International Journal of Advanced Science and Technology
Vol. 29, No. 11s, (2020), pp. 1496-1502

Development Technology for Increasing Durability and Longevity of Soil-processing Working Bodies

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Abstract

The article deals with the technological process of obtaining metal layered compositions (MLC) for tillage working bodies. Metallic layered compositions are given that were developed for various types of tillage working bodies. The stavas of the Fe – Cr – C system served as "inserts"; namely, ПГ-С27and ПГ-С27-ТН-20, and the supporting base is foundry structural steel 65GL. Based on the studies (studying the microstructure, micro-hardness, distribution of elements in the transition zone, x-ray phase analysis), technologies have been developed for obtaining a number of MLCs for tillage tools.
Keywords: *metal layered compositions, tillage working body, boron carbide, cast structural steel, insert, alloy, wear resistance, microstructural studies.*

1. Introduction

In the world, research is being carried out in a number of priority areas to develop the composition, technology and improve the heat treatment of metal layered compositions, including: to develop a new technology for the production of metal layered compositions; to create the theoretical and technological foundations of heat treatment of metals; revealing the formation mechanisms of multicomponent metal leaf systems; development of the scientific basis for the production of composite materials with specified technological and operational properties. At present, it is important to increase the economic efficiency of economic sectors in creating a new composition of the materials produced. Effective and economic improvement of technologies for producing products by casting is important to improve the performance of industries. In this aspect, focused research work, including conducting research in the following areas, is one of the important tasks of creating composite materials using special metal layered compositions that ensure product quality; development of technologies for producing metal layered compositions; improving the theoretical and technological foundations of heat treatment, contributing to an increase in the strength of metal layered compositions; the creation and production of energy- and material-dispersing new metal layered compositions based on the latest achievements of science and technology, which presuppose the saving of scarce instrumental materials and increased labor productivity.

For the manufacture of metal layered compositions it is necessary to perform the following basic technological methods: the preparation of polystyrene foam for the manufacture of foam models; manufacturing foam model tools; preparation of the work item; preparation and receipt of the casting; getting tool. Obtaining a metal layered composition such as foundry structural steel - a working insert is possible if the physical-mechanical characteristics are comparable materials. Compositions of this type are a connection between tool and foundry structural steels. The main advantage of this class of joints is a reduction in the consumption of alloyed tool steels, due to their partial replacement with more affordable structural steels, and a decrease in labor intensity
manufacturing tillage working bodies.

2. Methods

Modern theoretical and experimental methods for studying metal layered compositions (macro- and micro, as well as X-ray diffraction analyzes and others) were selected in the work. Strength and physical-mechanical characteristics of metal layered compositions and products are determined according to the requirements of state standards.

3. Research Results

The mechanism has been determined and the features of the formation of the connection between the MLC elements have been determined, according to which, upon contact of the structural steel melt with the surface of the insert - the working cutting element, crystallization occurs with the formation of a hard crust followed by melting of the material of the intermediate layer and the interaction of the formed melt with solid surfaces bounding it: on the one hand , tool material, on the other - steel. As a result, a transition zone of the composition is formed, having a complex structure and phase composition, including the interaction products between the melt elements and the main components of the composition. An analysis of the mechanism and features of the formation of compounds of all the obtained types of MLC allows us to predict the process and select technological conditions for creating MLC with desired properties.

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Obtaining a metal layered composition such as foundry structural steel - working insert is possible if the physical-mechanical characteristics of the materials are comparable. Compositions of this type are a connection between tool and foundry structural steels. The main advantages of this class of joints are the reduction in the consumption of alloyed tool steels due to their partial replacement with more affordable structural steels and the decrease in the laboriousness of manufacturing tillage working bodies.

4. Discussion

The article discusses the technological process of obtaining metal layered compositions for tillage tools. The proposed version of the technology for the manufacture of metal layered compositions (MSC) with a low-melting working element was intended mainly for the manufacture of tillage tools of various types. In this case, the powdered hard alloys on the binder are applied in the form of a paste or placed in the form of prefabricated inserts in a specially prepared cavity. The melt temperature at the time of pouring is 1650-1700 ° C [1,2]. The use of boron-containing compounds in order to manufacture various composite materials having a high level of mechanical, thermal, electrical and other properties is quite widespread, primarily through the use of boron-containing compounds themselves. It should be noted that the complex is especially that boron carbide possesses valuable physical and mechanical properties [1-3]. As a result of experimental studies, a high-temperature material is obtained, characterized by chemical resistance to aggressive environments, high wear resistance, sufficient mechanical strength, low specific gravity. Its hardness is second only to diamond and cubic boron nitride.

