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Microstructure and Properties of MoB/CoCr Cermet Coatings Fabricated by LPPS

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Abstract: MoB/CoCr cermet coatings were deposited by low pressure plasma spraying (LPPS). The microstructure and phase component of coatings were characterized with XRD, SEM and EDS, the coatings were also studied on bond strength and thermal shock resistance properties. The results show that phase component of powder and coating had little change. The coatings are dense and have excellent combination with substrate. The main constituents of coatings remain invariant and the coatings have excellent properties of bond strength and thermal shock resistance.

Key words: MoB/CoCr; low pressure plasma spraying; cermet; thermal shock resistance

INTRODUCTION

MoB/CoCr cermet coatings have properties of good corrosion resistance, heat resistance and wear resistance in the aluminum alloy (Mizuno *et al.,* 2005; Mizuno *et al.,* 2005). In the literature, MoB/CoCr coatings are usually prepared with high-velocity oxy fuel (HVOF) on the surface of sink roll (Mizuno *et al.,* 2006). While MoB/CoCr coatings prepared with low pressure plasma spraying (LPPS) on the surface of 20G high-pressure boiler tube have not been reported.

Compared with HVOF method, LPPS has higher process temperature and powders are not polluted. As hot spraying coating properties and microstructure are principally determined by the temperature and velocity of the sprayed droplets when impinging on the substrate, LPPS is promising to gain higher strength and lower porosity than those of HVOF method.

In this study, MoB/CoCr cermet coatings are prepared with LPPS method. The microstructure and properties of coatings are presented in this paper.

Experimental:

Materials:

The substrate material was used in this study was pressurization tube. Its wt% chemical composition was the following: 53%Mn, 25%Si, 17%-24%C, 3%Ni, 2%Cr ,2%Cu, 1.8%S and 1%P. The substrate was machined into samples of φ20mm×300mm. Prior to deposition, they were bombarded by Al_2O_3 grits for 10 min and then supersonically cleaned for 10 min.

The experiments were carried out by a low pressure plasma spraying system, which consisted of dual powder feeding device and a F4 gun manufactured by GTV Company in Germany. The MoB/CoCr powder used in the present work was produced by Shanghai Superior Machineries & Materials Co., China. The average particle size distribution of the MoB/CoCr powder was about 15-45μm. The SEM morphology of powder is shown in Figure 1.

Prior to spray MoB/CoCr coating , stellite 6 alloy transition layer with a thickness of about 130μm was sprayed onto the surface of substrate so as to increase the adhesive strength between MoB/CoCr coatings and the substrate. The average particle size distribution of the stellite 6 alloy powder was about 15-45μm. The SEM morphology of powder is shown in Figure 2.

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Fabrication:

During the procedure, MoB/CoCr powder was put in the powder feeding device, spraying equipment was stuffed pure Ar to make indoor pressure reach 1.3×10^3Pa. The MoB/CoCr coating with a thickness of over 170μm was produced within a few minutes. The spraying parameters are shown in Table 1.

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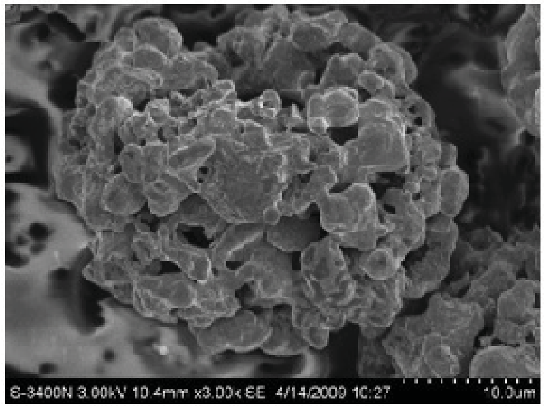


Fig. 1: SEM morphology of MoB/CoCr powder

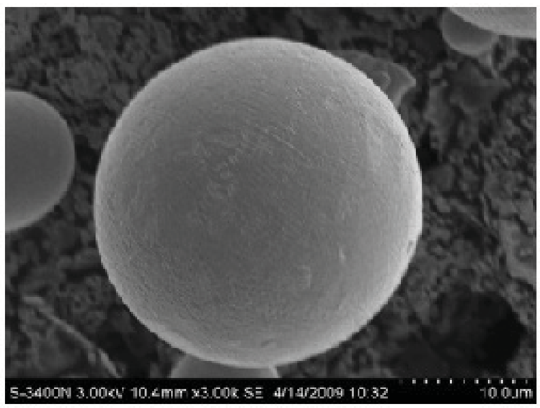


Fig. 2: SEM morphology of stellite 6 alloy powder

Table 1: Spraying process parameters

Process parameters	
Current/A	680 ~ 720
Power/KW	45 ~ 51
Gas flow slpm(Ar/H_2)	59/6
Feed rate /$g{\cdot}min^{-1}$	12
Chamber pressure/kPa	8 ~ 12
Spray distance/mm	125 ~ 300

Characterization:

XRD characterization was performed on the powder and surface of the coating by means of the D/max-Ultima X-ray Diffractometer 2500VPC diffraction instrument with a CuKa radiation. All specimens were ground and polished, and then specimens were observed by a HITACHI S-3400N scanning electron microscope. The porosity of coatings was mensurated by a LEICA DIMRM metallographic microscope and the bond strength of coatings was measured with JDL-50KN tensile-testing machine.

