SYSTEMATIC INVESTIGATION ON THE INTERFACE OF CARBON-CARBON COMPOSITE (I)

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Introduction

The interface of carbon-carbon (C/C) composite is influenced notably by the surface state of carbon fiber(CF) and the after -heattreatment temperature, as lots of research work has proved[1] . In this study, 4 kinds of CF state and 4 kinds of heattreatment are selected to investigate how these factors control the interface and interlaminar shear strength (ILSS) of C/C composites. The matrix precursor is coal pitch that is modified by some of phenolic resin. The density of these C/C composites is about 1.50 g/cm^3 .

Experimental

The coal pitch is mixed with some content of phenolic resin(10 ~ 20wt%),which is helpful to adopt hot-pressing process. The carbon cloth is respectively treated by 2500 ℃ heattreatment, 1500 ℃ heattreatment, sizing by liquid low-molecule organic resin and liquid oxidation after sizing. Experiments show that, the contents of oxygen group on these carbon fibers increase in proper order. After treated, the carbon cloth is infiltrated by the solution of pitch and phenolic resin in alcoholic, followed by pre-solidification.Then the pre-impregnated carbon cloth is cut out, layed up and hot-pressed from RT to 650 ℃ , and densified in turn. Finally, the specimens are after-heattreated to different temperature, which is 900℃ , 1500℃ and 2500 ℃ respectively.

Results and Discussion

The ILSS of all the materials is tested by three piont flexion, which is shown in table 1.

Table 1. The ILSS of the materials

No.	carbon fiber	after-heat-treatment(℃)	ILSS(Mpa)
1	2500 ℃ heat-treatment	2500	13.8
2	2500 ℃ heat-treatment	2500	11.8
3	1500 ℃ heat-treatment	1500	7.1
4	1500 ℃ heat-treatment	1500	14.6
5	liquid sizing	1500	17.2
6	liquid sizing	900	6.7
7	oxidation after sizing	900	13.8
8	oxidation after sizing	2500	16.9

The carbon fibers of NO.1 and NO.2 is heattreated at 2500℃, the final material of the NO.1 is after-heattreated at 2500℃ and the NO.2 is after-heattreated at 900℃ as in table 1.

The ILSS of NO.1 is 13.8 Mpa, which is more than the ILSS of 11.8 Mpa of NO.2 . After heat-treated at 2500 ℃ ,the carbon fiber turns to graphitic structure partly, the surface is cleaned, which means that the content of oxygen group on the fiber surface reduces. So the bonding between the fiber and matrix is very weak. During carbonization , the matrix shrinks and the interface of NO.2 debonds to be crack. the matrix shows carbonic structure . But the matrix of the NO.1 is graphitic structure after after-heat-treated at 2500 ℃ . The graphite matrix has good behavior in resisting crack expanding , but the carbonic structure doesn't so. So, the ILSS of the NO.1 is higher than that of NO.2. In NO.3 and NO.4, when heattreated at 1500℃ , the carbon fiber has some little graphitic structure and the surface is also cleaned as that of the

heattreatment at 2500℃, so the adhesion between fiber and matrix is also very weak. After after-heattreated at 900℃ in NO. 3, the matrix of material turns to be carbonic structure, of which the ILSS is less than that of NO.4, which has some graphitic matrix when after-heattreated at 1500℃.

The same results can be drawn out from NO.5 and NO.6 or from NO.7 and NO.8, when the carbon fiber and its surface are the same, but because of the difference of the after-heattreatment temperature, the ILSS and the surface is very different, the higher the temperature, the higher the ILSS.

When the composites are after-heattreated at the same temperature, such as 2500℃, but because of the difference in the surface of carbon fiber, the ILSS of them is also different, as No.1 and NO.8. In NO.8, the carbon fiber is treated by oxidation, the surface has more oxygen group than that of No.1, which means that the adhesion of NO.8 between the fiber and matrix is stronger than that of NO.1. When the composite is treated at 2500 ℃,the stress -graphitization can lead to more graphitic structure in matrix[2], so the interface has better behavior in resisting crack expanding, so the ILSS of NO.8 is higher than that of NO.1.

Conclusions

The carbon fiber and its surface is the same, but because of the difference in after-heattreatment temperature, the ILSS and interface is very different. The higher the temperature of after-heattreatment, the stronger the interface and the higher the ILSS;

The temperature of after -heattreatment of the composites is the same, but because of the difference in the surface of carbon fiber, the interface of ILSS of the composite is also very different, the more the content of oxygen group on the surface, the stronger the interface and the higher the ILSS.

References

1. Carbon,3,381(1988).
2. A.Kelly,S.T.Milelko,Fabrication of Composites, Handbook of composites ,Volume 4, 1983, New York.