Boron carbide has unique properties and is a promising component for creating composite materials for various fields of technology. These are chemical and wear-resistant, shock-resistant superhard materials on metal and ceramic basis. Boron carbide is an exclusively reactive compound, especially with respect to transition metals at elevated temperatures [1,2]. Its boron is active both in the free state and in some cases, especially in the presence of carbon, its activity increases [1,2].

The use of boron-containing compounds for the manufacture of various composite materials with a high level of mechanical, thermal, electrical and other properties is quite widespread, primarily the properties of boron-containing compounds themselves. Boron carbide possesses a complex of especially valuable physical and mechanical properties [3-5].

This is a non-metallic high-temperature material, characterized by chemical resistance in aggressive environments, high wear resistance, sufficient mechanical strength, low specific gravity. Its hardness is second only to diamond and cubic boron nitride.

With unique properties, boron carbide is a promising component for creating composite materials for various fields of technology. These are chemical and wear-resistant, shock-resistant superhard materials on metal and ceramic bonds.

Let us give a general description of the boron-metal-carbide systems of interest to us. Boron carbide is an exclusively reactive compound, especially with respect to transition metals at elevated temperatures [3-6]. Its boron is also active, as in the free state, and in some cases, especially in the presence of carbon, its activity is even higher [3-6].

Transition metals of groups IV – VI at temperatures of 1200–1700 ° C in a vacuum and inert medium react with boron carbide, forming borides of the corresponding metals of various compositions. Cobalt, iron, nickel also reacts with boron carbide at melting temperatures [1-6]. At a temperature of 1590 ° C, nickel interacts with boron carbide, forming three structural zones - boron carbide, an intermediate zone consisting of a mixture of nickel borides with precipitation of free carbon or its carboboride phases, and pure nickel [1-5].

Cobalt and iron at temperatures of 1500-1700ºC exhibits higher chemical activity with respect to boron carbide. The interaction zone is much more pronounced and represents the intertwined frameworks of borides of the corresponding metals and boron carbides [3-9]. To clarify the interaction mechanism in boron carbide - Me systems, it is advisable to introduce adhesive-active additives such as Ti, Zr, Hf, Mn.

Compositions were developed for various types of tillage tools (Fig. 1.) [3-9]. Alloys of the Fe – Cr – C system served as “inserts”; namely, ПГ-С27 and ПГ-С27-ТН-20, and 65ГЛ cast structural steel as the supporting base [1-5]. To maintain generality, the term "insertion" was retained, although the technology for making the composition implies a more correct use of the term "coating".

In this case, the “insert” coating is completely melted while preserving the crust. The coating thickness in the compositions “ПГ-С27 - steel 65ГЛ”, “ПГ-С27-ТН-20 - steel 65ГЛ” ranged from 2.8-3.2 mm. No discontinuity was found in the transition zone (Fig. 2) [1 - 6].

Microstructural studies of the composition are shown in Fig. 2 and have 5 characteristic subzones [1-6]:

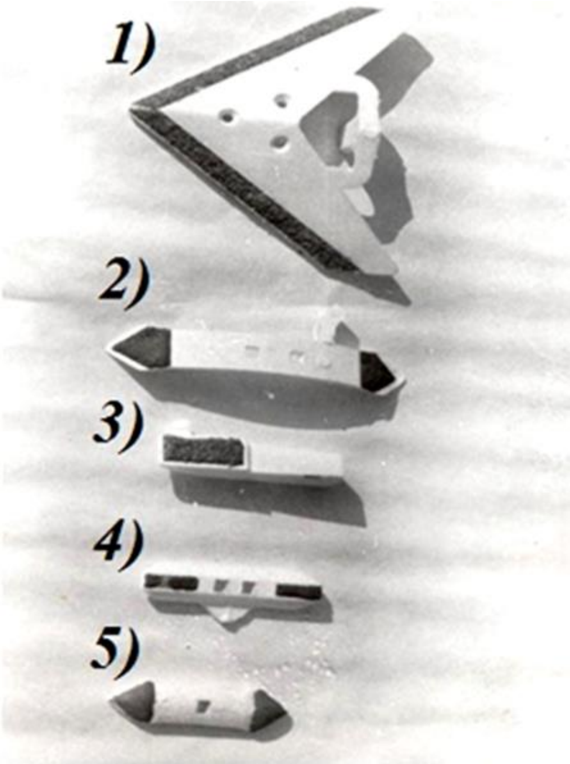
Subzone 1 - carbide, consisting of carbides of various morphologies with a predominance of carbides of needle-shaped and globular shapes. The thickness of the subzone is 0.4-0.6 mm;

