

INVESTIGATION ON THE NEW NEEDLED CARBON CLOTH REINFORCED C/C COMPOSITE

*Su Junming, Cui Hong, Li Ruizhen, Zhou Shaojian, Su Zhe'an, LiYadi
P.O. Box 101 of Xi'an, shannxi, P.R.China, 710025
The 43rd Institute of the 4th Academy of CASC, China*

Introduction

Carbon/carbon (C/C) composite has been widely used as solid rocket motor (SRM) throat, divergent section and exit cone, for it is an excellent aerospace thermal structure material, [1,2] but only very rarely it is used as ablative fall-away material for jet vanes. Being jet vane material, it must have good property of anti-ablation of combustion gas and good ablative regularity. The jet vane with special function, which can affects the reliability and accuracy of whole missile, is one of the most important technologies of SRM.

The new needed carbon cloth reinforced C/C composite discussed in this paper has the properties of higher inter-laminar shear strength (ILSS), good anti-thermal shock, and better anti-ablation. It has overcome the shortcoming of delamination of 2D C/C, and also overcome the low fiber content and low mechanical property of integral felt based C/C, it is a new kind of C/C composite acceptable for ablation fallaway material of SRM jet vane.

Experimental

1.Reinforcement

The carbon cloth and pre-oxidation fiber felt being laminated alternately, the quasi 3D-structure reinforcement has been made by the needling technology, which can introduce the fiber felt into the vertical direction of carbon cloth.

2.Densification process

Using propylene as carbon source gas and technology of isobaric chemical vapor infiltration (CVI), pitch pressure impregnation carbonization (HPIC), together with graphitization, the high density C/C had been made.

3.Characterization of structure and properties of C/C

The microstructure of C/C is observed by optical microscope (OM), the fracture topography is observed by SEM, and the mechanical, thermal, ablative properties are also tested in this study.

Results and Discussion

1. The relation between the process periods and the density of C/C

The C/C composite has been made by the technology of CVI and HPIC, together with graphitization. After eight periods of CVI and one period of HPIC, the density of C/C can get to 1.82~1.85g/cm³. (See figure 1)

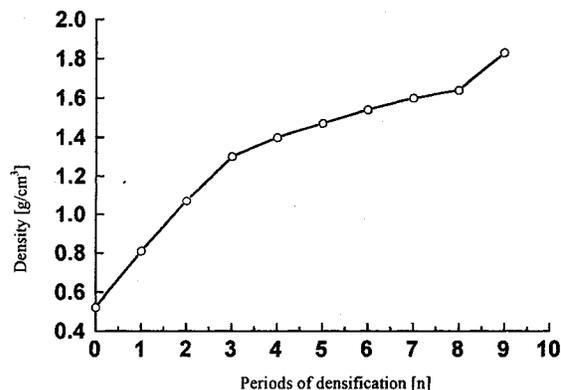


Figure 1. The increasing tendency of the density with densification periods

Figure 1 shows the increment of density is much bigger while the density of C/C is under 1.40g/cm³ in the CVI process. The reason is that the C/C has much more open porosity, bigger pore diameter, there is more surface area for carbon depositing reaction and more inner channel for carbon source gas diffusing into the material. While the density of C/C is between 1.40~1.70g/cm³, the increment will be lower. The reason is the material has less open porosity, smaller pore diameter at that condition, so there is less surface area for carbon depositing and more difficulty for carbon source gas infiltrating into the C/C material. After graphitization process, the open porosity of C/C increases one times because of the close pore being opened, and it is easy for liquid pitch infiltrating into the very small pores of C/C by the high

pressure of HPIC process. After HPIC, the C/C will get high density with great increment (Figure 2).

