# THE RESEARCH AND APPLICATION OF COPPER IMPREGNATED COARSE GRAIN GRAPHITE THROAT

Su Junming, Li Guilin, Hao Zhibiao, Cheng Wen, Zhang Yali
The 43rd Institute of the 4th Academy of CASC,china

## Introduction

The high working pressure solid rocket motor (SRM), which can almost reach 20Mpa, has been widely used in the advanced tactical missile. Those traditional SRM throat materials, such as the high strength graphite, high strength and high density graphite etc., have the shortcomings of brittle and defect sensitivity. Their property of anti-thermal shock can't satisfy the practical use. The principal aim of this study is to develop a kind of middle level throat material,of which the anti-thermal shock property is better than that of graphite and the cost is much lower than that of carbon/carbon composite. The coarse grain graphite used as matrix, after the new processing of impregnating copper to the graphite crucible at high temperature, the copper impregnated graphite composite can be made. It has the properties complementary and is suitable for the high temperature, high pressure environment.

## Experimental

1. Raw materials

High strength coarse grain graphite rod; copper ingot.

2. New impregnating copper process

Machine the coarse grain graphite matrix to the crucible shape,then put the copper ingot in it. heat the crucible up than the melting point of copper in the sintering oven, after that, take the crucible out of the oven and put it on the press working flat, make the graphite press end contact with the melting copper surface and give some pressure, so the melting copper impregnate the coarse graphite along the open pores and microcraks and form a net-like continuous phase, finally the copper impregnated graphite throat material can be made.

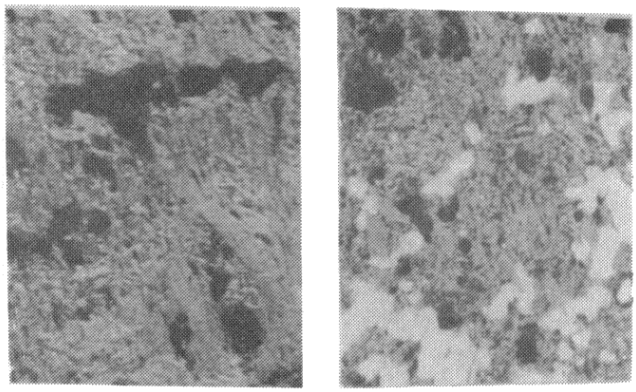
## Results and Discussion

1. The effects of impregnating copper on the graphite properties

Table 1 shows the mechanical and physical properties of high strength coarse graphite and those of the copper impregnated graphite. Figure 1 is their microstructure photos.

Table 1. Properties of the high strength graphite (pre-and after impregnating copper)

| material | high strength graphite | | copper impregnated high strength graphite | |
|---|---|---|---|---|
| | radial | axial | radial | axial |
| density $g/cm^3$ | 1.75--- 1.82 | | 2.03--- 2.35 | |
| tensile strength Mpa | 8.6 | 8.3 | 11.8 | 10.5 |
| compress strength Mpa | 35.5 | 36.5 | 44.1 | 47.6 |
| flexure strength Mpa | 19.7 | 15.6 | 22.1 | 17.9 |
| thermal conductivity 1000℃ W/k.m | 46.0 | 30.9 | 102.9 | 64.1 |
| thermal expansion coefficient × $10^{-6}$ 800℃ | 2.4 | 3.5 | 2.5 | 3.7 |



(a) × 63 (b) × 63

(a) high strength coarse grain graphite
(b) after impregnated copper

Figure 1 . The metallographic photos of the graphite and copper impregnated graphite

The high strength graphite is a kind of

porous materials and has the net-like micro-cracks. By the process of impregnating copper at high pressure and high temperature, the cop-per liquid can impregnate the open pores and microcracks, and form the continuous net structure phase, so the density of the material in-creases, the strength and toughness can be improved, especially the thermal conductivity grows multiplicatelly because the good thermal conduct--copper fill the open pores and microcracks of the graphite, it is 107 ~ 123% more than that of the graphite at 1000 ℃ .The great increment of thermal conductivity is very beneficial to modify the anti-thermal shock property of the material, because the higher thermal conductivity can make the material have lower thermal gradient, so the thermal stress can be reduced as far as possible .

2. The application of copper impregnated coarse grain graphite throat.

The copper impregnated coarse grain graphite throat used in the small-scale tactical missile SRM , has been successful in many times of ground firing test and flight test, it is now in the practicable application stage. Figure 2 shows the throat billet material. The SRM firing test condition is as following:

propellant: HTPB/Al/AP;
chamber pressure: 8 ~ 15Mpa;
work time: 6 ~ 35S;
throat initial diameter: 90 ~ 135mm;
liner ablation rate: 0.05 ~ 0.19mm/S.

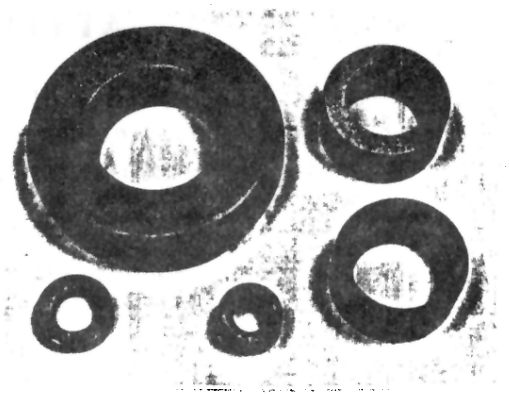


Figure 2. The throat billet of copper impregnated coarse grain graphite

## Conclusion

High strength coarse grain graphite used as matrix, after new process of pressing melted copper to the graphite crucible matrix directly, the copper impregnated graphite composite can be fabricated. Its technical approach is practicable, short-period and low-cost. Being small-scale tactical missile SRM throat material, its ablation rate is moderate, the anti-thermal shock property is better than graphite. It can meet demand for high pressure SRM and be a new kind of low cost throat material.