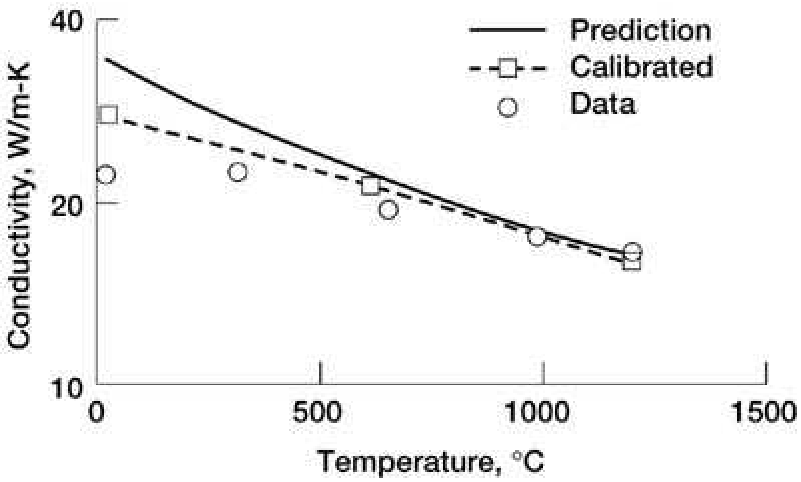
CEMCAN Software Enhanced for Predicting the Properties of Woven Ceramic Matrix Composites

Major advancements are needed in current high-temperature materials to meet the requirements of future space and aeropropulsion structural components. Ceramic matrix composites (CMC's) are one class of materials that are being evaluated as candidate materials for many high-temperature applications. For example, combustor liners made of these materials can withstand very high temperatures. Furthermore, they can be operated uncooled, thereby improving engine performance as well as meeting or exceeding emission requirements. Past efforts to improve the performance of CMC's focused primarily on improving the properties of the fiber, interfacial coatings, and matrix constituents as individual phases. Design and analysis tools must take into consideration the complex geometries, microstructures, and fabrication processes involved in these composites and must allow the composite properties to be tailored for optimum performance. Major accomplishments during the past year include the development and inclusion of woven CMC micromechanics methodology into the CEMCAN (Ceramic Matrix Composites Analyzer) computer code.

Woven composite analysis, which is based on micromechanics techniques, is applicable to generalized two-dimensional woven architectures. The technique can account for the complex microstructure of these composites (i.e., the distribution and the volume fraction of the multiple constituent phases that these advanced composites are now employing). Such an analysis tool is useful for preliminary screening of new candidate materials and to help material developers perform tradeoff studies by evaluating different fiber architectures, constituents, and their volume fractions.

The code enables one to calibrate a consistent set of constituent properties as a function of temperature with the aid of experimentally measured data. Such properties, though hard to find, are quite useful in computational design and analysis. With the aid of this code, the properties of an advanced five-harness SiC/SiC composite were predicted as a function of temperature. However, we realized that there were still some issues regarding the constituent properties at high temperatures and the confidence that can be put in these properties. The composite property predictions were compared with measured data available from the High-Speed Research (HSR) program to create calibrated constituent properties as a function of temperature. This information is very useful for material developers and design engineers. Such analytical tools can be used to predict the complete set of material properties needed by design engineers, whereas only a handful of them can be measured experimentally. In the figure, the through-the-thickness thermal conductivity of an advanced SiC/SiC composite is shown as a function of temperature. The predictions are shown for the initially assumed constituent properties as well as for the calibrated set of constituent properties with the measured data.



Through-the-thickness thermal conductivity. Constituents: F-34.[1]

Bibliography

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[1]A set of constituents that leads to an overall fiber volume ratio of 34 vol % in the resulting composite