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In situ synthesis WC reinforced iron surface composite produced by spark plasma sintering and casting

Zhanzhan Zhang [a,b,c,*], Yunbo Chen [a,b], Lingli Zuo [a,b], Yang Zhang [a,b], Yesi Qi [a,b], Kewei Gao [c], Hengsan Liu [a,b], Xin Wang [a,b]

[a] Advanced Manufacture Technology Center, China Academy of Machinery Science and Technology, Beijing 10083, China
[b] State Key Laboratory for Advanced Forming Technology and Equipment, China Academy of Machinery Science and Technology, Beijing 100083, China
[c] School of Material Science and Engineering, University of Science and Technology Beijing, Beijing 100083, China

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ABSTRACT

In situ synthesized WC reinforced iron based composites were prepared on a surface of 45# steel by means of spark plasma sintering and casting. The miscrostructure of this material were investigated with the help of SEM, XRD and microhardness. Results showed that the WC particles were uniformly distributed in the iron matrix on the surface of cast steel. The volume fraction and the mean grain size of WC particles in the composite layer were ~28% and 12 μm, respectively. A perfect metallurgical bonding between the surface composite layer and substrate was generated. From the surface of sample to that of 45# steel (matrix), the hardness decrease gradually. The microhardness of composite layer is about 2.4 times higher than that of 45# steel.

1. Introduction

In the process of repeated using of engineering components, metal surface is easy to suffer abrasion, which can cause the degradation or failure of material. It is necessary to improve the surfaces properties of engineering components, which is beneficial to prolong the service life and minimize loss of production. Metal matrix composites (MMC) coatings have been studied and applied in recent years. MMC not only make the best use of the plasticity and toughness of the metal substrates, but also possess the high wear resistance of the ceramic particles [1,2]. From the previous work, cast-sintering is used to prepare metal surface modification [3–6]. In general, this method involves first preparing composite performs by traditional powder metallurgy process, and being placed appropriated in the casting mold, then liquid steel is poured into the mold. Casting sintering can decrease the porosity of performs and realize metallurgical bonding to substrate. Yisan Wang et al. [5,6] found that iron-based surface composites reinforced by VC and TiC particles prepared by cast-sintering technique, whose wear-resistance is 10.5-times and 10.0-times more than that of the hardening medium-carbon steel under the condition of dry sliding with 588 N loads. K.Q. Feng et al. [4] and Wang Jing et al. [7] prepared TiC/Fe composite by cast-sintering technique, and TiC particles exhibit homogeneous distribution in the a-Fe matrix.

However cast-sintering wear-resisting layer still have a high porosity to limit their used. Therefore, the density of performs effect the properties of layer. Spark plasma sintering (SPS) is characteristic of relatively low sintering temperature and short sintering time by a plused direct current and applying mechanical pressure to the sintering powder [8], and have been received significant attentions in recent years. Using SPS, metal matrix composites with near theoretical densities and high wear resistance have been fabricated [9,10]. In this present study, the densification WC/Fe composites with approximately 32 vol% WC have been fabricated by spark plasma sintering (SPS) and placed appropriate placement in the sand mold, then pouring liquid steel into sand mold. The 45 steel was used as matrix alloy. The hardness and dry sliding wear resistance of the layer was investigated.

2. Experimental procedure

Commercial powders with average size of 25 μm of tungsten, copper, iron, and graphite were mixed in a composition of 46.9 wt% W, 1.5 wt% Cu, 47.5 wt% W, and 4.1 wt% C and used for the preparation of 32 vol% WC/Fe composites. Powders were mixed

* Corresponding author at: Advanced Manufacture Technology Center, China Academy of Machinery Science and Technology, Beijing 10083, China.
E-mail address: zhangzhanzhan0510@163.com (Z. Zhang).

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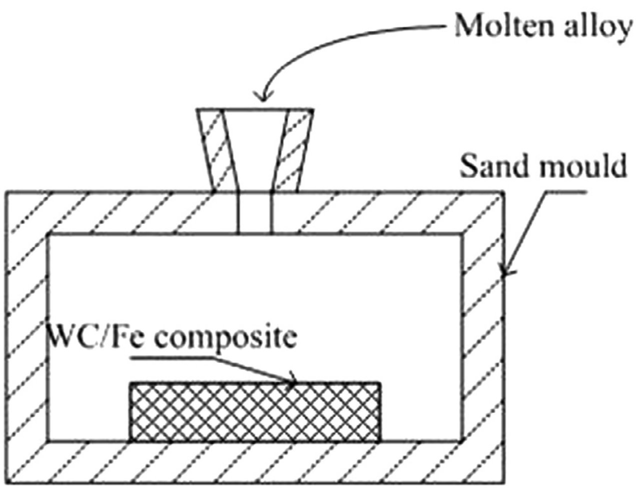

Fig. 1. The sketch map for the experiment.

Table 1
Chemical composition of substrate (wt%).

