Preparation and Testing of Low Cost Carbon-Carbon Composites for High Temperature Applications

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Introduction

Carbon-Carbon (C-C) Composites

These are the primary materials used in the manufacture of structures built to withstand high temperatures. Such structures include missile exit cones, skin for military aircraft, aircraft brake discs , among others.

Problems with C-C Composites

Despite their attractive qualities, a limitation of these materials is the high cost of production. One prominent procedure driving this cost is densification.

They also exhibit limited oxidation resistance

Motivation for Research

Aircraft brakes require a friction material, which must exhibit a number of attributes including high friction, high wear resistance, high temperature resistance, high strength and high stiffness. In addition, it should be thermally conductive for the purpose of heat dissipation. In case of aircraft brakes, the material should be low in density as well. The applications would be widened from aircraft brakes to high-speed train brakes, for example, if the material cost can be sufficiently lowered.

Aims

Objective

The objective of this project is to evaluate the improved C-C composites in terms of the ability of to withstand high temperatures and compare this ability with that of conventional carbon materials.

Improved C-C composites

As shown by Professor Chung, improvement of C-C composites can be obtained by the incorporation of an organoclay filler.

Thermal degradation mechanism investigation

The thermal degradation mechanism will be studied by examination of the microstructure after mechanical polishing using an optical microscope. Such observation will be made before and after heating in order to see how the microstructure changes due to thermal degradation.

Method and Implementation

The evaluation of the ability to withstand high temperatures (up to about 750°C in air) will be conducted by measuring the weight of the specimen as the temperature is increased at a controlled rate (e.g., 5°C/min). The weight will also be measured during subsequent cooling at a controlled rate. This method is known as thermogravimetic analysis (TGA).


Thermogravimetric Analyzer (TGA) used in raising the temperature of carbon samples.

Analysis of Microstructure

The specimens will be examined by metallography, which involves mechanical polishing followed by optical microscope. To facilitate the polishing, the specimen is mounted in a polymer. The polishing involves the use of a series of abrasives that are increasingly fine.

Composite fabrication

C-C composites will be fabricated by hot pressing at temperatures up to about 1000°C and pressures up to about 25 MPa in the presence of a nitrogen gas purge.

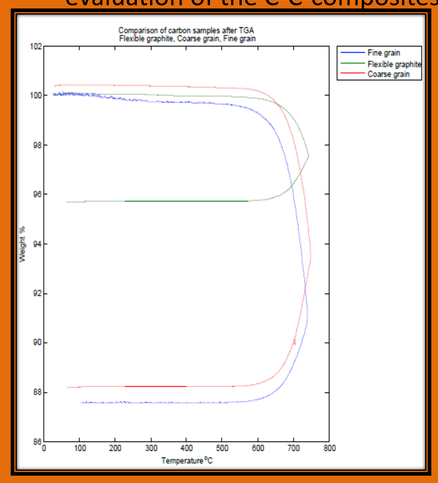
Future Work

- Preparation of C-C composites by hot pressing.
- Thermogravimetric analysis of C-C composites.
- Microscopic analysis of C-C composite after thermal degradation.

Preliminary Results

TGA Results

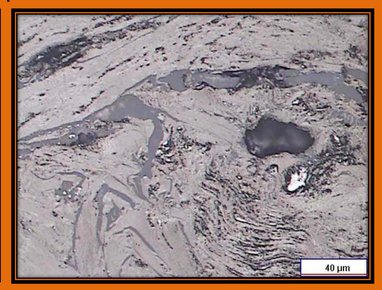
Various conventional carbon materials have been evaluated in terms of their ability to withstand high temperatures. This information is valuable for serving as reference data in the follow-on evaluation of the C-C-composites.



Metallographic Results

Micrographs of fine grain graphite

Raised to 750 and cooled



Sample from mold.

The micrographs show a drastic reduction in the size of the grains as well as generally smaller pores.

References

•A. FATZ, et al. ”Manufacture of Functionally Gradient Carbon-Carbon Composites”
•B Wielage, A.G Odeshi, H Mucha, H Lang, R Buschbeck, A cost effective route for the densification of carbon–carbon composites, Journal of Materials Processing Technology, Volume 132, Issues 1–3, 10 January 2003

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