Subzone 2 is eutectic and consists of complex eutectic colonies with separate carbide inclusions. The thickness of the subzone is 0.3-0.5 mm;

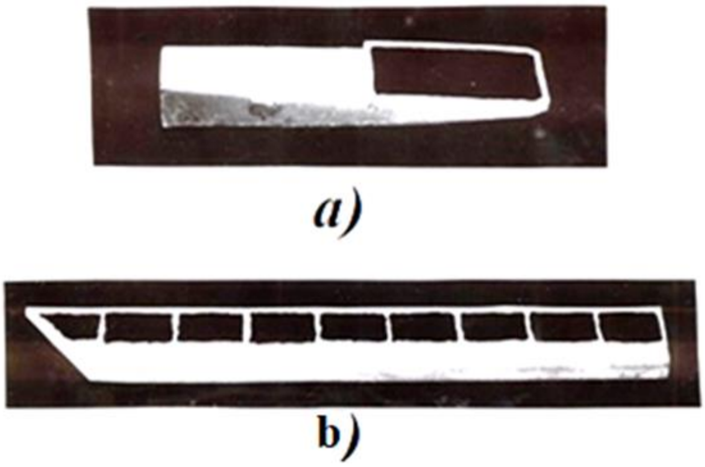
Subzone 3 - pre-eutectic with a characteristic ledeburite structure 2 mm thick;

Subzone 4 - a crust with a fine-grained structure 0.05 mm thick;

Subzone 5 - a carburization region with a pearlitic cementite or pearlite structure, with a thickness in the range of 0.2-0.4 mm, with a transition to the structure of cast high-carbon pre-eutectoid steel 65 ГЛ.



a)
1 - lancet paw; 2,3,4 - cultivator knife; 5 - chisel.



b)
a - sock model; b - blade model.

FIGURE 1: Polystyrene models of tillage (A) and cutting (B) elements of tillage tools

The microhardness distribution over the cross section of the compositions is shown in Fig. 3. As can be seen from the presented figures, the carbide subzone has the highest hardness (1100-1400HV). Then, the hardness curve (maximum and minimum) monotonically decreases in the eutectic and pre-eutectic subbands and reaches a minimum in the crust region and the carbonization region, 250 ... 350HV.

A special place in creating compositions is occupied by the material of the intermediate layer of compositions and must meet a number of requirements:

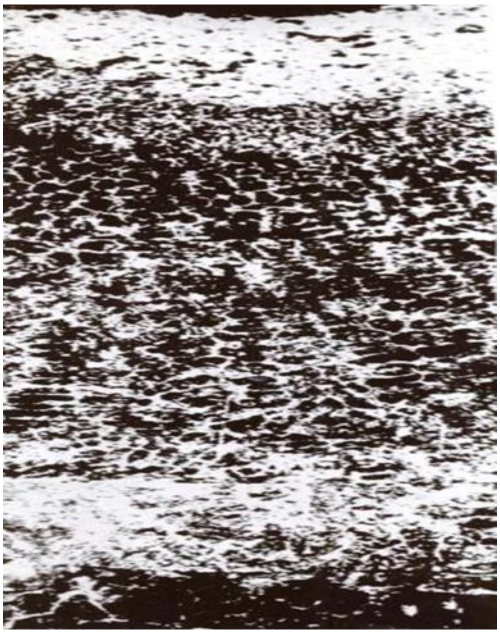


FIGURE 2: MLC macrostructure - solid working element " ПГ-С27 - ЛКС 65ГЛ "

