HARDNESS AND WEAR RESISTANCE OF SHS TIC+HSS COMPOSITE COATINGS, OBTAINED BY ELECTRON BEAM SURFACING

Baranovskiy A V[1, 2], Pribytkov G A[1], Krinitcyn M G[1, 2], Firsina I A.[1] Dankovcev G.O.[2] and Martynov R.S.[2]

[1]Institute of Strength Physics and Materials Science of SB RAS, Tomsk, Russia
[2] National Research Tomsk Polytechnic University, Tomsk, Russia
Nigalisha@gmail.com

High-speed steel (HSS) is widely used for the manufacture of metal cutting tools. Due to high heat resistance, this steel is also of interest as a material of wear-resistant coatings operating at high temperatures. The important advantage of the HSS for plasma or electron beam surfacing originates from well-known self-hardening effect during cooling of the cladded coating [1].

An additional properties improvement of the coatings cladded with high speed steel powder can be obtained by adding refractory compounds into the powder. Metal carbides are used as the additives most often [2-5]. The TiC carbide appears to be the most effective additive due to the highest hardness, compared to other metal carbides.

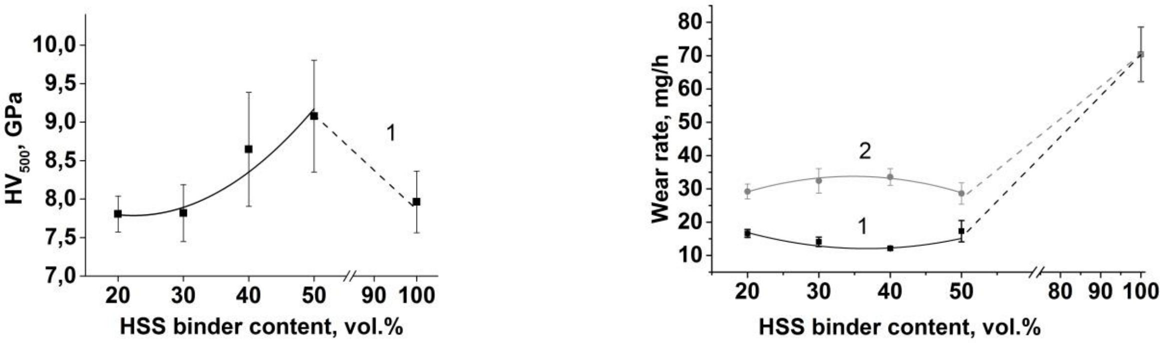
The powder mixtures are often used in coating technologies. Components segregation in the powder mixture and during delivery into melted bath can occur. That will result in inhomogeneity of elemental composition of the coating [6-9]. In this case, it is particularly necessary to use granulated composite powders, already composed of carbide particles embedded into metal binder.

Self-propagating high-temperature synthesis (SHS) in powder reaction mixtures of carbon, a carbide forming metal, and matrix metal should be recognized as the most technologically and highly productive way of obtaining composite powders "dispersed carbide-metal binder" [10].

SHS composite powders "titanium carbide – HSS binder" were obtained and investigated earlier [11]. In the present work, these powders were used for electron beam surfacing of coatings. The aim of the work was to investigate the influence of the structure of the deposited coatings on their hardness and wear resistance.

Coatings cladded by multipass electron-beam surfacing, have 2-5 mm thick (depending on the number of passes). A middle part of the coatings (outside of coating-substrate transition zone) has a specific structure including the grains of the composite powder and individual carbide inclusions embedded into the steel matrix.

It can be assumed that with the same integral content of the steel binder in the cladded coatings (80 vol. %) hardness and wear resistance can be affected by structural characteristics such as the volume content and average size of the non-dissolved granules, as well as the volume content and average size of the individual carbide inclusions in the steel binder. We cladded two kinds of coatings, using powder mixtures containing composite powder granules of different size.



a)

