MICROSTRUCTURE AND PROPERTIES OF C/C MATERIAL MOULDED AT SUPER HIGH TEMPERATURE

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Introduction

Development of lower-cost C/C material is a forward technique of composite material research in 21 century. Su Junming group has carried out an explore study on integrate processing of preforming, densification as well as graphitization and obtained an beneficial result, In the integrate processing method, short-cut carbon fiber, coke powder and pitch powder are successively subjected to mixing, mold loading and hot pressing at 2200-2500℃.To improve mechanical and ablation resistance properties of the material, additional vacuum impregnation/high pressure carbonization process with pitch are performed. In this paper, microstructure and properties of the C/C material are discussed.

Experimental

1. C/C composite material moulded at super high temperature

The density of C/C material moulded at super high temperature is 1.68-1.77g/cm^3, while the density of C/C material with additional HPIC treatment ranges from 1.85 to 1.94 g/cm^3.

2. Properties test

Scanning electron microscopy (SEM) is used to examine the microstructure of C/C material. Also the mechanical properties, thermal properties and graphitization rate of the C/C composite are measured.

Results and Discussion

1. Microstructure

Microstructure of C/C material determines its mechanical and thermal properties as well as ablation resistance properties. The SEM micrographs of C/C composite material moulded at super high temperature are shown in figure 1. Figure 1 indicates that carbon fibers are randomly oriented in X-Y direction and matrix carbon plays a role of bonding between fibers. But carbon fibers in aggregation states also can be found in partial region. Since the fibers are discontinuous and appear to be a layer structure, the properties in Z direction are low.

2. Mechanical properties

Mechanical properties of C/C material moulded at super high temperature are shown in table 1.Table 1 indicates that the tensile strength and flexural strength as well as compressive strength in X-Y direction is fairly high, while the tensile strength and flexural strength in Z direction is low.

3. Thermal properties

Thermal properties of C/C composite material moulded at super high temperature are shown in table 2. Table 2 indicates that the material shows obvious anisotropy, which dues to the great difference between thermal conductivity and coefficient of thermal expansion in axial direction and radial direction of carbon fiber, and the carbon fibers are oriented randomly in X-Y direction.

4. Graphitization rate

Owing to be graphitized with compression, using Si and B_4C as catalyst, C/C material moulded at super high temperature has a fairly high graphitization rate. The graphitization rate value is in the range of 67-86%. The data are shown in table 3

Conclusions

1. Additional vacuum impregnation/high pressure carbonization process with pitch increases greatly the density of C/C material moulded at super high temperature and improves the state of interface, thus dramatically increases the comprehensive properties of C/C material.
2. Microstructure of the material exhibits an obvious layer structure and the mechanical, thermal properties are very high in X-Y direction, but quite low in Z direction. This is the inherent drawback of a 2D C/C material.
3. Using needling technique or isostatic pressing technique may improve the properties in Z direction.

References

[1] Su Junming, Su Zhe'an, Cui Hong, Guo Chen, Li Ruizhen, Li Yadi. The Investigation on molded C/C composite in super high temperature. Extended abstracts, vol. II, 23rd Biennial conference on carbon. The American Carbon Society, 1997; 472-473.

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Table 1. Mechanical properties of C/C material moulded at super high temperature

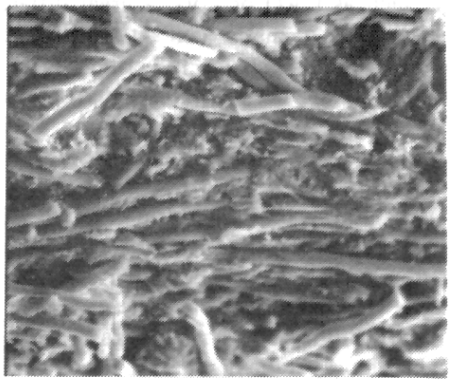
Item	C/C material moulded at super high temperature	
	X-Y	Z
Bulk density,g/cm^3	1.88	
Open porosity, %	3.37	
Tensile strength, MPa	20.3	3.8
Tensile modulus, GPa	16.8	--
Compressive strength, MPa	69.4	94.0
Flexural strength, MPa	57.8	5.4
Interlaminar shear strength, MPa	10.2	

Table 2. Thermal properties of C/C material moulded at super high temperature

Temperature ℃	α ×10^{-6}/K		Temperature ℃	K W/(m • K)	
	X-Y	Z		X-Y	Z
RT-100	0.17	5.08	20	52.44	20.21
RT-200	0.57	7.12	200	50.80	19.97
RT-300	1.00	7.98	400	47.34	19.38
RT-400	1.35	8.32	600	44.83	18.89
RT-500	1.66	8.53	800	40.75	18.49
RT-600	1.77	8.67			
RT-700	1.71	8.91			
RT-800	1.48	9.06			

Table 3. Graphitization rate of C/C material moulded at super high temperature

Specimen	d_{002} nm	Graphitization rate %
1	0.3382	67.00
2	0.3800	70.00
3	0.3730	78.00
4	0.3670	85.00
5	0.3660	86.00



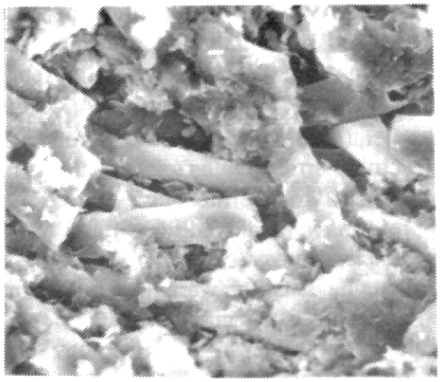


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Figure 1. The SEM micrographs of C/C composite material moulded at super high temperature