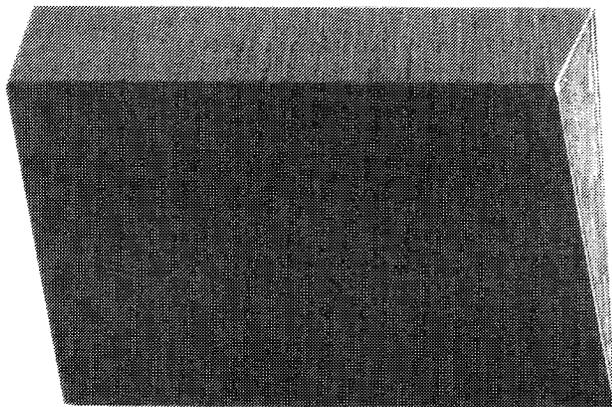


Figure 2. The billet of needled carbon cloth C/C jet vane

2. The effective of needled reinforcement process on the properties of C/C composite

The needled reinforcement technology is an improvement both of 2D C/C, which has the shortcoming of low ILSS and delamination, and the needled integral felt C/C, which has the shortcoming of low fiber content and low mechanical property.

Using the needling process, the pre-oxidation fiber can be introduced into the vertical direction of carbon cloth by the inverted crochet hook, it can reinforce the ILSS of C/C effectively.

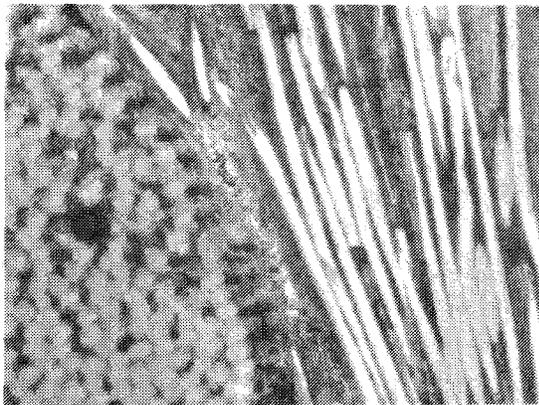


Figure 3. The distribution of Z direction fiber

While there is inter-laminar stress in the material, the stress will deliver from matrix to interphase. The fibers of Z direction can change the direction of cracking produced by stress, and hinder the expansion of cracking. This

function will stop until the fiber is broken, so as to improve the ILSS of C/C. The ILSS is the most important mechanical property of jet vane C/C material, it is the key-point of our study. Table 1 lists the mechanical properties of needled carbon cloth C/C composite.

Table 1. The properties of needled carbon cloth C/C

Properties	Needled carbon cloth C/C	2D non-woven C/C
Density, g/cm ³	1.85	1.80
Open porosity, %	4.67	6.45
ILSS, MPa	19.3	10.5
Tensile strength, MPa	79.1	55.7
Flexure strength, MPa	150.3	72.9
Thermal conductivity		
W/(m.K) x-y	103.6	95.4
(800°C) z	47.84	17.6

Table 1 shows, the ILSS of needled carbon cloth C/C is 19.3MPa, it increases 83.8% more than 2D C/C, and thermal conductivity of Z direction increases 171.6%. The combined efficiency of those properties make the C/c has excellent anti-thermal shock property, and modify the defect of part breaking of ablating C/C.

Conclusions

1. The technology of making high density C/C is practicable, that is the quasi 3D-structure reinforcement, produced by needling process of alternatively laminated carbon cloth, pre-oxidation fiber felt, being densified by the technology of CVI and HPIC, together with graphitization treatment.
2. The needled carbon cloth C/C has the properties of high ILSS, good thermal property, and excellent anti-thermal shock characteristic; it is an ideal ablation-fallaway jet vane material with great application capacity.

References

- [1] Su Junming, The Application and Development of High Efficiency High Impulse to Mass Ratio C/C Nozzles, *New Carbon Materials* 1996, No.4 Vol(11)
- [2] Mare Montaudon, *Novoltex Textures for Thermostructural Materials*, AIAA91-1848, 1991.6