Effect of Spraying Distance on Properties of B_4C Coating

Y. Zeng Y. F. Zhang J. Q. Huang C. X. Ding

Shanghai Institute of Ceramics, Chinese Academy of Science

1295 Dingxi Road Shanghai 200050 P. R. China

ABSTRACT

Boron carbide coating has some very attractive properties for nuclear and semiconductor industry. The potential of atmospheric plasma spray as manufacturing methods for B_4C coating was discussed. In this work, the boron carbide coating with low porosity, high microhardness and good life of thermal shock resistance was deposited by the control of spraying distance. The relationship between the properties of B_4C coatings and their spraying distance was studied.

Keyword: B_4C coating Spraying distance Porosity Microhardness

1. Introduction

B_4C is a low atomic number, low–density material with a high melting temperature, thermal conductivity and high specific heat resulting in excellent survivability against directed energy threats and cold X-rays[1-4], and is desirable candidate front-wall surfaces for experimental facilities used to demonstrate ignition in inertial confinement fusion[5]. B_4C coating is also used in other fields, including the wear resistance field and semiconductor industry due to its high microhardness, high modulus and good electronic conductivity[6].

Plasma spray is a potential method to produce B_4C coating. It is necessary to optimize the plasma spraying parameters, including the arc current, plasma gas, and spraying distance. Spraying distance is the most important factor among these parameters.

The objective of this work is to optimize the spraying parameter of B_4C coating and study the relationship between spraying distance and the properties of coating .

2. Experiment

B_4C powder with a particle size ranging from 9 to 60μm was used. The substrate for the plasma spraying trials was stainless steel. Before coating, Substrates were blasted with Alumina to increase the roughness of surface. The B_4C coating was deposited using the Sulzer Metco plasma equipment. In order to study the effect of spraying distance on the deposition efficiency, the porosity, the microhardness and the life of thermal shock resistance of B_4C coating, the different spraying distances, including 60mm, 80mm, 100mm, 120mm, 140mm, were selected as experimental parameters.

The cross-sections of B_4C coating specimens polished have been used for its properties and microstructure examination. The porosity and microhardness of B_4C coatings were investigated by optical microscope and microhardness analyzer, respectively.

The coatings with different spraying distance were heated to 500℃ for 10 min. and then submerged in water at room temperature for 5 min. The times of appearing first crack on the surface of coating and the half stripping were recorded.

3. Results and Discussion

3.1 The deposition efficiency of B_4C coating

The deposition efficiency is the most important parameters for B_4C coating. It is the ratio of the coating weight and the powder fed into the plasma gun. Fig.1 showed the influence of the spraying distance on the deposition efficiency of B_4C coating. From Fig.1, it could be seen that the deposition efficiency increased gradually with a decrease in spraying distance. Specially, the deposition efficiency increased from 33% to 52% while the spraying distance decreased from the 100mm to 80mm. The boron carbide powder was also sprayed at the spraying distance of 50mm, but the coating was peeled off instantly after sprayed. The shorter spraying distance may cause the temperature of substrate so high that the mismatch of expandation between the substrate and the coating was enlarged and the coating was stripped. Therefore, the spraying distance having high deposition efficiency is about 80mm in this study.

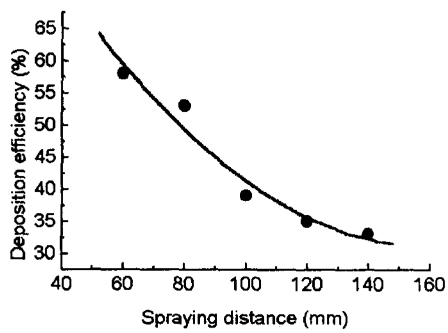

Fig.1 The dependence of deposition efficiency of B_4C coating on the spraying distance

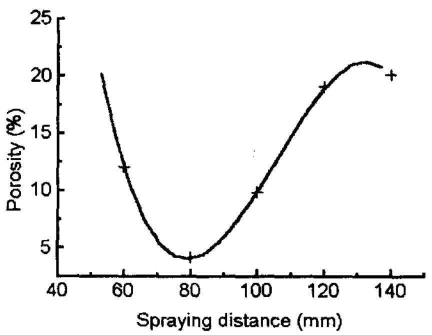

Fig.2 The dependence of porosity of B_4C coating on the spraying distance

3.2 The porosity of B_4C coating

The porosity of B_4C coating samples was measured in the microscope. The results showed in Fig.2. From Fig.2, it can be seen that the values of porosity of B_4C coatings ranged from 4% to 19%, which were severely dependant on their spraying distance. The short spraying distance may resulted in the bad melting of particles of B_4C powders in plasma jet, especially for B_4C powder having high melting point. There were many particles of B_4C powders not melted well in the B_4C

coating at shorter spraying distance and the melted B_4C particles have been cooled before impacting on the surface of substrate for longer spraying distance. The reason of higher porosity appeared in the B_4C coatings at longer and shorter plasma spraying distance will be discussed below.