RESULTS AND DISCUSSION

Phase and Component Analysis:

The XRD results of the MoB/CoCr powder and coating are shown in Figure 3 (a) and (b), respectively, in which powder and coating are mainly composed of double borides of both $CoMo_2B_2$ and CoMoB. The diffraction peak of the coating is wider than that of powder, which is caused by two reasons (Lima *et al., 2001*). one is the production of small-sized crystalline grain, the other is the influence of microstress. The melting powder lashed against the substrate in spraying, then crystalline grain was generated.

The EDS analysis of the MoB/CoCr section coating in Figure 4 shows that the main components of surface coating are Co, B, Mo, Cr. Compare with the components of powder, the main constituents of coating remain invariant in spraying. This is due to the entire process of spraying is carried out in low-voltage state, spraying materials are unpolluted and no oxidation.

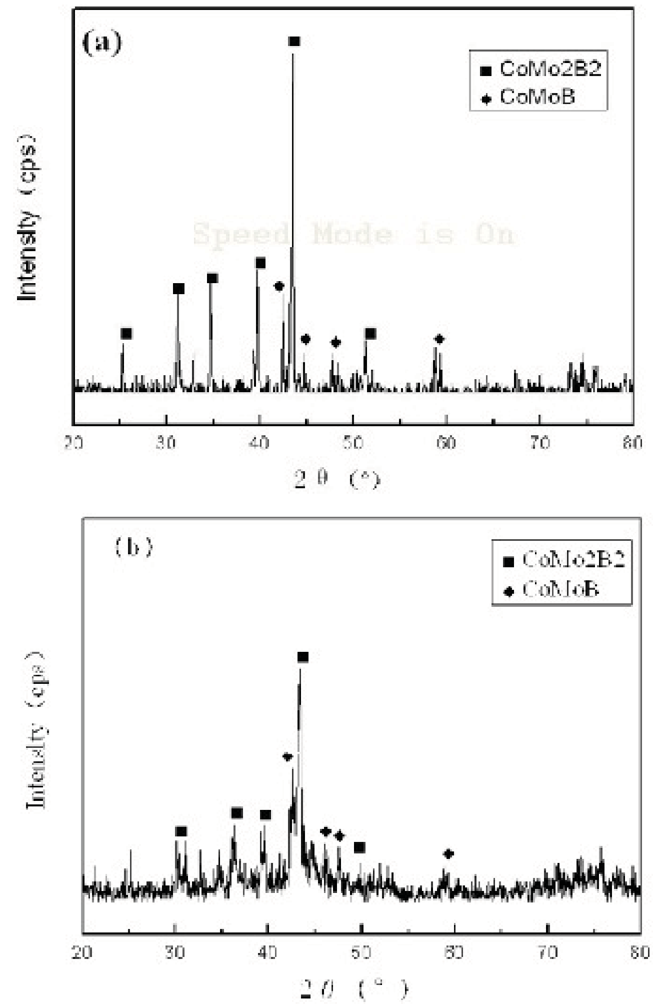
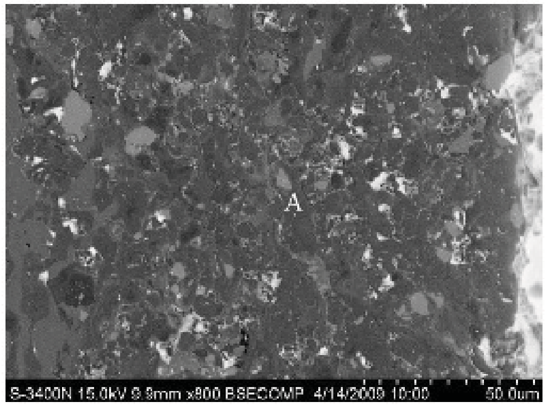


Fig. 3: XRD patterns of (a) powder and (b) coating.

Microstructure of the MoB/CoCr Coatings:

The SEM surface morphology of MoB/CoCr coating is shown in Figure 5. It is observed that there are partly-melted zone (P) and fully-melted zone (F) on the surface (Evans and Hutchison, 1993, Tbompson and Clyne, 2001). There are droplet-like particles and pore space on the surface which resulted from the rapid solidification of the sprayed droplets adhering to the surface in the P zone. Compared with the P zone, the surface of F zone is denser.

In general, with chamber pressure heightened, the ratio of F/P will be markedly increased and powders will be easily melted in spraying. Compared with coarse particle size powder, small particle size powder (15-45μm) in this study is easier to be melted.



