General Electric Corporate R&D

Toughened Silcomp™

Objective

The team is developing Toughened Silcomp™ ceramic composite materials for use in land-based gas turbine engines.

Materials and Processes

Toughened Silcomp™ consists of continuous silicon carbide fibers in a matrix of silicon carbide and silicon. Composites can be fabricated utilizing a variety of reinforcing fibers, such as Textron's SCS type monofilaments, Hi-Nicalon™, or Sylramic™ SiC fibers, permitting great flexibility in component design. Moreover, Toughened Silcomp™ achieves excellent mechanical properties with only 25 vol% reinforcement. The material is made by a silicon melt infiltration process that requires densification times on the order of minutes. A fibrous structure containing residual carbon is infiltrated with molten silicon metal which reacts to form the ceramic matrix.

The melt infiltration process produces fully dense, complex-shaped parts with controlled fiber architectures. Due to the material's lack of porosity, the composites possess good oxidation resistance, high thermal conductivity, high matrix cracking (or design) stress, and high ultimate strengths. The thermal expansion of the composite is relatively low, thus the materials exhibit excellent thermal shock resistance.

Applications and Benefits

Toughened Silcomp™ is well suited for gas turbine combustor liners and shroud applications. The CFCC components have higher temperature capabilities than current superalloys, which reduces the amount of compressor discharge air needed for component cooling purposes. By redirecting this extra cooling air through the combustor and turbine, the engine can operate at a higher cycle efficiency. This will result in:

- Fuel savings
- Increased power output
- Reduced unburned hydrocarbons, CO, and NO_x emissions.

Challenges

The General Electric team has several challenges to overcome before their CFCCs can be commercialized. The long life requirement of the target components, up to 48,000 hours, requires further modifications to the Toughened Silcomp™ composites to improve long-term stability and oxidation resistance. A mechanical property database must also be developed for the optimized material. Components must then be evaluated using rig tests that represent actual component use conditions.

Team Members

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Industrial gas turbine first stage shroud section made from superalloy (left) and a representative shroud section made of Toughened Silcomp™ (right).

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CFCC

Continuous Fiber Ceramic Composite Program

A 10-year joint R&D effort initiated in 1992 to develop processing methods to produce reliable and cost-effective CFCC components for industrial applications.

CFCCs are light, strong, and corrosion-resistant materials capable of performing at high temperatures.

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