3.3 The microhardness of B_4C coating

B_4C coating as a material resistant to wear is based on its high hardness. It was therefore of interest how the hardness is influenced by the process of plasma spraying, especially by the spraying distance. Fig.4 showed the dependence of microhardness of B_4C coatings on the spraying distance. From Fig.4, the high value of microhardness of coating corresponded with the low porosity of B_4C coating as can be seen from Fig.2. The optimum spraying distance to achieve the highest microhardness was 80mm. The microhardness of B_4C coating was high up to 28GPa.

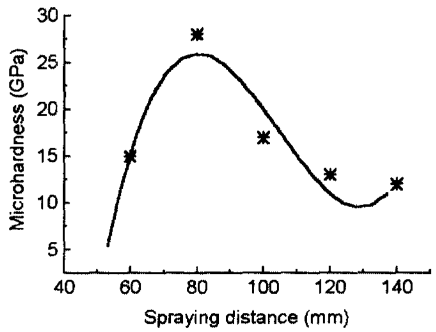

Fig.3 The dependence of microhardness of B_4C coating on the spraying distance

3.4 The life of thermal shock resistance of B_4C coating

Table.1 showed the life of thermal shock resistance of B_4C coating. From Table.1, it can be seen that B_4C coating of the spraying distance from 80 to 100mm had long life of thermal shock resistance.

Table 1. The life of thermal shock resistance of B_4C coating

Spraying distance	Thickness of coating	The times of appearing the first crack	The times of coatings being peeling off half
60mm	0.21	16	24
80mm	0.20	20	29
100mm	0.22	28	40
120mm	0.23	12	18
140mm	0.21	10	17

3.4 The microstructure of B_4C coatings

The microstructure of B_4C coatings with different spraying distance showed in Fig.5. From Fig.5, it can be seen that the pores and their distribution as well as the melted state of B_4C particles were different at different spraying distances. There were more pores and many particles of B_4C powder not melted well in the B_4C coating with 60mm spraying distance as can be seen from Fig.5(a). For the spraying distance of 100mm, the flying path of melted particles of B_4C powder is longer. The temperature of B_4C particles melted decreases when it achieves at the surface of substrate. Therefore more pores and interface of particles appeared in the coating, which was showed in Fig.5(c). The dense and even B_4C coating can be found from Fig.5(b). The less pores and porosity appeared in this coating. It is enough to prove that the suitable spraying distance for B_4C coating in this study is about 80mm.

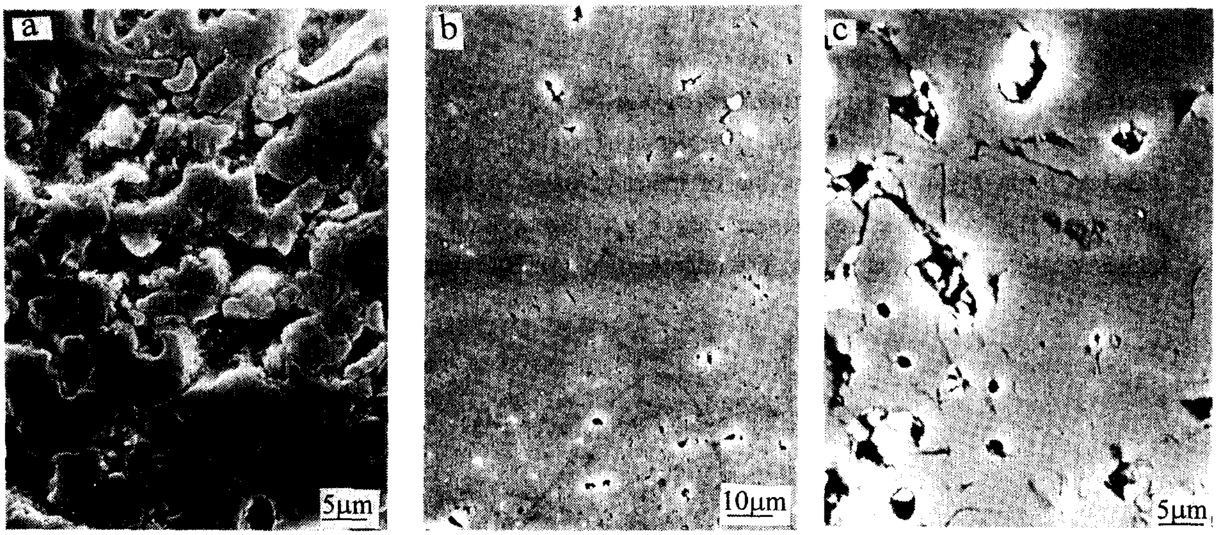

Fig.4 The micrographs of B_4C coatings with different spraying distances

(a) 60mm; (b) 80mm; (c)100mm

4 Conclusion

B_4C coating with high deposition efficiency, low porosity, high microhardness and long thermal shock life has been deposited by the control of plasma spraying parameters. The spraying distance is the key factor to affect the properties and microstructure of B_4C coatings. It was relative with the melting of B_4C powder in plasma jet. The optimistic spraying distance is about 80mm.

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