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DEVELOPMENT OF THEORETICAL AND TECHNOLOGICAL BASIS OF PRODUCTION AND HEAT TREATMENT OF METAL LAYERED COMPOSITIONS

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Abstract. The article discusses the technological process of obtaining and heat treatment of metal layered compositions (MSC) for tillage working bodies. The compositions of metal layered compositions, which were developed for various types of tillage working bodies, are given. Alloys of the Fe-Cr-C system were used as "inserts"; namely PG-S27 and PG-S27-TN-20, and the supporting base is cast structural steel 65GL. Based on the studies carried out (study of 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 tools.

Keywords: wear resistance, heat treatment, metal layered compositions, tillage working body, boron carbide, casting structural steel, insert, alloy, microstructural studies.

抽象的。 本文讨论了用于耕作工作体的金属层状组合物 (MSC) **的**获取和热处理工艺流程。给出了为各种类型的耕作工作体开发的金属层**状**组合物的组合物。 Fe-Cr-C**系**统的合金被用作“**插入物**”； **即**PG-S27**和**PG-S27-TN-20，**支撑底座**为铸钢65GL。 **基于所**进行的研究（微观

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结构、显微硬度、过渡区元素分布研究、X 射线相分析），已经开发了用于获得许多耕作工具 MSC 的技术。

关键词：耐磨性，热处理，金属层状成分，耕作工作体，碳化硼，铸造结构钢，嵌件，合金，显微组织研究。

INTRODUCTION

The development of the machine-building industry, its products, which must meet modern requirements to increase the reliability, safety and service life of manufactured machines and mechanisms, apparatus and equipment and their materials - all this has led to the achievement of significant results.

At present, it is important to increase the economic efficiency of economic sectors, to create a new composition of produced materials; effective and economic improvement of technologies for producing products by casting is important for improving the indicators of the national economy. In this aspect, purposeful research and development work, including research in the following areas, are among the important tasks: creation of composite materials using special metal layered compositions that ensure product quality; development of technologies for obtaining metal layered compositions; improvement of the theoretical and technological foundations of heat treatment, contributing to the increase in the strength of metal layered compositions; creation and production of energy- and material-saving new metal layered compositions based on the latest advances in science and technology, implying saving scarce tool materials and increasing productivity. The above research areas, as well as the results of scientific research carried out in these areas, serve to substantiate the relevance of this work.

MATERIALS AND METHODS

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

RESULTS OF STUDIES

Taking into account the results of the analysis of the manufacture of MSCs, a sequence of the following basic technological methods was developed:

- preparation of expanded polystyrene for the manufacture of foam models;
- production of a foam model of the tool;
- preparation of the work item;
- preparation of receiving casting;
- getting the casting of the tool.

Preparation Of Expanded Polystyrene For The Manufacture Of Foam Model.

Foam models were obtained from pre-foamed granular polystyrene. Thus, the obtained polystyrene grade PSVL-0.315 underwent preliminary foaming in a water or steam bath for

4. 6 min, followed by drying in a stream of warm air (30. 40 ° C).
Expanded polystyrene, pre-foamed, granulated, was loaded into a mold, finally foamed in an autoclave of an installation for making models.

Making A Foam Model Of The Tool.

Technological equipment for producing a foam model - molds - was made of aluminum alloys.
The working elements of the foam model were placed either on specially prepared places of the mold, or on ready-made foam models.
An important factor in the design of a mold for obtaining foam models with working elements is orientation, basing the place for their placement, and a constructive solution for fixing the working element in the mold. In addition, when designing molds, it is necessary to take into account the options according to which the formation of the joint can occur. For the purpose of mass production of tools, it is advisable to switch to multi-position molds with several cores - calibers.

Gating System, Melting And Pouring Of The Melt.

