RESEARCH OF MUTI-FUNCTIONAL C/C/Al_2O_3 COMPOSITES

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Introduction

C/C composites can use in high-temperature area above 1000 ℃,but it's rate of heat conductive is very high.So the structure material such as steel can't injoin to it indirectly.Usuraly some material such as SiO_2 fiber/phenolic whose thermal conductivity is lower (<1.0W/m·K)used between them.But the interface between C/C and SiO_2 fiber/phenolic is lower. So we want get a new muti-fuctional material which has good ablation-resistance property inside of it and good adiabatic property outside of it.

Experimental

Raw material

Whole carbon felt ρ=0.2g/cm^3;
Al_2O_3 inorganic glue
weight content of Al_2O_3: 20% .

The whole carbon felt can easily be shaped and it has been stiched in axial direction,so the strenghth in the direction can be increased and the delamination can't be occured easily.The mension of the preform is ϕ 250 × ϕ 100 × 200mm.

The reasons that we chosed the Al_2O_3 inorganic glue are it is avilable easily and can bear high temperature above 1000 ℃ and importantly has lower rate of heat conductive(see Tab.1).

Tab.1 Properties of α-Al_2O_3

crystal lattice	density g/cm^3	melting point ℃	thermal conductivity W/m·K
hexagon	3.97	2050±10	600 ℃ 9.16 1100 ℃ 6.17

Processes

The material can be made through under processes (see Fig. 1).

At first,by heat gradient CVD,the density inside of the preform can be obtained to 1.26g/cm^3,but there is few CVD carbon outside of the preform. Then by five vacuum-pressure impregnation and sinter,at last the average density of the material is 1.54g/cm^3. Thus the muti-functional C/C/Al_2O_3 obtained.The densities of all part of the material before and after impregnation and sinter are illustrated at Fig.2.

Results and Discussion

Analysis of composition

The weight content(WC) inside of the material which is obtained from Fig.2 by caculation is illustrated in Fig.3. From inside to outside of the material, the WC of the carbon acting as matrix changed from 65% to nearly zero, and the WC of Al_2O_3 acting as matrix changed from 8% to 85%.Thus the obvious content gradient in the material can be obtained.

Mechanics property

Because the contents inside of the material is different, the material is divided into three parts(inside,middle and outside). The axial and radial compressive strengthes of them are tested respectively. The results are listed in Tab.2. The datum of the compressive strength are lower. It is due to the interface between the carbon fiber and the Al_2O_3 is weak.

Tab.2 Compressive strength(CS) of C/C/A l_2O_3

Direction	Position	Density g/cm^3	CS (MPa)	S	Cv %
	outside		42.7	11	26
Axial	middle	1.54	69.2	26	37
	inside		73.3	22	30
	outside		53.7	24	36
Radial	middle	1.54	68.4	12	17
	inside		62.8	19	30

Ablation property

The ablation test acts to inside of the material by using oxygen and acetylene. The results are listed in Tab.3.

Conditions of the ablation:

Gas	Pressure of gas(MPa)	Flus(litre/s)
O_2	0.4	0.42
C_2H_2	0.095	0.31

Diameter of nozzle:2mm Distance of ablation:10mm

Tab.3 Ablation results of C/C/A l_2O_3

lasting time of ablation(s)	ablation coefficient (mm/s)	Cv (%)
20.3	0.012	5.9

The ablation coefficient of the material is very low, it is attribute to the CVD carbon.

Thermal property

The results of the calorifics properties of the material are listed in Tab.4.

Tab.4 Thermal conductivity (RHC) of C/C/A l_2O_3

Temperature (℃)	RHC W/m·K
25	0.86
200	1.052
600	1.420
800	1.730

The heat conductive of the material is also low. It is lower than that of pure Al_2O_3. It is because that there are a lot of pores in the material.

Conclusions

1. The process is feasible. The gradient muti-functional C/C/Al_2O_3 can be obtained by it.
2. The compressive strength of the material is above 50MPa, the thermal conductive is 1.73W/m·K(800 ℃),the ablation coefficient is 0.012mm/s.
3. The interface of the Al_2O_3 and carbon fiber is weak, so the strength of the material is lower.

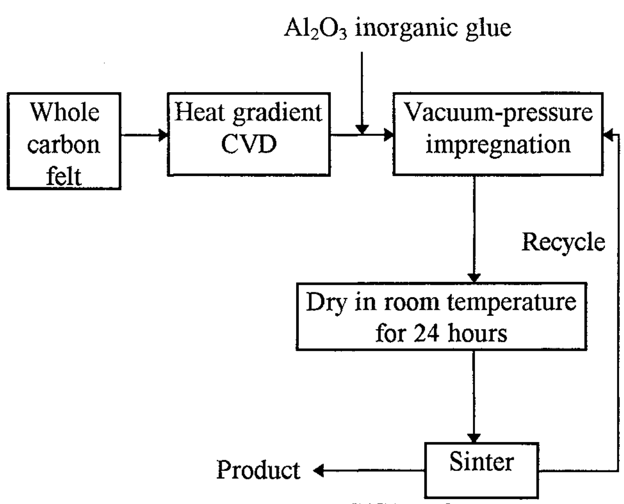

Fig.1 Processes of C/C/ Al_2O_3

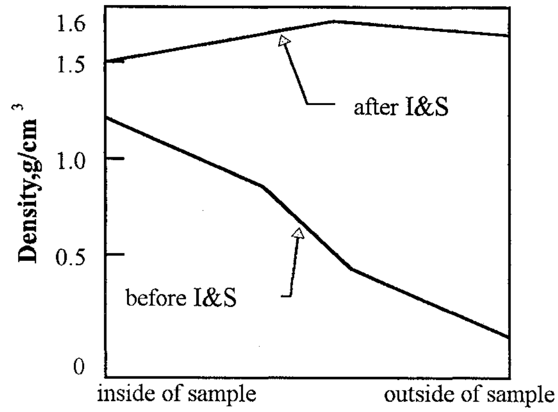

Fig.2 Changing of sample before and after impregnation and sinter(I&S)

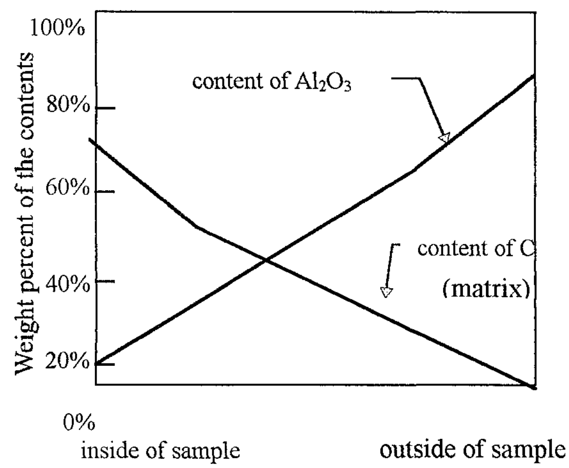

Fig.3 Changing of the contents in C/C/Al_2O_3