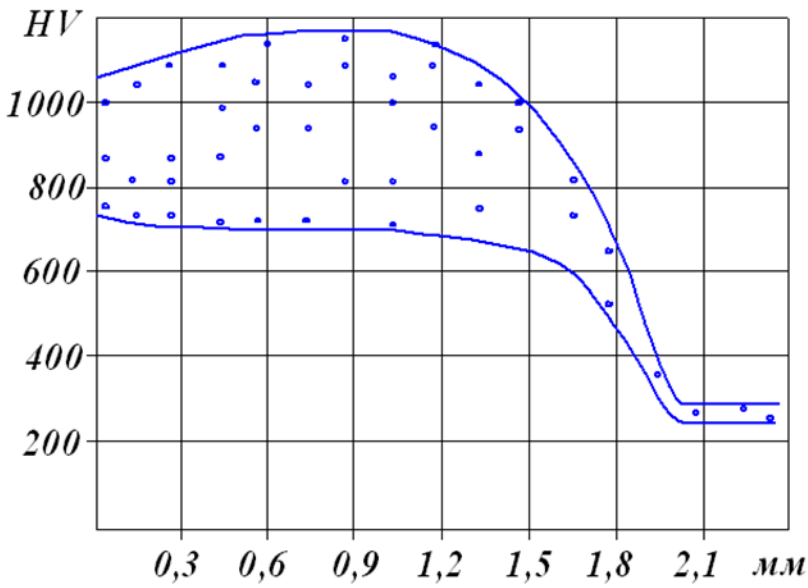


FIGURE 3: Distribution of hardness over the cross-section of a hard-alloy coating MLC - solid working element " ПГ-С27 - ЛКС 65ГЛ "

- have a melting point lower than the crystallization temperature of the alloy of the base and insert, which is dictated by the need to have a liquid layer during the formation of the compounds;
- well moisten both the insert and the supporting basis of the compositions;
- compensate for differences in the coefficients of thermal expansion between the elements of the connection.

Summarizing the results of studies of all types of compositions, one can imagine the mechanism and features of the formation of compounds between elements of compositions with the participation of the intermediate layer.

The formation mechanism obviously includes several successive stages:

1 - pouring of the melt is accompanied by gasification of polystyrene with partial assimilation of gasification products by the intermediate layer and their participation in the formation of the transition zone, which is confirmed by the presence of a carburization zone determined by the method of microstructural analysis of the transition zone of the composition;
2 - contact of the melt with the intermediate layer and its instant crystallization with the formation of a hard crust;
3 - heating of the intermediate layer to the melting point of copper, subsequent melting of Nickel with the formation of a liquid layer;
4 - interaction between the melt of the intermediate layer with hard surfaces bounding it on the one hand of the instrumental component and, on the other, a steel crust, which is caused by intensive dissolution followed by diffusion movement of the dissolved elements through the melt, as well as penetration of elements from the melt deep into the boundary layers;
5 - sequential crystallization of steel first, and then melt based on the intermediate layer.

When designing and developing a technology for the production of compositions of this type, attention should be paid to the following features of the formation of cast compositions:
- for large insert sizes, if the volume of the supplied melt is insufficient, the intermediate layer does not melt completely, which leads to a discontinuity, the calculated data are in good agreement with experimental data;
- it is impossible to prevent the melting or complete dissolution of the crust between the melts of the intermediate layer and steel, as this leads to the formation of pores in the transition zones, resulting in the loss of its performance [1-3]; an excessive increase in the volume of the supplied melt leads to melting of the crust before the onset of bulk crystallization of steel, which is proved analytically and experimentally;
- the presence of Ni in the intermediate layer and its penetration into the supporting base of the composition stimulates the formation of residual austenite, which is confirmed by the results of quantitative phase analysis.

In addition, in the cast state, the tool has reduced hardness and strength and has a heterogeneous structure. Thus, consideration of the mechanism and features of the formation of compounds of all types allows us to predict the process and choose the technological conditions for the creation of such compositions.

5. Conclusion

Based on the studies, the following conclusions can be drawn:
1. The mechanism has been determined and the features of the formation of a joint between the MSC elements have been established, according to which, upon contact of the structural steel melt with the surface of the insert — the working, cutting element, instant crystallization occurs with the formation of a hard crust with subsequent melting of the material of the intermediate layer and the interaction of the resulting melt with its limits hard surfaces: on one side of the tool material, on the other steel. As a result, a transition zone of the composition is formed, having a complex structure and phase composition, including the interaction products between the melt elements and the main components of the composition;
2.On the basis of the studies (study of the microstructure, microhardness, distribution of elements in the transition zone, x-ray phase analysis), technologies have been developed for obtaining a number of MSCs for tillage working bodies;
3. An analysis of the mechanism and features of the formation of compounds of all the obtained types of MSCs allows us to predict the process and select technological conditions for creating MSCs with desired properties.

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