C	Si	Mn	Ni	Cr	Cu	P	S
0.48	0.21	0.65	0.26	0.24	0.23	0.021	0.035

by planetary ball milling at 300 rpm for 2 h (QM-3SP04, China). After mixing, the powder was sintered by SPS (SPS-1050, Japanese) under a pressure of 50 MPa stay warm for 5 min at 1050 °C. The sintered composites were machined to cuboid with a dimension of 15 × 10 × 7 mm by wire-cutting, and then ground and polished. The samples were cleaned by alcohol and set at the bottom of the sand mould (Fig. 1) [4]. The melting procedure of the matrix alloy (45# steel, whose chemical composition was listed in Table 1) was carried out by a medium-frequency induction furnace. The liquid steel was poured into the sand mould at 1540 °C and air cooling.

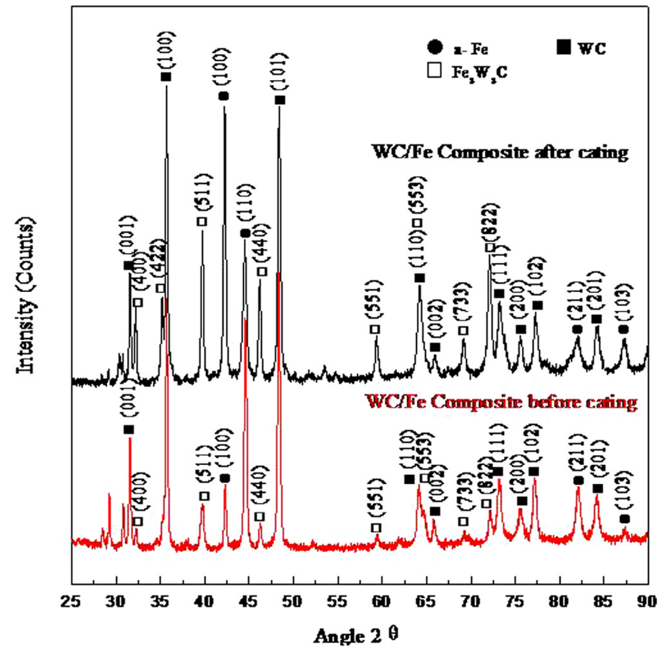

Fig. 2. XRD patterns of WC/Fe composite before and after casting.

Scanning electron microscopy (SEM) and X-ray diffraction (XRD) were employed to study the microstructural characterization of the composites. The hardness of the interface between matrix and composite was evaluated by microhardness test carried out under a load of 0.98 N using a Vickers indenter.

3. Results and discussion

In situ synthesized WC reinforced iron based composites with a thickness of about 7 mm are prepared on a surface of 45# steel by means of SPS and casting. In situ WC/Fe composites are sintered to

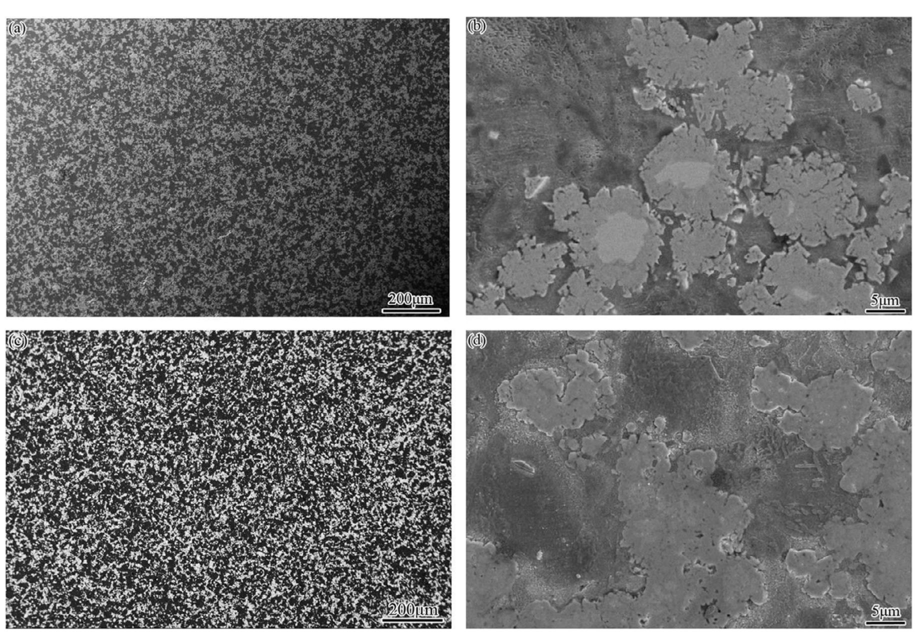

Fig. 3. SEM micrograph of WC/Fe composite before and after casting (a) low magnification SEM micrographs of WC/Fe composite before casting, (b) higher magnification SEM micrographs of WC/Fe composite before casting, (c) low magnification SEM micrographs of WC/Fe composite layer, (d) higher magnification SEM micrographs of WC/Fe composite layer.