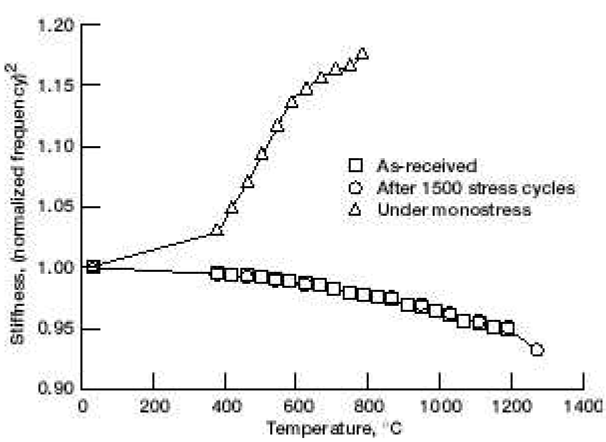
Method Developed for the High-Temperature Nondestructive Evaluation of Fiber-Reinforced Silicon Carbide Ceramic Matrix Composites

Ceramic matrix composites have emerged as candidate materials to allow higher operating temperatures (1000 to 1400 °C) in gas turbine engines (ref. 1). A need, therefore, exists to develop nondestructive methods to evaluate material integrity at the material operating temperature by monitoring thermal and mechanical fatigue. These methods would also have potential as quality inspection tools. The goal of this investigation at the NASA Lewis Research Center is to survey and correlate the temperature-dependent damping and stiffness of advanced ceramic composite materials with imposed thermal and stress histories that simulate in-service turbine engine conditions.

A typical sample size of 100 by 4 by 2 mm^3, along with the specified stiffness and density, placed the fundamental vibration frequencies between 100 and 2000 Hz. A modified Forster apparatus seemed most applicable to simultaneously measure both damping and stiffness. Testing in vacuum reduced the effects of air on the measurements. In this method, a single composite sample is vibrated at its fundamental tone; then suddenly, the mechanical excitation is removed so that the sample's motion freely decays with time.



Effects of various thermal and mechanical histories on temperature-dependent stiffness for a SiC/SiC fiber-reinforced ceramic composite.

The figure illustrates typical results. Notice the dramatic difference in behavior between composite samples with different thermal and stress histories. When its relative stiffness, as a function of temperature, is increased, the silicon-carbide-fiber-reinforced silicon carbide (SiC/SiC) composite under constant stress (monostress) at room temperature behaves differently from samples exposed to repeated stresses (1500 cycles) at 1200 °C in air and from the as-received composite. This indicates that combined thermally and mechanically induced oxidation is integral to understanding advanced composite material fatigue and ultimate performance.

This system was used to measure temperature-dependent damping and stiffness of advanced ceramic composites for Lewis' Advanced High Temperature Engine Materials Technology Program (HITEMP) and for Marshall Space Flight Center's Simplex Turbopump Project.

References

1. Ginty, C.A.: Overview of NASA's Advanced High Temperature Engine Materials Technology Program. HITEMP Review 1997. NASA CP-10192, Vol. I, 1997, paper 2, pp. 1-19. (Permission to cite this material was granted by Carol A. Ginty, February 19, 1998.)

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