For the manufacture of castings, stack molding is the simplest and most effective. The foam model was first assembled into a collector. Here the collector acts as a slag catcher and profit.
The model containing the working element is connected to the collector through a feeder, while the metal supply must always be siphon.
The calculation of the parameters of the gating system is carried out according to generally accepted methods. Before assembling with the manifold, the model is painted with non-stick paint.
The riser was assembled from separate elements. The assembled riser was placed in a flask and covered with dry K032 or K016 quartz sand. The molded flask was poured with molten steel (1600-1650ºC). After complete cooling, knockout was carried out. Sprues and risers were removed with an abrasive wheel. Cleaning treatment of castings was carried out in tumbling drums and shot blasting chambers.
Obtaining a metal layered composition of the type cast structural steel - working insert is possible if the physical and mechanical characteristics of the materials are comparable. Compositions of this type represent the bond between tool and foundry structural steels. The main advantages of this class of joints are a reduction in the consumption of alloyed tool steels due to their partial replacement with more affordable structural steels and a decrease in the labor intensity of the manufacture of tillage working tools.
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 fusible working element was intended mainly for the manufacture of soil cultivation tools of various types. In this case, powdered hard alloys on a binder are applied in the form of a paste or are placed in the form of pre-made 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 for the manufacture of various composite materials with a high level of mechanical, thermal, electrical and other properties is becoming widespread, primarily through the use of boron-containing compounds themselves. It should be noted that the complex especially
boron carbide possesses valuable physical and mechanical properties [1-3]. As a result of the

experimental studies, a high-temperature material was obtained, which is characterized by chemical resistance to aggressive media, high wear resistance, sufficient mechanical strength, and 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 extremely reactive compound, especially with respect to transition metals at elevated temperatures [1, 2]. Boron included in its composition is active both in a 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 becoming quite widespread, primarily, the properties of the boron-containing compounds themselves. Boron carbide possesses a complex of especially valuable physical and mechanical properties [3-5].

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

Possessing 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 carbide-metal systems of interest to us. Boron carbide is an extremely reactive compound, especially with respect to transition metals at elevated temperatures [3-6]. Boron included in its composition 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 IV-VI groups at temperatures of 1200-1700 ° C in vacuum and inert atmosphere react with boron carbide, forming borides of the corresponding metals of various compositions [121, 184].

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 precipitates of free carbon or its carboboride phases, and pure nickel [1-5].

Cobalt and iron exhibit higher chemical activity in relation to boron carbide at temperatures of 1500-1700 ° C. The interaction zone is much more pronounced and represents the mutually intertwined frameworks of borides of the corresponding metals and boron carbides [3-8].

For the purpose of clarifying the mechanism of interaction in boron carbide - Me systems, it is advisable to introduce adhesive-active additives such as Ti, Zr, Hf, Mn.

The compositions were developed for various types of tillage tools (Fig. 1, Fig. 2) [3-9].

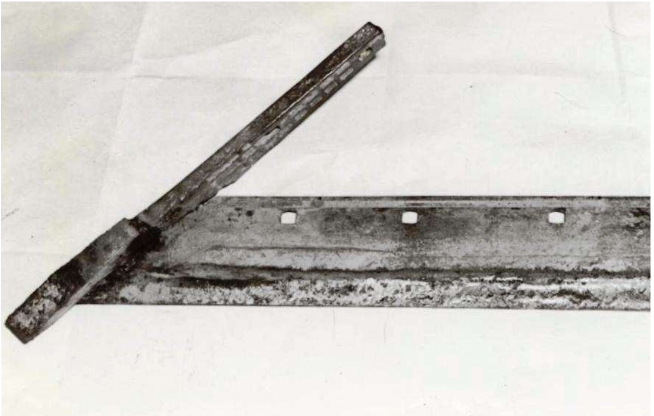
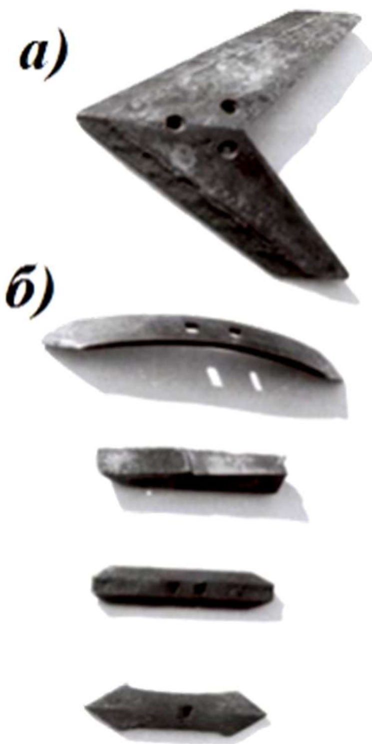


