MATERIALS AND STRUCTURES SYMPOSIUM (C2)
Advanced Materials and Structures for High Temperature Applications (4)

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PLASMA WIND TUNNEL TESTS FOR C/SIC COMPOSITE WITH ADDITIONAL MECHANICAL TENSILE LOAD

Abstract

Carbon fiber reinforced silicon carbide (C/SiC) composites can be beneficial to the design and development of lightweight, durable, reliable thermal protection systems, to increase the efficiency of structural concepts and to lower the TPS mass for future space transportation systems. But many micro-cracks and voids within the SiC matrix are appeared in the process of producing due to the differences in thermal expansion coefficients between the carbon fiber and the SiC matrix, for more important, the thermal induced stress field based on the non-uniform temperature gradient on aero-heating conditions may be open the micro-cracks, fiber and matix are exposed to the oxidizing environment, oxygen ingress into the cracks occur chemical reaction and degrade the material's strength, which is a latent danger for structural materials. So it's very essential to study mechanical properties degradation of C/SiC composites on mechanical/thermal/oxidation coupled load conditions.

In order to quantify the mechanical properties degradation effect of stress, time, temperature, and oxidation for the C/SiC composite, a series ablation tests with additional mechanical tensile load were performed in a high enthalpy hypersonic flow field, as provided by arc heated wind tunnel of CAAA. The tensile loading device include air cylinder, pulleys, rope and so on was designed and built specially for the wind tunnel, the test specimens were machined into a dog-bone shape to ensure the specimen failed in the hot zone. Some specimens were tested at intermediate surface temperature (about 800) and others were tested at high temperature (about 1500), the tensile load (about 70MPa) represents about 20% of the ultimate strength was enough to simulate the mechanical loads during re-entry and high enough to open the micro-cracks on the C/SiC. After 300 and 600 seconds ablation test, specimens were still retained vacuum environment to prevent any additional oxidation until to room temperature. And last, the results of room temperature monotonic tension to failure test after the plasma test were also described in this paper.