TECHNICAL INFORMATION

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FORMATION OF CONGLOMERATE STRUCTURES IN WEAR-RESISTANT FACINGS

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Properties of eutectic alloys are studied mainly in the presence of eutectic structures. An interesting study concerns the wear resistance of alloys with a phase composition characteristic for conglomerate structures.

The majority of wear-resistant metallic alloys have a eutectic structure, for example, white cast iron [1].

A. A. Bochvar has shown that one phase in a double-phase eutectic structure “drives” the crystallization process. The resulting double-phase coarse-grain structure is known as a coarse phase conglomerate [2].

In metallic alloys the formation of conglomerate structures is promoted by the presence of impurities that accumulate near the growing crystallites and hamper the underlying nucleation and joint growth of the eutectic phases.

It is known that molybdenum, tungsten, and phosphorus impurities promote the formation of conglomerate structures in white cast irons [1].

Using wide-layer surfacing we obtained iron alloys with a high carbon content (about 5%) into which we introduced Mo, W, Nb, V, Ti, B, P. Phosphorus was added to high-manganese alloys containing about 3.5% C.

A structure with more or less complete phase separation formed only in alloys with Mo, W, Nb, and P. The wear tests were conducted by the Brinell – Howorth method.

The alloys with niobium have a predominantly conglomerate structure although regions with a fine eutectic can be encountered. With increase in the niobium content from ~ 1 to 15% the wear resistance of the alloys hardly changes, and the hardness fluctuates within 51 – 57 HRC. It should be noted that at a 1-to-10 carbon-to-niobium proportion (~ 1% C and 10% Nb) the wear resistance of the alloy increased by a factor of 20. This is explainable by the fact that carbon and niobium in this proportion should bind completely into carbides; this should deplete the metallic matrix represented by ferrite. Indeed, the microhardness of the matrix of this alloy is 250 – 300 H.

Tungsten was introduced in an amount of 1 – 20%. Conglomerate structures were formed in alloys containing over 15% W (Fig. 1). Excess dendrites had a coarse acicular structure and a microhardness of 964 ± 92 H; the microhardness of the interdendrite matrix of the alloy with ~ 20% W was 1429 ± 125 H. The alloy with ~ 10% W had a typical hypoeutectic structure with “normal” spotty ledeburite and pearlitic excess dendrites (416 ± 6 H). With increase in the tungsten concentration the hardness increased almost linearly and the wear decreased monotonically by about a factor of 4 (Fig. 2).

The most interesting results were obtained with the introduction of molybdenum. At ~ 1% Mo the alloys still possessed a conventional hypoeutectic structure with spotty ledeburite (Fig. 3a). However, beginning with 5% Mo the structure was characterized by complete phase separation (Fig. 3b).
The microhardness of the structural components increased with the molybdenum content to very high values. For example, in excess dendrites it increased to ~1200 H, and in the interdendrite matrix in increased to ~1500 H. The structure of alloys with 15–20% Mo changed substantially (Fig. 3c, d) and resembled a structure with coarse primary lamellar carbides of cementite type with an acicular intercarbide space. The microhardness of the carbides was 1590–1780 H, and that of the acicular structure was 860 H, which corresponds to martensite. It is known that separate growth of phases can be caused by a relatively large volume occupied by primary crystals of the driven phase. If the phase-separating layers of the eutectic liquid are narrow enough, the short diffusion distances make the phase separation process occur by further growth of the available primary crystals and by autonomous nucleation and growth of crystals of the other eutectic phase, i.e., structures known as degenerate are formed [1]. The wear of alloys with 15–20% Mo turned out to be insignificant (Fig. 2). For example, it was 3 times lower than that of wear-resistant sorbite. Note for comparison that the wear of alloys with niobium was on the average 0.06 g and that of an alloy with an elevated content of phosphorus (~0.8%) was about 0.1 g.

Thus, we have obtained and studied a group of alloys of white cast iron type in which the conventional chromium additive was replaced by other alloying elements, specifically,