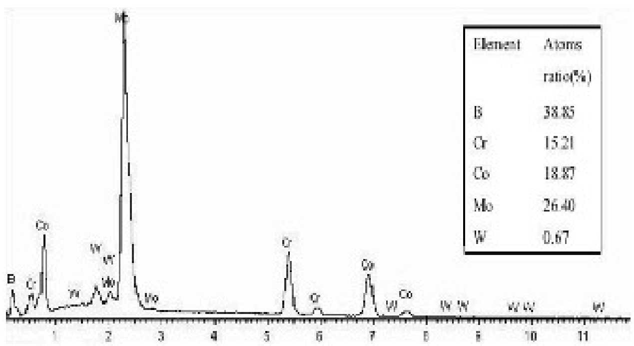


Fig. 4: EDS analysis of the MoB/CoCr section coating.

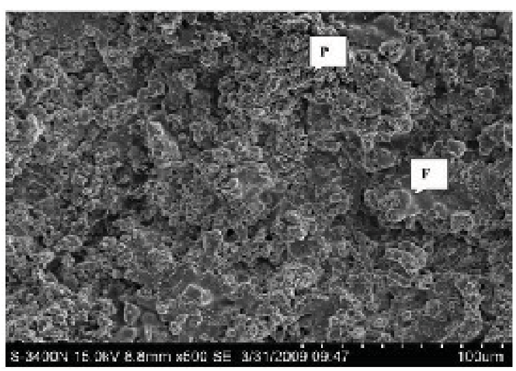


Fig. 5: SEM surface morphology of MoB/CoCr coating.

The SEM section morphology of MoB/CoCr coatings is shown in Figure 6. It is observed that the surface and transition coatings are dense and the transition layer has excellent combination with substrate. This is due to the surface of substrate that was treated with grit blast is accidented and spraying material diffuses into substrate in spraying, it helps to form a good combination between transition layer and substrate.

Compared with surface layer, the transition layer has lower pore space due to lower melting point of stellite 6 alloy and adequately melted powders. The porosity of surface layer is 1.78%, and that of transition layer is 0.84%.

Bond Strength of Coatings:

The bond strength of coatings can reach 70MPa, which is high bond strength between coatings and substrate. This result is due to high temperature and high pressure in collision region and intensive P-type breakage or plastic yield in contact zone when unpolluted powder lash against substrate surface in high speed.

It not only enhances physical combination, but also accelerates interaction and volume diffusion between coatings and substrate Treasury and Wen, 1981.

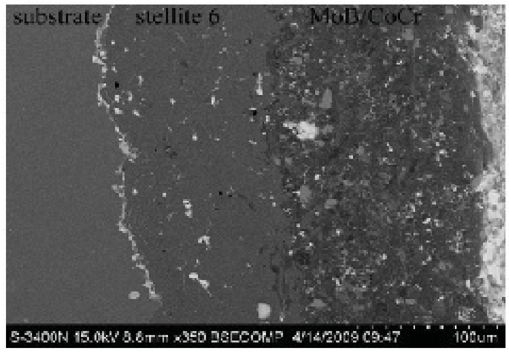


Fig. 6: SEM section morphology of MoB/CoCr coating.

Property of Thermal Shock Resistance:

The property of thermal shock resistance was tested by water quench method. The specimen was put into electric box furnace (700) 20min, then took it out and put into water (20) to cool down. Figure 7 (a) and (b) are micrographs of coatings after thermal shock test of 70 times. It shows that vertical distribution crack and pores appeared on the surface coating, and the obvious fissure appeared between coatings and substrate, but the vertical distribution crack can be in favor of releasing of stress to prolong the life of thermal shock resistance.

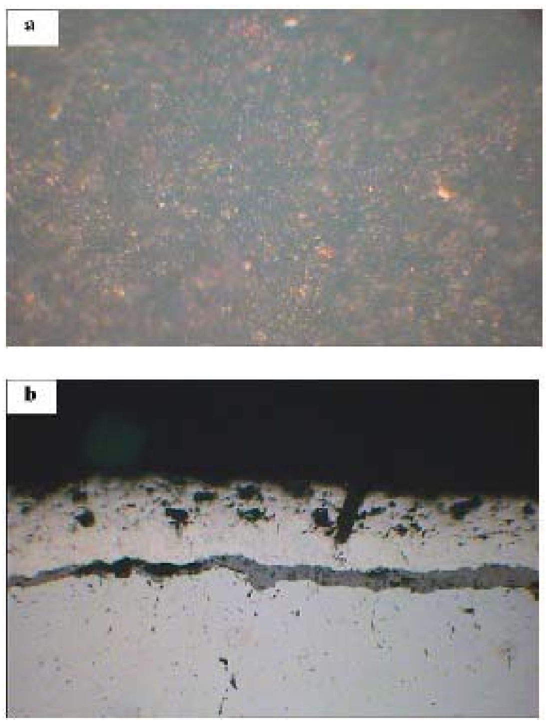


Fig. 7: Micrographs of coatings after thermal shock test (70 times), (a) surface morphology×100; (b) section morphology×100

Conclusions:

From the above discussion, some conclusions can be drawn as follows:

(i) The MoB/CoCr coatings with a thickness of about 300μm were prepared by low pressure plasma spraying method. The coatings were quite dense and had excellent combination with substrate. The main constituents of coatings remain invariant after spraying.

(ii) According to the experimental results, the sprayed coatings exhibit excellent bond strength and high thermal shock resistance properties.

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