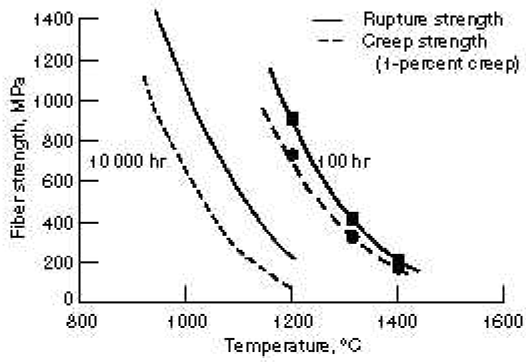
Thermomechanical Property Data Base Developed for Ceramic Fibers

A key to the successful application of metal and ceramic composite materials in advanced propulsion and power systems is the judicious selection of continuous-length fiber reinforcement. Appropriate fibers can provide these composites with the required thermomechanical performance. To aid in this selection, researchers at the NASA Lewis Research Center, using in-house state-of-the-art test facilities, developed an extensive data base of the deformation and fracture properties of commercial and developmental ceramic fibers at elevated temperatures. Lewis' experimental focus was primarily on fiber compositions based on silicon carbide or alumina because of their oxidation resistance, low density, and high modulus. Test approaches typically included tensile and flexural measurements on single fibers or on multifilament tow fibers in controlled environments of air or argon at temperatures from 800 to 1400 °C. Some fiber specimens were pretreated at composite fabrication temperatures to simulate in situ composite conditions, whereas others were precoated with potential interphase and matrix materials.

For application conditions under which the fibers display time-dependent mechanical behavior, tests measured fiber creep, rupture, and stress relaxation properties under constant temperature and stress (or strain) for up to ~100 hr (ref. 1). Because of the many test variables in such studies, mechanism-based analytical models (ref. 2) were developed for these properties. Such models not only allow accurate interpolation of time, temperature, and stress effects within the data set, but also permit prediction of fiber behavior outside the data set (see figure). This modeling capability is particularly important for the time variable because fiber test times are generally much shorter than the service lives required for some advanced heat engine components (>10^4 hr).

Currently, the thermomechanical property data base and models for a variety of ceramic fibers are publicly available in numerous reports, publications, and review papers (refs. 3 and 4). For component developmental programs outside and within NASA (Enabling Propulsion Materials (EPM) and the Advanced High Temperature Engine Materials Technology Program (HITEMP)), these results are being used by composite designers and fabricators to select the optimum fiber for each application and also by the fiber manufacturers to understand and improve fiber performance. Research at Lewis is continuing in order to expand the data base and improve the property models, particularly for those fiber types with the most technical potential.



Creep and rupture strengths of Hi-Nicalon silicon carbide fibers for service lives of 10^2 and 10^4 hr. Symbols indicate actual data points and lines indicate predictions from property models.

References

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