ON THE ANTIOXIDATION AND GASTIGHTNESS PROPERTIES OF C/C COMBUSTION CHAMBER MATERIAL

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Introduction

C/C composite materials offer significant potential benefits for various aerospace applications because of their low density($\leqslant$1.90g/cm^3) and excellent comprehensive properties at elevated temperature. If they are used as the attitude control thruster material, which is subjected to a high temperature, high pressure and oxidizing atmosphere condition, the material tends to erode through oxidation and porosity of the material may result in fuel leakage. So the two critical problems of anti-oxidation and gas tightness must be overcame for a C/C thruster. In this paper, the fabrication process and their effects of multi-coating to solve the problem of anti-oxidation and gas-tightness are discussed. Firing test indicates that the multi-coating can meet the needs very well.

Experimental

C/C thruster used for anti-oxidation and gas-tightness treatment is a braided composite, densified by the combination process of CVI and HPIC. Its final density is about 1.80g/cm^3.

1.Anti-oxidation and gas-tightness coating

(1) By chemical vapor reaction process at 1700-2000℃, SiC coating is formed on the C/C surface to provide a oxidation protection on material.

(2) By reactive sintering process at 1400-1600℃ , $MoSi_2$ coating is applied to the material to fill the microcrack and porosity of SiC coating.

(3) Using CVD method to deposit pyrolitic graphite over the inner surface of the thruster, The gas-tightness C/C composite can be achieved. Figure 1 shows schematic of the multi-coating.

2.Test

Density and open porosity of C/C thruster measurement are conducted using the Archimedes displacement method with water. Gas tightness test is carried out at 0.4MPa using the water immersion technique. Following gas tightness test, the thrusters are subjected to firing test.

Results and Discussion

1. SiC coating

Using chemical vapor reaction process, SiC coating is formed on the surface of C/C component. The reaction mechanism is as follow

$$SiO_2+SiC=2SiO$$
$$SiO+2C=SiC+CO-260cal$$
$$SiO_2+3C=SiC+2CO$$

In the reaction, a C atom is replaced by a Si atom. At the same time, the material undergoes a high temperature treatment (1700-2000 ℃), thus the porosity increases significantly. So fire leakage can not be avoided. Due to the anti-oxidation properties of SiC, the thrusters are not burnt through. The firing test results are show in table 1.

2. $MoSi_2$

Due to difference in thermal expansion coefficient between C/C and SiC, microcrack occurs during the cooling down part of the process. Also SiC-coating C/C composite material has fairly high porosity. So the anti-oxidation properties of the C/C material lowered. $MoSi_2$ coating formed by reactive sintering process overcame the drawback of SiC. Firing test indicates that multi-coating of $MoSi_2$ + SiC can solve the oxidation problem.

3. Pyrolitic graphite

Pyrolitic graphite with a fairly high density of 2.1g/cm^3, which is very close to the true density of carbon, has a sufficient low porosity. Using CVD method, a film of pyrolitic graphite is deposited over the inner surface of the thruster. The thrusters are subjected to gas-tightness test and firing test. The test results are showed in table 2. In the gas-tightness test and firing test, gas leakage and fire leakage are not observed which indicates that pyrolitic graphite coating can meet the demand.

Conclusions

From the firing test results, it is obvious that

(1) SiC+ $MoSi_2$ multi-coating can solve the oxidation problem very well

(2) The pyrolitic graphite of proper process and thickness can make the porosity C/C be a gas-tightness material.

Table 1. Properties of SiC-coated C/C thruster

Specimen	Porosity, %	Density,g/cm^3	Firing test
Uncoated C/C thruster	2.65	1.76	Fire leakage was observed and the thruster is burnt through
SiC-coated C/C thruster	4.90	1.83	Fire leakage was observed but the thruster is not burnt through, the coating is undamaged

Table 2. Properties of C/C material treated with pyrolitic graphite

Specimen	Porosity, %	Gas-tightness test result	Firing test result
Anti-oxidation coated C/C	<4.90	Critical gas leakage	Fire leakage
Pyrolitic graphite coated C/C	Close to 0	No gas leakage	No fire leakage

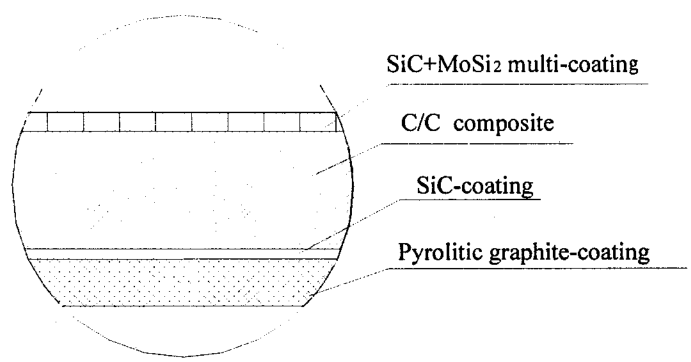

Figure 1. Schematic of the multi-coating