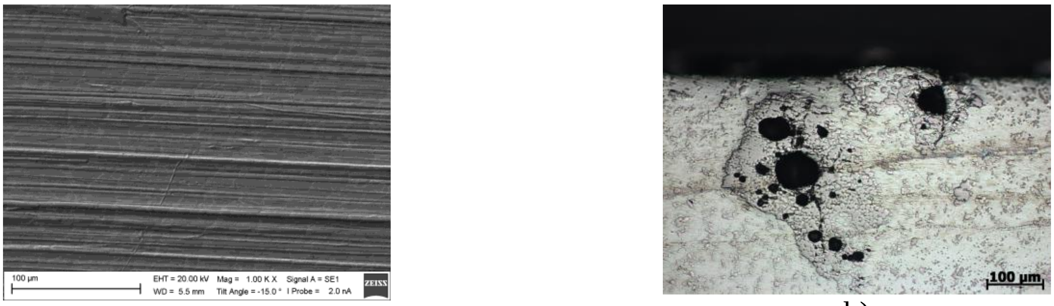
b)

Figure 1. Dependence of hardness (a) and wear rate (b) of coatings from HSS powder and powder mixtures with different content of steel binder in SHS compositie powders. The integral content of HSS in the powder mixtures is 80 vol. %. 1: - cladding with powders of 200-315 μm; 2: - cladding with powders of 125 - 200 μm.

The average hardness of coatings cladded with small-scale composite powders granules increases with increasing binder content (Figure 1a). A scatter in the coatings hardness values cladded with a large-scale powder is wider, than in coatings cladded with small-scale powder. It is interesting, that the hardness of the coating, deposited by the steel powder is approximately in the middle of the interval, in which the hardness of coatings cladded with composite powders varies. So it could be stated, that, due to the effect of self-hardening of HSS steel, the titanium carbide additive into HSS binder has little effect on the composite coatings hardness in contrast to its effect on abrasive wear resistance (Figure 1b). The wear resistance of coatings cladded by a small-scale composite powders is 2.3 times higher than the wear resistance of HSS coatings, and approximately 4.7 times higher for coatings cladded with large-scale powders.

The parallel grooves on the worn surface of the HSS surface (Figure 2a) points on the microcutting wear mechanism of the steel by sharp corundum particles with about 20 GPa hardness. Composite coatings wear mechanism is influenced by the rest granules in the composite coatings structure.

References



a) b)

Figure 2. Pictures of worn coating surfaces from HSS powder (a) and from composite powder TiC +20%HSS (b - side view).

1. Chiew S. P., Zhao M. S., Lee C. K. 2014 Mechanical properties of heat-treated high strength steel under fire/post-fire conditions Journal of Constructional Steel Research – vol 98 pp 12-19.
2. Wang X. H. et al. 2006 Fabricating TiC particles reinforced Fe-based composite coatings produced by GTAW multi-layers melting process Materials Science and Engineering vol 441 №1-2 pp 60-67.
3. Qu S. et al. 2008 Microstructure and wear properties of Fe–TiC surface composite coating by laser cladding Journal of Materials Science vol 43 №5 pp 1546-1551.
4. Emamian A., Corbin S. F., Khajepour A. 2005 Effect of laser cladding process parameters on clad quality and in-situ formed microstructure of Fe–TiC composite coatings Surface and Coatings Technology vol 205 №7 pp 2007-2015.
5. Wang Z. et al. 2016 Fabrication and properties of the TiC reinforced high-strength steel matrix composite Int. J. of Refractory Metals and Hard Materials 2016 vol 58 pp 14-21.
6. Saidi A. et al. 1997 Preparation of Fe - TiC composites by the thermal-explosion mode of combustion synthesis Ceramics international vol 23 № 2 pp 185-189.
7. Fan Q., Chai H., Jin Z. 1997 Role of iron addition in the combustion synthesis of TiC–Fe cermet Journal of materials science vol 32 №16 pp 4319-4323.
8. V.V. Fadin, A.V. Kolubaev, M.I. Aleutdinova 2011 TiC composites obtained by technological combustion Perspective materials №4, pp 91-96.
9. E.V.Ruzhitskaya 2012 Research of processes of mechanochemical synthesis of an alloy of Ti-C-R6M5 system FEFU School of Engineering Bulletin №4 pp 42-49 (in Russ).
10. He S. et al. 2017 TiC-Fe-based composite coating prepared by self-propagating high-temperature synthesis Metallurgical and Materials Transactions B vol 48 №3 pp 1748-1753.
11. Pribytkov G. A. et al. 2016 Effect of Fe base alloy content in Ti-C-Fe base alloy powder mixtures on the SHS products structure AIP Conf. Proceedings vol 1783 №1 pp 020189.