FIGURE 1. Metallic layered compositions (MSC) -
plow share for two-level plowing



a - lancet paw; b - cultivator knife
FIGURE 2..Metallic layered compositions (MSC) -
tillage tools of various
intended purpose

Alloys of the Fe-Cr-C system were used as "inserts"; namely PG-S27 and PG-S27-TN-20, and 65GL structural steel cast as a load-bearing base [1-5].

For the sake of generality, the term "insert" has been retained, although the manufacturing technology of the composition implies a more correct use of the term "coating". In this case, the "insert" coating is completely melted with preservation of the crust. The thickness of the coating in the compositions "PG-S27 - steel 65GL", "PG-S27-TN-20 - steel 65GL" ranged from 2.8 to 3.2 mm. No discontinuity was found in the transition zone (Fig. 3) [1 - 6].

Microstructural studies of the composition are shown in Fig. 3 and have 5 characteristic subzones [1-6]:

Subzone 1 - carbide, consisting of carbides of various morphology with a predominance of needle-shaped and globular carbides. Subzone thickness 0.4-0.6 mm; Subzone 2 - eutectic and consists of complex eutectic colonies with the presence of individual carbide inclusions. Subzone thickness 0.3-0.5 mm; 3 subzone - hypoeutectic with a characteristic ledeburite structure 2 mm thick; Subzone 4 - a crust with a fine-grained structure 0.05 mm thick; Subzone 5 - area of carburization with a perlite-cementite or pearlite structure, thickness within 0.2-0.4 mm with a transition to the structure of cast high-carbon hypoeutectoid steel 65GL. The distribution of microhardness over the cross section of the composites is shown in Fig. 4. As can be seen from the presented figures, the carbide subzone has the highest hardness (1100-1400HV).

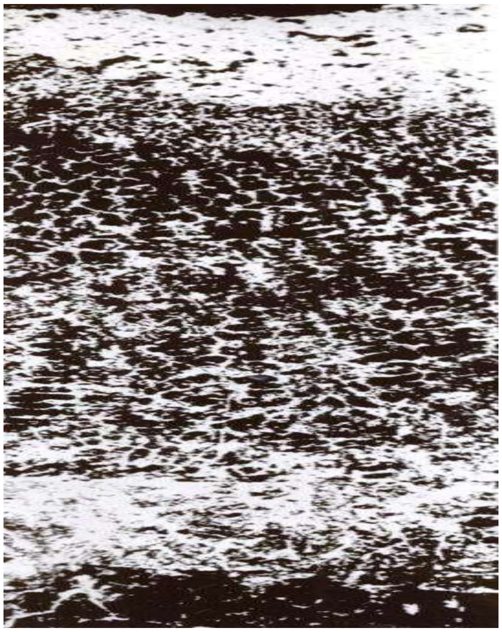


FIGURE 3. - Macrostructure of MSC - solid working element "PG-S27 - LKS 65GL"

