The Influence of Matrix Content on the Properties of 2D Carbon/Carbon

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Introduction

C/C composite is one distinguished thermoproof engineering material in Aerospace. 2D-C/C has the feature of simple process and low cost, It's fitful to making thin-wall C/C parts, such as solid rocket motor exit cones[1]. But 2D-C/C has low interlaminar shear strength(ILSS),people always worry about delamination. To improve ILSS, the needling technology is used in Society of European Propulsion[2]; Rosette exit cone was made in USA and Russia[3]; the pressed carbonization was employed in our institute. These measures have remarkable effects on improving ILSS and preventing from delamination. In this article, what the high matrix content in carbon/phenolics preform (C/P) can also improve the laminate C/C's ILSS is studied.

Experimental

Phenolic resin is analysed by DSC anf TGA,the curing process and carbon yield are listed in tab.1 . The selected phenolics has very high carbon yield. The PAN based carbon cloth are treated by 1600 ℃,which causes strength down by 40 ~ 50%.The preparation process of 2D-C/C is depicted in fig.1. The 2D-C/C with different matrix content is obtained by differental curing process. The carbonization period is about 200h,the lowest heat ratio is 2 ℃/h. After 120h's densification by CVD , the ultimate density of 2D-C/C is above 1.5g/cm^3 . The matrix content of C/P is attained by corrosion of heat thick sulphuric acid; through short beam shear, the ILSS is measured .

tab.1 the thermal analyses of phenolic resin

DSC 10 ℃/min	peak-on temp.(℃)	167.91
	peak temp.(℃)	209.03
	peak-off temp.(℃)	250
TGA(900 ℃) 10 ℃/min	50wt% resin(%)	45.43
	cured resin(%)	71.98

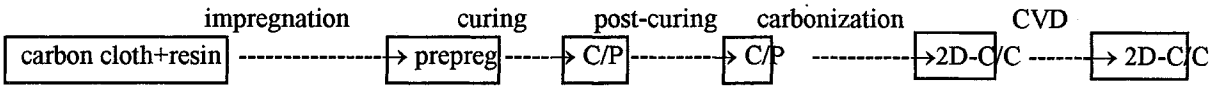

Fig.1 the preparation process of 2D-C/C

tab.2 testing resullts of ILSS and delamination state (ILSS unit:MPa)

number		1	2	3	4	5	6	7
matrix content/wt%		20.23	27.09	27.6	32.56	33.05	34.86	37.57
C/P	ILSS	16.68	17.26	20.34	17.40	18.6	20.42	20.82
carbonized 2D-C/C	ILSS	/	5.56	5.42	5.34	6.77	8.7	8.23
	state	De.	N	N	N	N	N	N
densified 2D-C/C	ILSS	/	9.03	8.534	13.6	15.34	13.44	16.1
	state	/	N	De.	N	N	N	N

De.— delamination; N — non-delamination

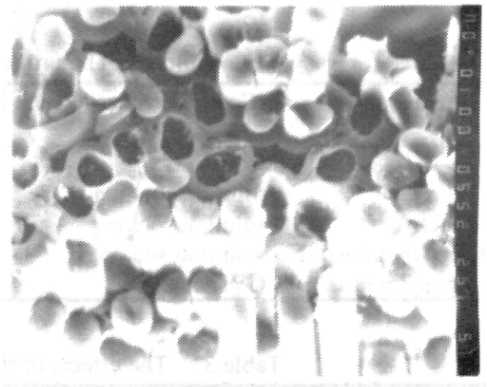

Fig.3 the SEM of 2D-C/C

Results and Discussion

the influence of matrix content on ILSS

The dada in tab.2 are diagrammed in fig.2,the relationship

between ILSS and matrix content is approximately treated into 3 line segments. With the matrix content of C/P increase, the ILSS of C/P,carbonized 2D-C/C and densified 2D-C/C linearly improves respectively.

Interface is crucial in determining the properties of composite. Several researches point out that interfacial interaction result in strong interface bonding,which improves the interfacial shear strength in resin carbon matrix C/C[4,5]. The surface oxygen functional groups may firmly bridge the carbon atoms between the fibres and matrix and then form C/C bonds by the release either CO or CO_2 during pyrolysis, resulting in strong chemical bonding at the fiber/matrix interface[4].

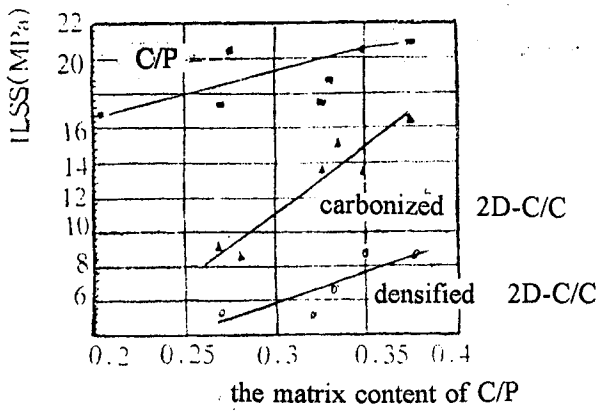

Fig.2 the relationship between ILSS and matrix content of C/P

In this experiment,the fiber surface is analysed by XPS, the oxygen functional groups is about 13% after 1600 ℃ treatment. Fig.3 is the SEM shear section from no.7 C/C,fibers are seldom pulled out,and the lengths are very short even for pulled out fibers. For the above two reasons,we can conclude that this 2D-C/C has strong interaction in interface. So the matrix content higher in C/P,residual carbon higher after carbonization,the chemical interaction higher, ILSS of carbonized 2D-C/C higher. The densified 2D-C/C is more denpend on carbonized 2D-C/C, so the ILSS is also increased linearly.

anti-delamination

It can be seen from tab.2 that no.1 C/C delaminates after carbonization and no.3 C/C delaminates after CVD when machining. In fig.2, when C/P has low matrix content, the 2D-C/C has low ILSS, can't stand thermal stress in process,so delamination occurs. For no.1 C/C, the matrix content of C/P is very low, about 20.23wt%, so delamination happens during carbonization. No.3 C/C also has low content of 27wt%,and low carbonized ILSS of 5.42MPa, delamination is occured because of thermal stress during process. The other 2D-C/C in tab.2 have the high content of above 32wt%,the ultimate 2D-C/C have the ILSS of above 13MPa,they are all delamination-free. In the Russian references of 2D-C/C, the matrix content of C/P is as high as 40 ~ 45wt%,the ILSS is about 20MPa, it's infered from Fig.2 that the ILSS of densified 2D-C/C can be improved further when the matrix content is increased.

Conclusions

1) As the matrix content of C/P increases, the ILSS of carbonized 2D-C/C,densified 2D-C/C linearly improves respectively.The no.7 C/C has the highest ILSS of 16.1MPa.

2) The matrix content of C/P affects the delamination of 2D-C/C,when it lowers, the ILSS is too low to prevent from delamination.For example: When matrix content is less than 20wt%,the 2D-C/C delaminate after carbonization;when content lowers 32wt%, the 2D-C/C may delaminate because of the thermal stresss during process;when the content is more than 32wt%, the ultimate 2D-C/C is delamination-free during the whole process.

References

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