RESEARCH OF PROCESSING OF LOW-COST CARBON/CARBON COMPOSITES

Liu Honglin Zeng Xiaomei Huo Xiaoxu
The 43rd Institute of the 4th Academy,Shaanxi,China,710025

Instruction

Carbon/carbon(C/C) composites exhibit excellent thermal, mechanical, chemical and physical properties. However, C/C composite materials have found use in only a few of applications, such as thermal protection of the leading edges and nose cones of the space shuttle, rocket nozzle and friction application such as aircraft brake discs. Only C/C brakes represent a price sensitive commercial market. C/C composites have a clear potential for numerous commercial applications. However, commercial applications of C/C composites are hindered by their high manufacturing cost. C/C composites, made by a new process, are much less expensive and have significantly shorter fabrication time than C/C made by state-of-the-art processes. The new process and the properties of the C/C made by it are discussed.

Experimental

A variety of carbon reinforcements (carbon felt, carbon cloth, braided carbon fabric, needled carbon fabric, etc.) and a kind of liquid hydrocarbon as precursor are used in making low-cost carbon/carbon composites. At firstly, the interior surface of the reinforcements is heated by induction heating to the pyrolytic temperature, wherein the liquid hydrocarbon is converted into pyrolytic carbon, which can adhere around the carbon fiber. Then the densified fabric acts as a heater, which can be heated up to a certain temperature. The outer undensified carbon fabric which adjoins the heater can be densified by the pyrolytic carbon. The pyrolytic process thus moves from interior to exterior of the preform. At last, the whole preform can get a higher density (>1.6g/cm^3) within tens of hour(Figure 1). The ablative properties were measured using a plasma generator. Compressive strength was measured using a cylinder specimen ϕ10×10mm. Density was calculated on the geometric basis. SEM was used to assess how about the adherence between the carbon fiber and the pyrolytic carbon.

Results And Discussions

Table 1 shows the densities and the compressive strengths of the carbon/carbon composites made from different reinforcements by this process respectively. The connection between carbon fiber and carbon matrix is strong. Because the temperature gradient created inside the preform is very large, inside the preform the deposite belt can thus be very narrow. The liquid precursor between the preform and the device wall maintains a vapor state at boilling point so that it can be easily penetrate into the preform. And on account of the existence of the narrow deposite belt, there is few closed pore inside the densified preform. As a result that the manufacture time of C/C composites can be very short and it's density can reach a high level. So by this new process the cost of C/C composites cand reduce rapidly, nearly to $120/kg. Table 2 shows the ablative properties of the composite materials. The ablative properties of the material are excellent because the matrix of the material is deposited carbon. So it can be used as thermal protection materials.

Figure 2 shows the SEM photograph of the material. It is clearly shows that the connective between carbon fiber and matrix carbon is strong. Figure 3 shows the SEM of the material after ablation. From which we can see the carbon fiber is earlier ablated than pyrolytic carbon.

Conclutions

1. The process is feasibility, it can densified the carbon preform within a short time. The cost of the C/C composites can be reduced rapidly. So the new technology

provides a chance for extending the C/C composites applicatione fileds.

2. The strength of the C/C made by this process is high, that is to say, the connection between the carbon fiber and the carbon matrix is high.
3. The ablation rate of the material is very low. So it can be used for thermal protection components.

References

1. J.C.Withers, et al. in Carbon'99 (Ext. Abstr. 24th Biennial Conf. Carbon), Charleston, South Carolina, 1999,pp39-40
2. Hondayer, et al. U.S.P. 4,472,454 Sep.18,1984
3. Scaringolla, et al. U.S.P. 5,547,717 Aug.20,1996

Table 1. Physical and mechanical properties of C/C made by the process

Preform	Fabrication time (h)	Density (g/cm^3)	Compressive strength(MPa)
Braid carbon fabric	7.5	1.3	-
Carbon cloth	14	1.43	48.0(axial) 146.6(radial)
Carbon felt	2	1.64	115.6(axial) 139.0(radial)
Needle carbon	14	1.70	166.0(axial) 55.4(radial)

Table 2. Ablation properties of C/C made by the process

Preform	ablation rate (mm/s)
Carbon cloth	0.074
carbon felt	0.004
Needle carbon	0.040

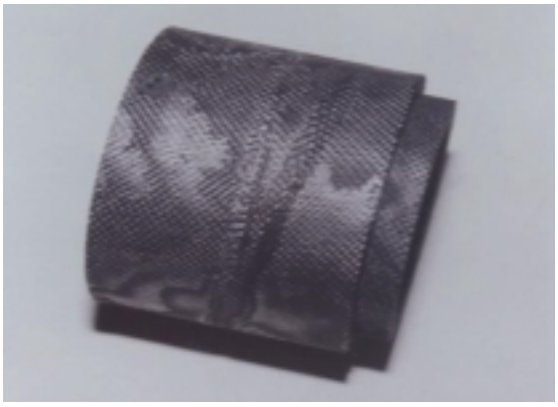

Figure 1. C/C composite material made by the new technology

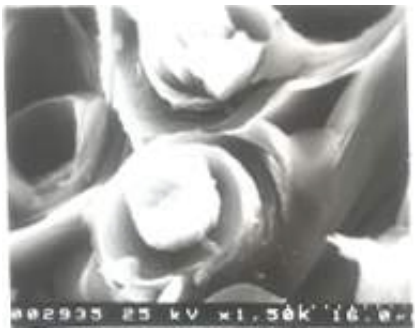

Figure 2. SEM photograph of C/C made by this process

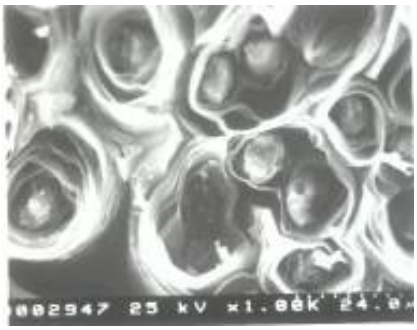

Figure 3. SEM photograph of C/C after ablation