength results are compared to the conventional split-disk test method. To evaluate the effect of high fiber volume fractions on composite fatigue performance, fatigue tests were conducted at multiple stress levels. The data are presented in the form of an S-N curve that can be used for the design of composite energy storage devices subjected to fatigue loading histories.

*Oak Ridge National Laboratory, managed by UT-Battelle, LLC, for the U.S. Dept. of Energy under contract DE-AC05-00OR22725.