



Short Communication

Mechanical properties investigation of carbon/carbon composites fabricated by a fast densification process

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ABSTRACT

Carbon/carbon (C/C) composites were prepared by thermal gradient chemical vapor infiltration with a fast densification rate. The fracture morphology and mechanical properties were examined by scanning electron microscopy and mechanical testing, respectively. The effects of preform type and heat treatment temperature (HTT) on the mechanical properties of C/C composites were analyzed. The results show that the average flexural strength drops from 47.8 MPa to 38.6 MPa as the HTT increases from 2100 °C to 2500 °C. C/C composites with felt as preform show brittle fracture and samples with needle-punched felt as reinforcement present obvious pseudoplastic property. The interlaminar shear strength of needle-punched felt reinforced composites is higher than that of sample with felt as preform by 44.26% owing to the needle-punched fiber in the thickness direction. The strength of interfacial bonding plays a key role to mechanical properties and failure behavior of C/C composites.

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1. Introduction

Carbon/carbon (C/C) composites are widely used as structural materials in space and aeronautic industries due to their excellent properties such as low density, low thermal expansion, high thermal stability and high strength. Moreover, the mechanical properties of C/C composites do not decrease but even increase at elevated temperature [1]. So, many studies on their mechanical properties have been carried out. It was reported that the mechanical properties of C/C composites depend on many factors such as carbon matrix type and structure, carbon fiber type and orientation, various interface between fiber and matrix, porosity and cracks in the composites [2–5]. The investigation on mechanical properties is very important to choosing and applying C/C composites reasonably and efficiently.

Chemical vapor infiltration (CVI) with liquid hydrocarbon as matrix precursor is one of successful methods for fabricating C/C composites with fast densification rate and short total fabrication time [6–9]. The deposition mechanism of pyrocarbon and the microstructure of C/C composites prepared by this fast densification process have been reported [8,9]. Nevertheless, the mechanical properties investigation has not been developed under the condition of short densification time.

In the present paper, C/C composites were fabricated by CVI with a liquid precursor using a homemade device. The microstructure, mechanical properties and fracture morphology of C/C

composites were investigated by X-ray diffraction (XRD), mechanical testing and scanning electron microscope (SEM), respectively. Then, the effects of heat treatment temperature (HTT) and preform type on the mechanical properties of C/C composites were analyzed. Finally, the failure mechanism of C/C composites was discussed.

2. Experimental

2.1. Preparation of C/C composites

Two types of preform were used in this study. One is polyacrylonitrile-based carbon fiber felt (made in Lanzhou Carbon Plant in China), the other is needle-punched felt with long carbon fiber (provided by Yixing Tianniao Co. from Jiangshu province, China). The apparent density and size of preforms were as follows:

- Felt 0.20 g cm⁻³ 150 × 85 × 15 mm⁻³
- Needle-punched felt 0.60 g cm⁻³ 120 × 85 × 20 mm⁻³

Commercial kerosene, with boiling point and molecular formula of 180–230 °C and C₁₀H_n–C₁₆H_m, respectively, was chosen as the matrix precursor.

The preform samples were densified by CVI processes in an inductive heating reactor which has been described elsewhere [8]. The infiltration temperature was 1100 °C and the whole infiltration process included several densification cycles. Most of the as-infiltrated composite samples were treated at a high temperature of 2100–2500 °C for 2 h under argon atmosphere.

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