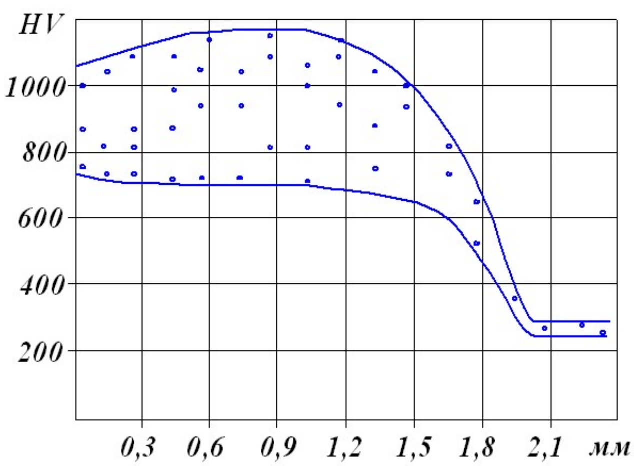


FIGURE. 4 - Hardness distribution over the cross-section of the hard-alloy coating MSK-hard working element "PG-S27 - LKS 65GL"

Then the hardness curve (maximum and minimum) decreases monotonically in the eutectic and hypoeutectic subzones and reaches a minimum in the crust and carburization region, 250 ... 350HV.

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

- have a melting point lower than the crystallization temperature of the alloy of the carrier base and insert, which is dictated by the need to have a liquid interlayer during the formation of joints;
- it is good to wet both the insert and the supporting base of the compositions;
- compensate for differences in the coefficients of thermal expansion between the elements of the connection.

DISCUSSION

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

The formation mechanism includes, obviously, several sequential stages:

1 - pouring 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, followed by the melting of nickel with the formation of a liquid interlayer;

4 - interaction between the melt of the intermediate layer with solid surfaces bounding it on one side of the instrumental component, on the other - a steel crust, which is due to intensive dissolution followed by diffusion movement of dissolved elements through the melt, as well as the 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:

- at large sizes of the insert, if the volume of the supplied melt is insufficient, the intermediate layer does not melt completely, which leads to discontinuity, the calculated data are in good agreement with the experimental data;
- it is impossible to allow 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, which results in the loss of its performance [1-3]; an excessive increase in the volume of the supplied melt leads to the melting of the crust before the bulk crystallization of the steel, which is proved analytically and experimentally;
- the presence of N_i in the intermediate layer and its penetration into the support base of the composition stimulates the formation of retained austenite, which is confirmed by the results of quantitative phase analysis.

In addition, in the as-cast state, the tool has a reduced hardness, strength and has an inhomogeneous structure.

Thus, consideration of the mechanism and features of the formation of all types of compounds makes it possible to predict the course of the process and select the technological conditions for creating such compositions.

As a method of increasing the wear resistance of the working bodies of soil-cultivating working bodies made of MSC, the technology of heat treatment of metal layered self-sharpening tools is proposed, as applied to cast cutting elements, which makes it possible to increase the wear resistance of both the coating and the base.

The proposed heat treatment preserves the ratio of the relative wear resistance of the base metal and the hard-alloy coating as 1: 6, which is the main one for ensuring the self-sharpening process and increases the tool life by 2.5… .3.0 times [9, 10].

Field operational tests have shown that the operating time of the restored working bodies of soil-cultivating working bodies by the casting method according to gasified models with a multilayer structure is 30 ... 60% higher than the serial ones, due to the stabilization of the working profile and reducing the wear rate. With subsequent heat treatment, an increase in operating time by 100 ... 120% is achieved.

CONCLUSION

Based on the research carried out, the following conclusions can be drawn:

1. The mechanism is determined and the features of the formation of the connection between the elements of the MSC are determined, 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, followed by the melting of the material of the intermediate layer and the interaction of the resulting melt with the limiting it hard surfaces: tool material on one side, steel

on the other. As a result, a transition zone of the composition is formed, which has a complex structure and phase composition, including the products of interaction between the elements of the melt and the main components of the composition;

2. On the basis of the conducted research (study of microstructure, microhardness, distribution of elements in the transition zone, X-ray phase analysis), technologies for obtaining a number of MSCs for tillage working bodies have been developed;

3. Analysis of the mechanism and features of the formation of compounds of all the obtained types of MSCs for tillage working bodies allows predicting the course of the process and choosing technological conditions for creating MSCs with desired properties.

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