THE EFFECT OF CNT ON MECHANICLA PROPERTIES OF Carbon/Carbon COMPOSITES

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Introduction

Carbon/carbon composites (C/C) have superior characteristics of low density, high strength, extremely low ablation ratio, good thermal shock resistance, and increased strength and modulus within the elevated temperature of 2000℃. These outstanding properties of C/C composites make them become the essential candidate materials in the high temperature fields, such as aerospace industry [1]. When we produce the C/C composite, carbonization is primarily a process of pyrolysis of hydrocarbons of a carbon precursor [2] . In carbonization process, the high temperature pyrolysis made of carbon, hydrogen, oxygen and other elements, resulting in C/C composites were many within the void. Therefore, the densification should be required to fill void. But densification is a time-wasting and complex process, which increases production costs in the manufacturing process. In this study, we use the well properties of CNT [3] to reduce the formation of void, making production costs down. And also enhance the mechanical properties of C/C in thickness direction.

Experimental

Materials

The fiber and resin used for the preparation of the present C/C composite are plane carbon cloth of type 3K PAN-based carbon fiber (WCC 3C0401, Woh Hong Industrial Copr, Taiwan) and a resole-type phenolic resin (PF-650, Chang Chun Petrochemical Industry, Taiwan), respecti- vely. The CNTs obtained from Applied Nanotechnologies, Inc., USA. The CNTs have an average diameter of 30 nm and average length of 15 μm.

First the CNTs were mixed with isopropanol, then sonicated for two hours, making carbon nanotubes disperse uniformly in isopropanol. The weight fraction of the CNTs ranged from 0 to 1.5 wt% to help identify the loading with the best mechanical properties. Then the solution was mixed with phenolic resin by high-speed stirrer for 12h. Second, The carbon fiber impregnated with CNTs/phenolic to form prepreg. The polymer matrix prepreg was placed in an oven at 83℃ for 3h to remove excess solvent. Third, cut prepreg into square pieces of 200mm×200mm, and laid up the prepreg in 26 layers. Using hot press curing process in a stainless mold at 175℃ for 30min under a pressure of 1500psi. Then post-curing at 145℃ for 3h in an oven. Forth, sectioning the polymer composite into appropriate size that we used in testing. The polymer matrix composite perform underwent carbonization.

Testing and analysis

Flexural tests were performed according to ASTM D790 under a three-point bend configuration. The test samples were cut off to be the nominal dimension of 60mm×25mm×3mm. The support span length is 48mm and the crosshead speed was 1.2 mm/min. The ILSS was tested under the method of short beam shearing with the specimen dimensions of 18mm×6mm×3mm. The support span length is 12mm and the crosshead speed was 1.0 mm/min. The density and open porosity of C/C composites were measured using Archimedes' principle.

Results and Discussion

The density and open porosity of the CNT/C/C composites at various of the CNT content is shown in

Table 1. There is no significant variation in density of CNT/C/C composites. And open porosity decreased with increasing concentration of CNT. But if adding 1.5 wt% CNT into C/C composite, the open porosity increasing significant relative to the C/C composite with 1.2 wt% content CNT. Because of adding 1.5 wt% CNT into C/C composite, the CNT will agglomerate easily. The agglomeration of CNT can be seen as the impurities in composite, which not only decrease reinforcement effect, but also produces the porosity easily. Therefore, the open porosity increasing when the loading of CNT over 1.5 wt%.

Table 1 density and open porosity of CNT/C/C composites.

CNT (wt %)	Density(g/cm^2)	Porosity(%)
0	1.299	28.85
0.5	1.286	26.86
1.0	1.291	22.74
1.2	1.298	19.46
1.5	1.313	25.38

As shown in Fig.1, adding 1.2 wt% CNT can get the best flexure strength and flexure modulus, because the CNTs can bridge cracks effectively. Therefore, CNTs restrict the crack propagation, and reduce the extent of plastic deformation experienced by the matrix. In addition, as shown in Fig. 2, 1.2 wt% CNTs in C/C composite can also get the highest interlaminar shear strength, because CNTs can transfer stress effectively between fiber and matrix, and increase the interface strength between matrix and fiber.

Conclusion

Above all, it's seem that CNTs is one of the best reinforcement in C/C composite, not only the open porosity can be reduced, but also increase the mechanical properties in C/C composite. Unfortunately, agglomeration problem of CNTs is needed to be overcome.

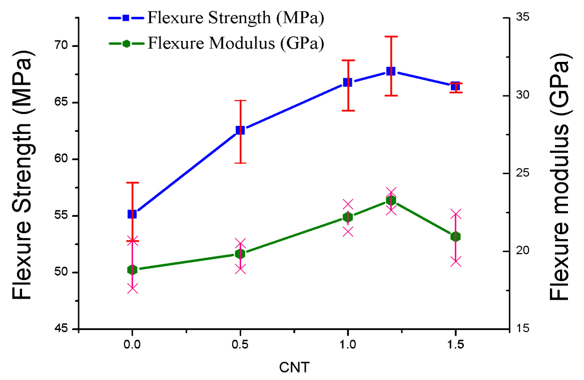

Fig. 1 Effect of CNT content on strength and modulus of C/C composite.

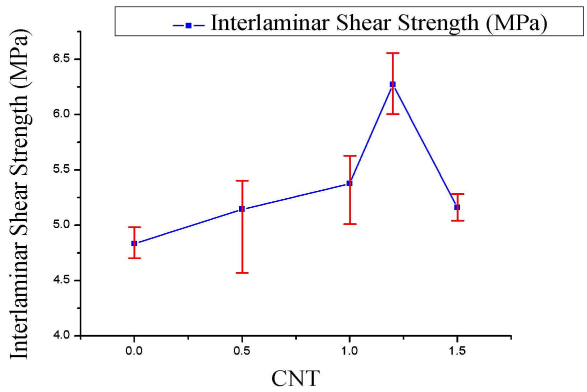

Fig. 2 Effect of CNT on ILSS of C/C composite.

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